Silicon Sam's Technology Resource (SSTR) - V3.86
Main Table of Contents (ToC)

Note: If you know of something that is incorrect or missing from this page or if you have any additions, please contact me via the Sci.Electronics.Repair FAQ Email Links Page.

Everything in SSTR is now accessible directly from the S.E.R FAQ Main ToC. It may be better to link there instead.

See What is the Sci.Electronics.Repair FAQ? if you are really not quite sure you should be here.

Please check out the Home and Mirror Site Locations page to access or download the latest versions of these documents.

The SSTR Expanded ToC lists ALL files of mine resident at this site. This may be convenient if you are attempting to locate or download a particular photo, schematic, or other file not referenced directly by the top level ToC or its Sub-ToCs.

Sci.Electronics.Repair FAQ Search on Drexel Mirror Site

The following provides a fast search facility but it is currently only present on the S.E.R FAQ mirror site at Drexel University which is maintained up to date almost daily.

Search the entire Sci.Electronics.Repair FAQ for [ ] Submit
More Search Options

You may get  if you don't read these Notes on Safety

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Samuel M. Goldwasser's **"Notes on the Troubleshooting and Repair of..."**:

- Troubleshooting and Repair of Consumer Electronic Equipment

- Small Household Appliances
- Audio Equipment and Other Miscellaneous Stuff
- AC Adapters, Power Supplies, and Battery Packs
- Compact Disc Players and CDROM Drives
- Optical Disc Players and Optical Data Storage Drives
- Microwave Ovens
- Computer and Video Monitors
- Small Switchmode Power Supplies
- Television Sets
- Video Cassette Recorders
    - VCR First Aid
- Hand Held Remote Controls
- Electronic Flash Units and Strobe Lights
- Small Engines and Rotary Lawn Mowers
- Printers and Photocopiers

Samuel M. Goldwasser **"Other Repair Information"**:

- Sam's Repair Briefs
- Interesting Repair Related Stories and Anecdotes

- VCR Power Supply Hybrid Regulators
- Pinouts for Various Common Chips and Hybrids

- Capacitor Testing, Safe Discharging, and Other Related Information
- Testing of Flyback (LOPT) Transformers
- Basic Testing of Semiconductor Devices

- TV and Monitor CRT (Picture Tube) Information
- TV and Monitor Deflection Systems

- RCA/GE TV CTC175-187+ Solder Connection and EEPROM Problems
- Sony TV Tuner and IF Solder Connection Problems

- On-Line Tech-Tips Databases

- Major Service Parts Suppliers

Samuel M. Goldwasser **"LASERS: Safety, Info, Links, Parts, Types, Drive, Construction"**:

- Sam's Laser FAQ - A Practical Guide to Lasers for Experimenters and Hobbyists.

- Sam's Laser FAQ Expanded Table of Contents - HTML, photos, diagrams, schematics.
- Sam's Laser FAQ Comprehensive Table of Contents - Direct links to every chapter and section.

- Laser Equipment Gallery - Photos of various laser systems, power supplies, and components (Link).

Samuel M. Goldwasser **"General (Mostly Electronics) Information and Links"**:

- Various Schematics and Diagrams

- Simple High Voltage Generator
- Jacob's Ladders

- Basics of High Voltage Probe design

- Salvaging Interesting Gadgets, Components, and Subsystems

- Performance Testing of Computer and Video Monitors
- Approaches to using Fixed Frequency or Non-Standard Monitors on PCs
- Notes on Video Conversion

- Fluorescent Lamps, Ballasts, and Fixtures
- Gas Discharge Lamps, Ballasts, and Fixtures

- International Power and Standards Conversion

- Engineering, Science, and Other (Pretty Clean) Jokes Collection

- Sam's Neat, Nifty, and Handy Bookmarks - Over 1000 Technology Links (Electronics, lasers, more).

- Sam's Classified Page - Sam's stuff for sale or trade and items wanted.

Home and Mirror Site Locations

On-Line Access and Download of:

The Sci.Electronics.Repair (S.E.R) FAQ
Sam's Laser FAQ
Silicon Sam's Technology Resource (SSTR)
Other Sam's Documents

Version 1.75

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

Table of Contents

Introduction

These listings and links identify those web sites where I have some sort of control and attempt to maintain up-to-date versions of all the documents where possible. Additional options may be found at the mirrors info of the Sci.Electronics.Repair FAQ sites themselves. Some Web sites get updated more frequently than others. The latest versions of the S.E.R FAQ (including Sam's Laser FAQ) are at three Web sites, which are the absolute latest or updated almost daily:

- S.E.R FAQ Galactic Home
- S.E.R FAQ Drexel Mirror
- S.E.R FAQ UPenn Mirror

Zip files for downloading the complete FAQs may be found on the Drexel and UPenn mirror sites (direct links below).

Descriptions of the Various FAQ Collections

The Sci.Electronics.Repair (S.E.R) FAQ is an extensive set of documents on consumer electronics (and other) troubleshooting and repair, testing, general electronics, reference information, assorted schematics of interesting and sometimes unusual devices, links to over 1000 technology related Web sites, and more. It was developed specifically for the DoItYourselfer (DIYer) and tinkerer, hobbyist, experimenter, engineer, dentist, and poet. The S.E.R FAQ includes all of the material I have written (nicely formatted by Filipg G.) as well as many articles and references from others. To the best of my knowledge, this is the most comprehensive collection of information of its kind in the explored universe.

Note that the latest documents I have authored (see SSTR, below) are now linked from the S.E.R Main ToC. The older versions will eventually be phased out.

Sam's Laser FAQ (SLF) - A Practical Guide to Lasers for Experimenters and Hobbyists - contains extensive practical information on a variety of laser related topics. Sam's Laser FAQ is present at all S.E.R FAQ (and SSTR - see below) sites, but due to its nature and size, is also available as a self contained document and at other sites as well. Version may vary slightly by site but all are quite recent and nicely formatted including a full table of contents, list of all associated files, and extensive cross-links. The complete Sam's Laser FAQ may be downloaded for convenient high speed local access. See: Sam's Laser FAQ Local Installation for details.

The **Laser Equipment Gallery (LEG)** includes a collection of photos of various laser systems, power supplies, and components. Due to its size, the LEG is only present at selected sites and is NOT part of the FAQ distributions.

Silicon Sam's Technology Resource (SSTR) includes all the documents I have authored and are now linked from the main S.E.R FAQ ToC. They are nicely formatted and eventually the older similar documents of the S.E.R FAQ will be phased out. In other words, the latest versions of the S.E.R FAQ documents I have authored ARE exactly the same as what's in the SSTR directory. The complete SSTR collection may also be downloaded for convenient high speed local access. See: Silicon Sam's Technology Resource Local Installation for details. Note that while SSTR sites include Sam's Laser FAQ, it is NOT part of the SSTR download package and must be installed separately.

Copies of some of these documents, particularly the various repair guides of the Sci.Electronics.Repair FAQ, may be found at other totally independent sites. However, unless they are live links back to one of the sites below, the versions are likely to be quite old (relatively speaking, at least). There are also some additional sites which have copied and modified some of these documents to provide a more user friendly graphical user interface. So, if you stumble across something that looks vaguely familiar, you will know where it came from. In either case, if there is no acknowledgement of the origin in the links or at the beginning of the document, please let me know!

The Main Table of Contents (ToC) links, below, are the usual jumping off points for the good stuff for on-line viewing. :-) Those labeled as 'Zip' may be downloaded as a single compressed file and easily installed to create a local browser accessible copy. See the descriptions of the FAQs, above, for links to installation instructions.

Sci.Electronics.Repair FAQ Home Site

The latest versions of these documents are available at the Home site, Repairfaq.org.

(SSTR=Silicon Sam's Technology Resource, SLF=Sam's Laser FAQ, LEG=Laser Equipment Gallery.)

- USA-SC: S.E.R FAQ Home (RepairFAQ.org) - S.E.R. FAQ Main ToC | SSTR | SLF | LEG.

Sci.Electronics.Repair FAQ Mirror Sites

These sites have various versions depending on who maintains the content. For those where I have upload access at least, versions will be quite recent. UPenn is my "live" site - it's where I do all development and is thus guaranteed current (complete with screwups). Repairfaq.org and Drexel are updated from UPenn almost daily. Hopefully, some sites will have fully automatic mirroring but that is in the future (I've been saying this for about 10 years now!).

The primary mirror sites (Drexel and UPenn) are listed first, followed by the remainder in no particular order - maybe alphabetic, then EDU/COM, then USA/Foreign, then by distance, maybe. :)

(SSTR=Silicon Sam's Technology Resource, SLF=Sam's Laser FAQ, LEG=Laser Equipment Gallery, Zip=Zipped file for the preceeding FAQ collection.)

- USA-PA-E1: S.E.R FAQ Mirror (Sam, Drexel U. ECE) - Main ToC, Zip | SSTR, Zip | SLF, Zip | LEG.
- USA-PA-E2: S.E.R FAQ Mirror (Sam, U. of Penn CIS) - Main ToC, Zip | SSTR, Zip | SLF, Zip | LEG.

- USA-IL: S.E.R FAQ Mirror (David Gersic, NIU) - Main ToC | SSTR | SLF.
- USA-NH: S.E.R FAQ Mirror (Timothy. J. Quill, Dartmouth U.) - Main ToC | SSTR | SLF.
- USA-NY: S.E.R FAQ Mirror (Jameel Akari) - Main ToC | SSTR | SLF.
- USA-PA-W: S.E.R FAQ Mirror (Greg J. Szekeres, UPitt) - Main ToC.
- USA-CA: S.E.R FAQ Mirror (EIO) - Main ToC | SSTR | SLF.

- USA-FL: S.E.R FAQ Mirror (Chris Hoaglin) - Main ToC | SSTR | SLF
- CA (Canada): S.E.R FAQ Mirror (University of Alberta EECS) - Main ToC.
- DE-1 (Germany): S.E.R FAQ Mirror (Daniel Brune) - Main ToC | SSTR | SLF.

The entries marked 'Zip' provide a convenient way of creating a local browser-accessible copy of SSTR and/or Sam's Laser FAQ. See Silicon Sam's Technology Resource Local Installation and Sam's Laser FAQ Local Installation for details.

Sci.Electronics.Repair FAQ Archive

The complete Sci.Electronics.Repair FAQ (including information and links from other sources) may also be downloaded from the Circuit Cookbook Archive (CCA) sites. Both ASCII and local HTML versions are available but they are generally older than those at many other sites:

- CA (Canada): CCA Home (University of Alberta EECS) - Electronics FAQs | Repair FAQs - Zip.

Sci.Electronics.Repair FAQ Italian Translation by Antonio Cristiani

Most of the individual repair and testing documents (but not Sam's Laser FAQ) have been converted including the colloquial English phrases!

- IT (Italy): S.E.R FAQ in Italian (Antonio Cristiani)
- CA (Canada): S.E.R FAQ in Italian Mirror (University of Alberta EECS) - Main ToC.

Sci.Electronics.Repair FAQ French Translation by GUILBAUD Christophe (Tophe)

Portions of some of the individual repair and testing documents (currently just TVs and VCRs) have been converted. This site is under construction.

- FR (France): Tophe's Homepage and Table of Contents

Additional Sites with Silicon Sam's Technology Resource

(I'm not sure if this one is maintained.)

- USA-MA: GB7IPD's Web Site - SSTR | SLF.

Additional Sites with Sam's Laser FAQ

In addition to being included in the S.E.R FAQ and SSTR sites, there are several other sites which include Sam's Laser FAQ (SLF).

- USA-MD: K3PGP's Web Site - Experimenter's Corner | SLF | LEG.
- USA-PA: Don Klipstein's Web Site (Home) - Don's Laser Page | SLF.
- DE-2 (Germany): LaserFreak.net's Web Site - SLF | LEG.

Going to laserfaq.net or laserfaq.org will also work and are the same Web site.

Miscellaneous Sites with Sam Stuff

A variety of documents that I have authored or coauthored are available on: Don klipstein's Lighting Technology Web Site. (Most of these are also part of the S.E.R FAQ and SSTR collections.)

One of the latest versions of the document: "Notes on the Troubleshooting and Repair of Electronic Flash Units and Strobe Lights, and Design Guidelines, Useful Circuits, and Schematics" usually resides at:

- Don's Xenon Flash and Strobe Page - Strobe FAQ.

Fluorescent and discharge lamp info and troubleshooting documents:

- Don's Lighting Info Center - Fluorescent Lamps | DC-AC Inverters | Discharge Lamps.

High Voltage Stuff:

- Don's High Voltage Page - Simple HV Generator.
- Don's Plasma Spheres, Jacobs Ladders, and Other Things Page - Jacobs Ladders.

- Back to Home and Mirror Site Locations Table of Contents.

-- end V1.75 --

Silicon Sam's Technology Resource

Expanded Table of Contents (ToC): HTML, Photos, Diagrams, and Schematics

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

Introduction

This Expanded Table of Contents (ToC) provides links to all of the files of Silicon Sam's Technology Resource (SSTR). These pages may be used in place of the normal Main ToC, to identify those graphics files which are part of any given FAQ, or simply as a means of just looking at the pretty pictures. :-)

Note: There are *zillions* of additional diagrams and schematics included within the HTML files themselves. Those that are listed here are only the ones that are in .pdf, .gif, .jpg, or other graphics or compressed format.

Silicon Sam's Technology Resource Expanded Table of Contents

SSTR Top Level Pages, Mirror Site Info, Local Installation

The Most Important Document - Must Read

Notes on the Troubleshooting and Repair of...

Meter Movement From Classic Simpson 260 VOM(mmmove1.jpg). D'Arsonval Meter Movement Anatomy(mmanat1.jpg).

- AC Adapters, Power Supplies, and Battery Packs (aapsfaq.htm).

- Compact Disc Players and CDROM Drives (Link, cdfil.htm).

- Optical Disc Players and Optical Data Storage Drives (odfaq.htm).

- Computer and Video Monitors (monfaq.htm).

  - Typical SVGA Monitor Block Diagram (mon1blk.gif).
  - Major Parts of Typical SVGA Monitor with Cover Removed (mon1rear.gif).
  - Typical Switchmode Power Supply for Small SVGA Color Monitor (mon1ps.gif).
  - Symptoms of Some Common Deflection Problems (deflprob.gif).

- Microwave Ovens (micfaq.htm).

  - Typical Microwave Oven Electronics Bay (mwoven1.gif).
  - Typical Magnetron Anode and Resonant Structure (maganode.gif).

- Switchmode Power Supplies (smpsfaq.htm).

  - Block Diagram of Basic Flyback Switchmode Power Supply (smpsbd.gif).
  - Typical SMPS Input Voltage Select Circuit (smpsvs.gif).

- Television Sets (tvfaq.htm).

  - Symptoms of Some Common Deflection Problems (deflprob.gif).

- Video Cassette Recorders (Link, vcrfil.htm).

- VCR First Aid (vcrrx.htm).

  - Typical VHS VCR Transport - Top View (vcrxprt.gif).
  - VHS Cassette - Inside Top View (vhscasin.gif).

- IR Remote Controls (irrfaq.htm).

- Electronic Flash Units and Strobe Lights (Link, strbfil.htm).

- Printers and Photocopiers (printfaq.htm).
- Small Gasoline Engines and Rotary Lawn Mowers (lmfaq.htm).

Sam's Other Repair Information

- Sam's Repair Briefs - Complete 1-100 (rball.htm).
- Interesting Repair Related Stories and Anecdotes (stories.htm).
- Testing Capacitors with a Multimeter and Safe Discharging (captest.htm).
- Testing of Flyback (LOPT) Transformers (flytest.htm).
- Basic Testing of Semiconductor Devices (semitest.htm).
    - Simple In-Circuit Tester Schematic (curve.gif).
- TV and Monitor CRT (Picture Tube) Information (crtfaq.htm).
- TV and Monitor Deflection Systems (deflfaq.htm).
- VCR Power Supply Hybrid Regulators (vcrreg.htm).
- Pinouts for Various Common Chips and Hybrids (chippins.htm).
- RCA/GE CTC175-187+ Solder Connection and EEPROM Problems (rcatune.htm).
    - RCA CTC175A Tuner Solder Locations (ctc175a1.jpg).
- Sony TV Tuner and IF Solder Connection Problems (sonytune.htm).
- On-Line Tech-Tips Databases (techtips.htm).
- Major Service Parts Suppliers (srvcprts.htm).

LASERS: Safety, Info, Links, Parts, Types, Drive, Construction

- Sam's Laser FAQ - A Practical Guide to Lasers for Experimenters and Hobbyists (Link, laserfil.htm).

Sam's General Electronics Information and Links

- Various Schematics and Diagrams (Link, schfil.htm).
- Simple High Voltage Generator
- Flyback Based RF Source (flybkrf1.gif).
- Jacob's Ladders
- Simple High Voltage Probe design (hvprobe.htm).
- Performance Testing of Computer and Video Monitors (montest.htm).
- Approaches to using Fixed Frequency or Non-Standard Monitors on PCs (ffmon.htm).
  - IBM9517 Monitor Modifications for use with PC VGA/SVGA (vga9517.gif).
- Notes on Video Conversion (vidconv.htm).
- Fluorescent Lamps, Ballasts, and Fixtures (flamp.htm).
  - Low Power 220 VAC Fluorescent Lamp (linefl.gif).
- International Power and Standards Conversion (pwrfaq.htm).
- Salvaging Interesting Gadgets, Components, and Subsystems (gadget.htm).

  asdf
- Engineering, Science, and Other (Pretty Clean) Jokes Collection (humor.htm).
- Sam's Neat, Nifty, and Handy Bookmarks (sambook.htm).

Warning Signs and Essential and Optional Icons :-)

- Electrical Safety Warning Sign (Shock.gif).
- Sci.Electronics.Repair FAQ Icon (Browser, serfaq.gif).
- Sci.Electronics.Repair FAQ Icon (Windows, serfaq.ico).

- Laser (HeNe Tube) FAQ Icon (Browser, laserfaq.gif).

- Silicon Sam's Technology Resource Icon (Browser, sstr.gif).
- Silicon Sam's Technology Resource Icon (Windows, sstr.ico).

- Go to Silicon Sam's Technology Resource.

Silicon Sam's Technology Resource

Including:

Electronics (and more) Repair Guides and Laser and Other Information

Welcome to Samuel M. Goldwasser's latest and most fabulous "Notes on the Troubleshooting and Repair of..." series of comprehensive repair guides for consumer electronic equipment and other household devices. Detailed diagnostic and repair procedures are provided for: small electrical appliances, audio equipment, TVs, VCRs, CD players, computer monitors, microwave ovens, even lawn mowers - and much much more! There are also articles on the testing of various types of electronic components without fancy test equipment, 100 complete repair briefs including diagnostic procedures - not just solutions, repair related stories, pinouts for common chips and hybrids, and the list goes on and on.

Basic information includes essential safety guidelines when working on high voltage and/or AC line powered devices as well as a complete document on getting started in electronics troubleshooting. Some of its topics are: diagnostic tips and rules-of-thumb; recommended tools, supplies, and parts inventory, test and ancillary equipment; schematics for some easy to build incredibly handy widgets(tm); soldering and desoldering; sources of information in print and on-line; parts sources; and how to perfect diagnostic and repair skills.

In addition, there is a great deal of other information on a variety of areas of technology.

Sam's Laser FAQ has a great deal of information on a variety of laser and optics related topics including a comprehensive treatment of diode, helium-neon, argon/krypton ion, and CO2 lasers as well as amateur laser construction including numerous examples of truly home-built lasers. Much of this is not available anywhere else either on-line or in print!

Also included are documents on video conversion, use of fixed frequency monitors on PCs, international power, fluorescent and discahrge lamps, many new schematics, salvaging useful parts, links to over 1,000 technology related sites - and much much more.

This resource was developed specifically for the Do-It-Yourselfer, electronics experimenter, hobbyist, technician, engineer, and possibly even including the dentist and poet! To the best of my knowledge, it represents by far the largest most in depth collection of on-line information of its type - anywhere.

Silicon Sam's Technology Resource Sites

The links below take you directly to the documents at this site:

- SSTR Main ToC - Comprehensive Repair Guides, FAQs, Testing Info, Assorted Schematics, etc.
- Sam's Laser FAQ - A Practical Guide to Lasers for Experimenters and Hobbyists.

The documents at Sam's Home (RepairFAQ.org) will normally be the latest and greatest. However, the large FAQs of the "Notes on the Troubleshooting and Repair of..." series located at the various Sci.Electronics.Repair FAQ sites under the "S.E.R FAQ Main Table of Contents" pages may be more nicely formatted with complete tables of contents, cross-linking, and feedback forms for comments as well as complements, corrections, or complaints. The most popular of these are also available in convenienct small segments or as a single file. There is also a lot of additional information and links beyond what I have written.

- Sci.Electronics.Repair FAQ Home Main Table of Contents - Everything nicely formatted plus much information from other sources.

For all of these documents, please check the Home and Mirror Site Locations page to identify the best site for your needs.

Please Read at Least Once

A word about the philosophy of this site: These pages are declared to be a fluff-free zone! There will be no unnecessary, superfluous, or useless graphics of any kind - including but not limited to: dancing, gyrating, or other animated icons, colored textured backgrounds that are impossible to read through, or forced downloading of bit intense pictures that may be of no interest to you. Nor, will I ever expect you to use a particular brand of Web browser to be able to effectively access these pages. There are and never will be any advertisements, cookies, or other impositions on your time and space. In the time that it may take wading through a single monstrosity of the professional Web page designers at other sites, you will be able to find out what you want to know, when you want to know it! What a concept. :-) (Note, however, that your browser needs to be configured properly to make sense of ASCII diagrams, schematics, and tables. See the document: Suggested Browser Settings for font and other related information.)

In return for this gold mine of information, please make a serious effort to find the answers to your questions before contacting me. It may take just a wee bit of effort and could stress a few neurons in the process, but there is an excellent chance that what you seek is covered at these sites. Should you be really stuck, I will respond to email in a timely manner. However, if your question indicates that you haven't even gotten past the Main Menu, AND I am in a good mood, you will get a somewhat polite reply to read the #$%& FAQs. On the other hand, if it is a bad day, and you are really really lucky, you will probably be ignored. In any case, I expect to be able to hit the reply key for my mail program and not get bounced email. I will not attempt to unjumble any anti-SPAM email addresses! I have posted over 20,000 articles to the USENET newsgroups using my true email address. (And, you won't pick up SPAM via private email anyhow.) Yes, SPAM is a pain but I tolerate the small amount I get so others will not be inconvenienced.

Note: I NEVER send email attachments. If you receive a message supposedly from one of my addresses with any sort of attachment, it is bogus and possibly a virus. Someone's address book includes my address and their computer is infected. Send me the complete headers and I'll attempt to check it out, or just delete it.

Where you have a model specific repair question, it will probably be more expedient to post a complete but concise description of your problem including manufacturer, model, symptoms, and what you have already tried, directly to the USENET newsgroup: sci.electronics.repair. I really don't have access to that much model specific service information - and that is probably what I will tell you to do anyway! See the document: Troubleshooting and Repair of Consumer Electronic Equipment for more information. Or, consult a **Tech-Tips** database to see if your specific problem has already been solved a million times. See the document: On-Line Tech-Tips Databases.

Troubleshooting and Repair Notes Introduction

Version 1.23

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Introduction to the Introduction

The most up-to-date public versions of these articles which constitute a major portion of the Sci Electronics Repair FAQ currently reside at the:

- RepairFAQ.org Home Site

Keep this in mind if you are reading this elsewhere as your versions may not be the latest. Major new releases come out every few months but minor corrections or additions may appear at any time.

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Purpose of the "Notes"

The "Notes on the Troubleshooting and Repair of..." series was developed to provide a resource for the hobbiest, tinkerer, engineer, weekend mechanic, housewife, dentist, and poet. For you, I am doing this because I would like to help provide information that is not always readily available. The sincere appreciation I receive via personal email is generally enough of a reward to retain my interest.

The purpose of these articles is not only to help you repair your CD or VCR but more importantly, to educate. Therefore, they are not quite 'FAQs' but rather complete maintenance and repair guides. What this means is that you cannot depend on every problem to show up in the index. For example, if you have a problem with say, a breadmaker, but there is no entry for it in the guide for small appliance repair, think of what is inside such a device: power supply, controller, motor, heating element, etc. Then, find the sections on something similar. It is difficult enough to provide coverage for every type of device ever marketed in this sector of the galaxy let alone the more remote parts of the universe :-).

If all you want is a quick fix, the various 'Tech Tips' databases may be better alternatives. They will likely list the most common problems and solutions for your equipment. However, these seem to deal mostly with TVs, VCRs, monitors, and microwave ovens. For anything else, you are largely on your own. A quick fix may be possible but you will not learn much that can be applied to other problems in the future. In addition, you may end up replacing many parts that are actually good since you will have done little or no testing.

With the Notes, a quick fix may still be possible but you will have to do some leg work (or at lest finger and mouse work) on your own. How much you will benefit will be a direct consequence of how much effort you put in - but there should be a significant amplification or multiplication factor. Wherever possible, explanations of the equipment operating principles and likely causes of failures are provided. You will gain at least some understanding of 'what makes it tick' and be able to carry over general troubleshooting approaches from one brand to another and even one type of device to another.

I realize that not everyone will have the capability - or desire - to actually apply the information in these Notes towards a repair. However, awareness of the likely causes and remedies for a particular problem goes a long way toward being able to make an informed decision with respect to repair or replacement options. If you do take the unit to a service center or repair shop, this knowledge will enable you to deal with the sales droid or technician from a position of strength.

For those of you who are professional technicians in business for profit, much of the information contained in the Notes is no doubt familiar. However, if you are routinely referring to these documents, I expect that you consider them beneficial in some way. This probably means some combination of savings in terms of time and money - which translates to increased profits. I would hope you feel some minimal obligation to show your appreciation in some concrete way. I am not sure what form this should take but you must realize that maintaining this continuously evolving and expanding site is a very non-trivial and time consuming task for both Filip and myself. These Notes and other articles do not grow on trees or spontaneously sprout from the bowels of the Web server at this site!

- Back to Introduction Table of Contents.

Why do I do this?

I am an electrical engineer by profession. I have spent significant time in both academia and industry teaching and designing in the areas of the architecture and implementation of digital systems. The development of one particular special purpose high performance image and graphics processor with three of my students led to the creation of a business plan. I have done the startup thing, been taken over by a big company, spent some time there, and become bored with corporate life.

I also have always had a passion for fixing mechanical and electronic devices. As a kid, household appliances represented the beginning of my fascination with technology. It wasn't long before the workings of the TV were of more interest to me than the mostly stupid shows. Naturally, I had to see what was inside nearly everything. Mechanical clocks seemed to suffer the most at first but fairly soon I figured out that getting things back together again was generally not that much more difficult than disassembling them in the first place. This insatiable curiosity and unending search for challenges continues to this day.

For several years the obsession with repair kept me out of trouble. I was an independent engineering consultant but spent much of my time helping others on the Internet newsgroups, writing these guides and other articles, providing free repairs for those who cannot afford professional service, going to garage and tag sales in search of interesting technology to repair or restore, and bicycling when weather and time permited. For a while, this was more fun and much more rewarding than a real job. But, phases of my life tend to run in six (6) year cycles (counting from when I discovered USENET newsgroups in 1994)....

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What I'm doing now

Since the last revision of this introduction, I've been spending an increasing percentage of my time developing Sam's Laser FAQ which is by far the largest collection of practical laser and optics information for experimenters and hobbyists in the entire Universe. I still maintain the repair FAQs including the "Notes" but my main emphasis is on lasers and I rarely get to do much fun repair anymore - only when something breaks and I have no choice!

I have also joined the faculty of Drexel University (Philadelphia, PA) as a Research Professor at the Center for Microwave and Lightwave Engineering in the Electrical and Computer Engineering Department. So, now I can do real laser work in a university setting. Should you care, the research involves high performance mode-locked and chirped solid state microchip lasers for millimeter wave communications, lidar/radar, and biomedical imaging.

I still do engineering consulting if the job seems like it will be fun and rewarding and I still spend a great deal of time developing Sam's Laser FAQ. The auction site, eBay, has largely replaced garage and tag sales but mostly for (usually junk) laser equipment and parts. I already have way too many CD players and VCRs in various states of health, rapidly decaying into obsolescence. :(

Since I am not into repair on a daily basis, if you have specific comsumer electronics questions that aren't addressed in the FAQs, please ask them directly on the usenet newsgroup: sci.electronics.repair. This will save us both a lot of time and aggravation since I don't have many service manuals and schematics and will probably just direct you to newsgroup.

Thanks.

--- sam

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-- end V1.23 --

Troubleshooting and Repair of Consumer Electronic Equipment

Including:
Test Equipment, Supplies, Parts, Incredibly Handy Widgets(tm),
Sources of Information, and Where to Find Broken Stuff

Version 2.21

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

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Introduction

Getting Into Troubleshooting

This document attempts to provide an entry to the world of consumer electronics troubleshooting and repair. It also covers test equipment selection, tools and supplies, parts, home made troubleshooting aide - Incredibly Handy Widgets(tm) - and safety.

Mostly, you will learn by doing. However, you do need to prepare.

There are many schools dedicated to electronics repair. Some of these are quite good. Many are not. This document, however, is written from the perspective of the motivated do-it-yourselfer, hobbiest, and tinkerer.

The Repair FAQs usually list suggested references for each area. Your local public or university library will probably have some of these or other repair oriented electronics books.

Above all read and understand the document: Safety Guidelines for High Voltage and/or Line Powered Equipment. Your life may depend on it. That fabulous large screen won't be of much use to you if you are dead.

Collect broken electronics and appliances from your friends, relatives, the dump, garage sales and flea markets, etc. Start on those that have been written off - you will screw up at first. We all did. As times passes, your batting average will improve. It may not happen overnight but it will happen if you apply yourself. There will be many relatively easy successes but the 'tough dogs' may make up for these triumphs. Don't let them get to you - not everything can be repaired. Sometimes, the basic design is flawed or someone before you messed up royally. Troubleshooting is like being a detective but at least the device is generally not out to deceive you.

Experience will be your most useful companion.

If you go into the profession, you will obtain or have access to a variety of tech tips databases. These are an excellent investment where the saying: 'time-is-money' rules. However, to learn, you need to develop a general troubleshooting approach - a logical, methodical, method of narrowing down the problem. A tech tip database might suggest: 'Replace C536' for a particular symptom. This is good advice for a specific problem on one model. However, what you really want to understand is why C536 was the cause and how to pinpoint the culprit in general even if you don't have a service manual or schematic and your tech tip database doesn't have an entry for your sick TV or VCR.

While schematics are nice, you won't always have them or be able to justify the purchase for a one-of repair. Therefore, in many cases, some reverse engineering will be necessary. The time will be well spent since even if you don't see another instance of the same model in your entire lifetime, you will have learned something in the process that can be applied to other equipment problems.

As always, when you get stuck, the sci.electronics.repair newsgroup will still exist!

Happy repairing!

Comments on How to Learn Repair

(From: Nicholas Bodley (nbodley@tiac.net).)

Here's how I see it:

By all means, do what you can to understand basic principles first. Your success will be much more likely when you understand how a device works. If you can, read Electronics Now and Popular Electronics, as well as Nuts and Volts (http://www.nutsvolts.com). Also have a look at the Radio Amateur's Handbook.

These periodicals are not carefully edited, unfortunately, and now and then things get into print that are simply wrong or misleading, but they are still useful; I learned quite a bit from their predecessors (Radio Craft and Radio News!).

I can't speak firsthand, but it might be a very good idea to become (eventually) a Certified Electronic Technician. Look up the I.S.C.E.T.

Hearsay and folklore sometimes indicate that you should replace a given part when certain symptoms occur, and in the case of frequent failures of such parts, this information might even be true. But that's no way to become a competent technician.

My personal take is that you have to know when to 'let go' of an hypothesis about what the cause of the trouble is. A tech. who persists beyond a certain point in his belief that such-and-such is causing the problem is stuck and spinning his wheels. (I'm sexist; I think women are far less likely to get stuck this way! I think it's a male trait. :)

Troubleshooting is a special field of knowledge and has its own special outlook on things. The device did work, after all.

Production testing and troubleshooting is different; you are likely to be the first person to apply power to a device, and the device has never worked before. If the assemblers aren't giving you excellent quality, you can have some remarkably-bizarre symptoms with a poorly laid-out board from solder shorts, for instance.

A variable toroidal autotransformer (universally known by what used to be a General Radio trade-name, Variac) is priceless for troubleshooting circuits that handle any amount of power and which are powered by the AC line. (Not all devices function at all at, say, half of rated AC input; I work on a poorly-designed amplifier that draws many amps at something like 70 volts with no signal and no load. Unfortunately, Variacs and their equivalents are horribly expensive, at least from some sources! If you get a used one, see that the contact area of the winding is undamaged; you might need to remove a knob and some covers to see it. If the knob is stiff, try some contact/control cleaner/lube; it did wonders for mine!

Learn how to operate a 'scope, and learn why you see what you do. I suspect that some techs are not too well-informed about what goes on inside a 'scope; learn from reliable sources!

Learn to use a digital multimeter, and an analog one as well; the latter is easily damaged if you don't know what you're doing, but it's a great trend indicator.

Learn to use a function generator, and use the triangle output as well! Nothing like a triangle to show a wee bit of clipping or limiting in an amplifier...

Learn how to solder! Solder is not an adhesive; it's a metallurgical bond, according to some sources I trust. It just about has to be with gold, at least! If you *really* want to learn soldering, NASA has developed training courses that will make you a disgustingly good solderer.

(From: Phillip R. Cline (pcline@iquest.net).)

I used to repair consumer electronics from VERY high end stereos down to lowly boom boxes. When repairing stereos there is no substitute for good troubleshooting techniques which come from empirical means. Good knowledge of circuit functions helps a great deal. VCRs are almost always a mechanical problem (70% or more in my experience). Audio stuff can be destroyed by the user and often times the design is just plain crap. All low and mid-fi Japanese stuff made within the last ten years isn't worth a crap from a design standpoint. Even a lot of the high-end stuff is junk. They have 71 volt rated caps running at 69 volts etc.... US and most European stuff is way better designed! There are exceptions. I once saw a Philips amp that had a transformer for the power amp supply that wasn't centertapped yet the supply was bipolar. They just rectified and filtered the AC with series caps and the common was the point they were connected to each other. This is fine if you rate the caps at more voltage than the power supply can deliver but these were rated at just over half the total voltage of the supply from rail to rail. One cap shorted and the other one exploded and launched the can sideways across the component side of the amp PC board. This basically did a nice job of depopulating the board along the ballistic path of the cap's can. I laughed for a good while after seeing this.

I gave up repairing stuff when the customers asked, and rightly so, why it costs $80 to fix something that costs $100 new. The OEM parts cost on some stuff was intended to make the customer go buy a new unit instead of repairing the old one. This basically made most of the stuff disposable.

My background was and still is as an electronic hobbiest so the theory of operation was not a big deal and circuit function wasn't either. I have a brother that was the person from whom I learned a great deal of what I know now about electronics.

Soldering ability cannot be overstressed in importance especially with SMT being very common nowadays. As for the guys that seem to be ripping you off in their pricing, they could be gouging you but most often the overhead in the shop and their cost on parts is the most likely cause of high pricing. While labor might seem high a great deal of repair can be accomplished in an hour by a competent technician and some shops have a flat rate for a given repair. This can work to the benefit of the shop sometimes and to the customer sometimes. Our shop was this way. We had the lowest pricing in town(Indianapolis) and the customers still bitched. Sometimes they would take their units after we gave them the price for labor and a estimate of parts cost. We didn't charge for estimates. They would storm out only to come back with their tail between their legs in a few days after checking around for labor charges elsewhere. Depending on their attitude we might go ahead with the repair. Often times we would decline by telling the customer that the other shops may have done something while checking the unit out.(This depended on the shop that the customer took the unit to.) Some of these places had some real winners for techs!! We really didn't feel like undoing some yoyo's handiwork just to get the unit back to it's original nonworking state!

An EE in electronics is useless by itself and will cause a lot of undue troubleshooting to the beginning tech. They will overlook the obvious easy stuff for some possible but unlikely fault. A few years of repairs under their belt though and they can find the most difficult electronic problems with relative ease.

The best way to become proficient is with hands-on training under an experienced tech. A good overall background in electronics doesn't hurt either.

(From: Michael Black (blackm00@CAM.ORG).)

I think one of the problems of home repair is fear. If you're willing to spend the money to have something repaired, then you may think that if you fiddled with it you may make it worse. On the other hand, if you are about to throw something out because it doesn't work, you have nothing to lose by playing around with it and trying to fix it. Or find some stuff other people have thrown out, and start with that.

You may not fix it, but your willingness to open the cover allows you a familiarity that you won't get from a book. You de-mistify the equipment, and by actually adjusting things and seeing the results, you will learn.

I picked up a VCR for cheap at a garage sale this past summer. I was buying it as a tuner for use with a monitor. The guy said it "must be the power supply because it keeps turning off". Actually, it kept turning off because the mechanics weren't working properly. By moving the parts by hand, I saw how they were supposed to work. With the first hand experience, the S.E.R FAQ made more sense than if I'd just read it first, and so did a book on VCR repair that I took out of the library. I saw that the belts needed replacing because I'd figured out how things were supposed to work, and saw that they weren't working that way.

(From: Malcolm MacArthur (malcolmm@rustic-place.demon.co.uk).)

I have two years' of an Electronic Engineering degree behind me (I gave up on the degree and became a computer programmer. ;) It has been little, if any, help. What you really need is experience... which you'll only gain by fiddling with things. I've been doing repairs since about age 13. After twelve years, I now have a fair success rate, but those first few years were not easy. Best thing to do is get hold of old equipment and just have a go with it (Beware of CRTs, though ;). Be warned, you may break quite a lot of stuff initially! But as the others have said, most of the problems are due to mechanical failures (including dry solder joints).

Tall repair stories time:

- The IDE hard drive, given free, with two broken pins. Fixed with bits of bent paper clip soldered in place of the original connectors.
- The record player which wouldn't play at the right speed, and there wasn't enough adjustment in the pot.

Fix: cover belt spindle in Araldite, leave to harden, machine down with scalpel.

- The VCR which wouldn't play. Roughened up drive tire with sandpaper, did same to spindles, worked a treat. Still working fine after 3 years. :)
- Another VCR, rejected by a repair shop as uneconomical to repair, and given back to my friend's aunt. Took it apart. found nothing wrong, cleaned it, reassembled. Still working fine (I have no idea what the "fault" the shop found was).
- A computer monitor with incorrect colour balance. Fixed by adjusting the guns at the back WITHOUT an insulated screwdriver (Hairy!). I didn't have one, so used a normal screwdriver taped with insulating tape to a (dry) 1 ft. wooden spoon. Oh, because of poor design, the CRT kept threatening to impact with the mainboard when I had the back off, so I had to hold it at the front with my other hand. Visions of 25,000 V going straight through my chest made it all a bit scary. :)
- First ever repair (this is true!): taught my mother how to wire up a household (e.g. at power meter) fuse because I'd watched my Dad do it (he's good at this sort of thing as well. :) Age? Five.
- A TV with a broken tuner, had been to a repair shop twice, they'd given up on it. Received it for free, found out the composite video in worked fine, so ran 20 ft. of cable to a spare video downstairs (there was no aerial in my room, see). Must fix that tuner sometime...
- A CDROM drive which couldn't read near the edge of some discs. Disassembled whole unit, (eventually) reassembled it, found out that I was the spring which holds the CD down. Fixed by plugging into computer, running a cdrom and wiggling the spring with my finger until I felt the least vibration. Still works fine, although I am replacing it soon with a faster unit.
- The dropped TV with a crack at the corner of the mainboard. Repaired all the cracks by patching with wire, TV nearly blew up in my face (hence, beware of CRTs). Thank goodness for the fuses... this little incident put me off repairing TVs for over a year. It was eventually chucked, a failure.

As you can see above, most of these repairs are pretty simple and can be accomplished with mechanical know-how, more than anything else. Be prepared to experiment - but also be prepared for the fact that some of your experiments might fail! I guess I've just been lucky, but few of my repairs even involved using a multimeter.

Have fun.

THE Question: To Repair or Not to Repair

One of the themes, repeated more than once in emails to me and in reader feedback from Poptronix/Electronics Now was of the following general flavor:

> "Why bother with repair of VCRs (or anything else) when I can buy a new model for $79.95?"

Actually, I've seen prices as low as $39.95 for a promotion (but not requiring the purchase of anything else)!

or:

> "This stuff may have been useful 5 years ago but now some/much of the material doesn't apply to newer VCRs."

While both of these deal with VCRs, it should be understood that it applies equally well to much other consumer electronics.

Depending on your background and interests, these statements may have some validity. Thus, the need for some objective (if possible) way of making a decision as to whether to bother at all, and whether to attempt the repair yourself.

So, when does it make sense to attempt *any* repair yourself rather than to toss the item in the trash or take it to a professional? People do this sort of stuff for several reasons:

1. For the challenge and rewards associated with success.

2. To save money.

3. Because they like a particular set of features or the controls or the styling of the equipment and don't want anything new!

4. To avoid cluttering land-fills.

The first of these is likely most relevant to the readers of the S.E.R FAQs.

It's quite difficult to suggest an approach in deciding when something is worth repairing. You have to decide how much the equipment is worth to *you* in terms of monetary, sentimental, or other value; how much time you are willing to put into a repair; and whether the failure represents a good excuse to upgrade! To what extent each of the factors is significant will also be determined by how much you enjoy troubleshooting and tinkering. If you'd rather be doing something else or keep thinking about all the time you are spending on this rather than something you can charge for, perhaps you should be doing that something else.

However, it is easier to identify specific situations where equipment probably *isn't* worth attempting to repair on your own (or possibly at all):

1. Serious damage due to water (especially salt water), fire or smoke. Even if the obvious faults can be found and corrected, there are likely to be latent failures just waiting to strike in a few weeks or months.

2. Lightning strike. Lightning is like the 900 pound gorilla - it can go anywhere it wants. Even if you can repair the obvious damage and get the equipment working, there could be hidden problems waiting to appear at a later time due to components that aren't totally fried but just weakened.

3. Extremely high electrical power surge like a 13,000 V feeder line falling across the 115 V wiring to your house. Similar comments as lightning apply.

Where any of these are covered by insurance, that is the best option where the settlement is at all reasonable. If the insurance company allows you to keep the damaged equipment, there is nothing to stop you from attempting repairs as a challenge - you may get lucky. But, it could also be a long drawn out and expensive frustration.

4. Serious physical damage, especially for equipment with mechanical parts like VCRs. It may be impossible to replace broken parts. Twisted metal can be straightened but there is a good chance there will still be erratic misbehavior.

5. Equipment where prior attempts at repair may have resulted in an undetermined number of new unidentified problems. At least when something breaks on its own, your only opposition is the device itself. But, if another person attempts a repair and they are a novice or just plain incompetent, the dumpster may be the best solution.

6. Equipment with known design or manufacturing problems. When we undertake a repair, one assumption that is usually made is that the equipment originally worked correctly and/or that the fault isn't something that was designed in before the name went on. :) For most things, this is a valid assumption. Even the famous RCA/GE/Proscan and Sony TV solder problems, while no doubt resulting in 100s of thousands of sets ending up in the trash, are repairable with modest effort at low cost. And, the result is a well performing reliable TV. However, some computer monitors may die when fed a particular scan rate or during boot when mated with a particular video card - a design flaw which may not have a (known) solution.

7. Newer throw-aways. I can pretty much guarantee that a $39.95 VCR isn't worth any effort unless the problem is obvious. This junk is built as cheaply as possible with a lot of plastic parts, no thought given to access for testing or repair, and with attention only to the short term bottom line. There has been no miraculous invention to reduce construction cost of the relatively complex VCR mechanism - it comes out of reliability.

8. Equipment like cell phones, pagers, and other modern wireless devices as well as cordless phones; PC mainboards, peripheral boards, and disk drives; TV set-top, cable boxes, satellite receivers, etc. It is essentially impossible to obtain service information on any of these so unless the problem is an obvious broken connector or broken trace on the printed circuit board, or possibly a dead power supply, forget it. You don't have the documentation, test equipment, rework equipment, or any chance of buying many of the repair parts in any case.

9. Any situation where safety would be compromised by your repair. For example, attempting to reconstruct a smashed microwave oven door or jerryrigging a flyback transformer that has serious arcing. Where items (1) to (3) are involved, one must very carefully inspect for any possible safety related damage (like charred insulation in hidden areas) that may not have affected operation.

10. If you really don't know what you are doing, leave it to a professional! Not only is it dangerous to be poking around inside many types of equipment if you don't even know what not to touch, there is a strong likelihood that such attempts will cause additional, possibly fatal damage to the circuitry. Even if the equipment can be repaired, the ultimate cost will end up be much greater than had you not done anything in the first place, both in terms of labor (troubleshooting and repair) and parts. If you can't justify a professional repair, just set it aside until you have gained more experience and can deal with the equipment safely (for you and it).

11. Finally, don't attempt to repair a piece of equipment for which you are not equipped in the tools or test equipment department. Attempting to remove a part from a multilayer printed circuit board without proper desoldering equipment will just make an unsalvageable mess. Guessing at a replacement part ("I heard that the flyback transformer is a likely cause for a dead monitor.") will just end up being frustrating and expensive (unless you've won the Lottery recently in which case maybe your luck is still holding).

In the good old days when life and electronics were simpler and you could count the total number of transistors in a TV on your hands and feet, service information was included with the equipment or was readily available either from the manufacturer or Sams Technical Publishing (formerly Howard Sams) as Sams' Photofacts (no relation to me). There are still Sams' Photofacts for many TVs at least, but for anything else, obtaining schematics may be impossible or even if they are available, the cost may be excessive. Paying $100 for a mediocre copy of a service manual for a computer monitor that can be replaced for $250 may not be justified.

One way to get an idea of your chances of success for popular brands and models is to search the archives of the USENET newsgroup sci.electronics.repair via Google Groups (formerly Deja.com/Dejanews. There are other public USENET archives but even though this archive keeps changing its name, I see little reason to use others which may come and go and provide less reliable coverage.) Where others have experienced - and repaired - similar problems, your chances of success are greatly increased. Then, if you have detailed symptoms, asking for suggestions on that newsgroup may also be beneficial, especially if you have already done some initial testing. If, on the other hand, the consensus from the newsgroup is that your problem is hopeless, then you may be able to save a lot of time and frustration by giving up immediately (or at least postponing your efforts until you have more experience.

What about older equipment?:

The basic technology of TVs and VCRs hasn't changed significantly in 10 or 15 years. Yes, there are convenience features like "auto clock set" which are supposed to make life easier but often don't (if the station transmitting the clock information has their clocks set wrong or uses a feed from a source in a different time zone!). But as far as picture and sound quality, that VCR from 10 years ago will be just as good or better than one purchased today. Any, it will almost certainly be better constructed and more maintainable.

For example, Panasonic VCRs from the mid to late '80s were solid machines that could be kept in shape with a bit of periodic maintenance (cleaning, rubber parts replacement) and repair of known problems (failed electrolytic capacitors in the power supply after 10 years or so). One could not expect that $39.95 special to provide such service. If it lasts through the warranty period, you're probably ahead of the game. I'd still take a middle age Panasonic over any new low to medium priced model. And, even the high-end VCRs may be based on flimsy chassis.

Case studies:

Here are 4 examples of equipment that I did eventually repair but where serious consideration should have been given to the dumpster. The following can be found described in more detail at in the document: Sam's Repair Briefs/

1. **GE TV dropped:** (From: Repair Brief #69: GE Portable Color TV - Dropped.)

This TV had taken a nose dive off of a 4 foot shelf onto an unknown surface. And, of course, someone had probably attempted to operate after this with possible additional damage. While the exterior didn't show any major abuse, it was obvious that there was severe trauma as soon as the back was removed. The main circuit board was broken near the (heavy) flyback transformer. Several dozen traces were severed including some to surface mount parts.

A repair shop would be unlikely to want to tackle this for several reasons: (1) the obvious repairs to circuit board traces would take a couple hours at least, (2) there could be unseen damage to the CRT in form of a distorted shadow mask and this wouldn't be known until the circuit board was fixed, and (3) any repair might not catch everything so future problems could develop.

As it turned out, the only damage was to the circuit board and after 2 or 3 hours of soldering - and then finding additional traces to solder - the set was fixed, and has continued to operate reliably for several years.

2. **GE TV with 'rivlets':** (From: Repair Brief #59: GE 13AC1504W Color TV - Dead (with Other Problems)).

   In the early 1980s, some brilliant manufacturing engineer working for GE decided that a good way to save money on circuit boards would be to use what were dubbed 'rivlets' instead of actual plated through holes to connect top and bottom. A rivlet is basically a rivet which, the theory goes, is then soldered to the copper traces. That's the theory. In practice, due to the thermal mass of the rivet, soldering was never reliable. And, as a result of thermal cycling, cracks developed between the rivet and traces over time. Problems ranged from a dead set to loss of color depending on which rivlet happened to be unhappy on any given day.

   Attempting to repair just the problem rivlets was impossible because as soon as you found a bad one and soldered it, another in its vicinity would decide to fail. The only approach that worked was to reheat every one that could be located using a soldering gun. Since there were many dozens of these on the circuit board, this took quite awhile and it was easy to miss some. In fact, the only truly reliable repair would be to remove the solder from each rivlet, snake a bare wire through it, and solder the wire directly to the traces top and bottom. This repair would also take a couple hours and likely be too expensive for a small TV, though if the same chassis were used on a 27 incher, might be worth it.

3. **CD player restoration:** (From: Repair Brief #10: Pioneer PD5100 CD Player Trashed).

   Here is a case of a piece of equipment being partially destroyed by previous repair attempts. The Pioneer PD5100 is a basic solid CD player but this one had broken parts in the loading mechanism and was in unknown operational condition. If it were taken to a repair shop, the response would probably be something along the lines of: "Well, that certainly looks like a CD player.". It simply wouldn't be worth the time and effort to repair what was obviously broken with the possibility of finding more serious electronic problems after that.

   I had nothing better to do (!!) so decided to attempt to restore it to something usable. After repairing the mechanical damage, there was indeed a servo problem which ultimate required the replacement of a motor driver chip - for which I got lucky. The player would read the disc directory but was unable to seek to any track, even #1. One of the chips was getting hot. So, I replaced it and after servo alignment, the play problems were cured. If that hadn't worked, there was probably little more I could have done. Very likely, the servo chip was the original problem and the previous repair attempt created the mechanical mess.

4. **Sony TV with bad butchered soldering:** (From: Repair Brief #81: Sony KV-19TR20 Color TV - No Reception).

   The final example is of a Sony TV that had the infamous tuner/IF box solder problems. This is normally a fairly easy repair, especially for this particular model where the IF box (which was faulty in this case) is readily accessible without taking the whole thing to bits. Once repaired, like the RCA/GE/Proscan TVs with similar solder problems, the result is a solid reliable TV. However, the friend of a friend who had attempted to replace it, apparently used a Weller soldering gun to do the fine soldering, leaving nearly every pad detached or missing. Fortunately, only the pads appeared to have suffered and after 20 minutes and several jumper wires, this one was healthy again.

Repairs for the novice:

It would be way too easy to poison your future outlook on servicing by attempting to repairs multiple times and failing or making things worse.

Equipment that is good to learn on because there will likely be immediate or at least ultimate gratification might include: small appliances, power tools, remote controls, and basic audio equipment like tape decks and low power amplifiers (not big power amps!). And, while electronic troubleshooting of CD players and VCRs is definitely for the advanced course, they often have problems that can be easily remedied by a proper cleaning and/or general maintenance. Electronic problems are tough to diagnose but most are mechanical. Microwave ovens are generally easy to repair but due to the very serious safety issues, I'd suggest holding off on these unless you are experienced in dealing with high voltage high power equipment.

With reasonable care, PC troubleshooting involving basic swapping of components, can also be rewarding. But, don't expect to repair a mainboard with a peculiar failure of IRQ2 (unless you find a lockwasher that ate through to some PCB traces!).

Intermediate level troubleshooting and repair would add TVs since service information in the form of Sams' Photofacts is available for the majority of popular models. Video (not computer) monitors are also straightforward to deal with. And perhaps, audio amplifiers and receivers.

For those just starting out, there are some types of equipment to avoid (beyond those mentioned above). One in particular is modern computer monitors. With their wide scan rate range, microprocessor control, need for decent test equipment, dangerous voltages, and the general difficulty in obtaining service information, even professionals will stay away from many of these - particularly no-name or non-major brand models. Except for obvious problems like bad solder connections, a blown fuse (replace ONCE only, might have been a power surge), or the need for degaussing, they may not be worth the frustration, certainly not as your first project. TVs are not only much simpler than computer monitors, but as noted, complete service information is usually available.

If You Decide That You Don't Want to Bother Repairing Something

So, you already have 10 VCRs and really don't want to even pop the case on yet another one.

Don't just toss it in the trash. See if a local charity like the Salvation Army or Goodwill accepts broken appliances and electronics. They may have someone on staff who can perform at least simple repairs and then resell the item. Not only will this reduce clutter in the land fill, you may benefit on your taxes (and in the good deeds department). However, it really isn't proper to do this if you have already worked on the item and given up or reduced it to a pile of slag!

Smoking Around Electronic Equipment

Note: This is my token editorial but the effects on both people and equipment are very real.

If you still doubt the harmful effects of the chemical compounds in tobacco smoke on your health and that of others around you, whatever I say below probably won't matter and you may want to skip it since it may upset you. However, perhaps, you worry more about your fancy, costly, finely tuned electronic entertainment and computer equipment. In that case, read on.

The several hundred chemical compounds found in tobacco smoke have the following effects on electronic equipment. What isn't trapped in your lungs or in the lungs of those around you:

- coats the precision optics of CD and DVD players, CDROM and DVDROM drives, and other optical disc/k equipment AND the media they use.
- coats the read/write heads of floppy disk drives, Zip drives, tape drives, AND the media they use.
- coats the tape path of VCRs and audio decks including the audio, video, and control heads AND the cassettes and tape inside.
- coats mechanical parts and promotes the loss of lubrication in all equipment.
- may contribute to deterioration of plastic and rubber parts.
- coats the screens of TVs and monitors, display windows of VCRs and other devices, and the outside and inside of everything eventually resulting in ugly brown discoloration and a horrible stench.

This list of effects goes on and on.

The resulting film WILL eventually cause problems and is very difficult to remove. Damage done due to chemical action may require the replacement of costly parts. Increased maintenance will be needed or the equipment may simply fail before its time and not be worth fixing. Contamination will often find its way into critical places that are not accessible and to media which is irreplaceable.

When someone trys to get me to look at something that has been in a smoker's residence (I know because it will reek of stale tobacco smoke essence), my first inclination is to put it in a sealed bag to go out with the garbage. (I have been known to drop portable TVs directly into the nearest trash can under these circumstances.) If this isn't an option, my next objective is to get it evaluated and repaired or refused as quickly as possible. However, my concentration may not be at its peak for such equipment! It is a good thing that I don't need to do this for a living - I would have to refuse service to a good portion of the world's population :-(.

So, now you have a few more reasons to give up the stupid, disgusting, filthy, obnoxious, inconsiderate of others, costly, dangerous, killer habit!

Sorry, end of editorial. :-)

General Safety Considerations

Depending on the type of equipment you will be working on, there can be a variety of dangers - some potentially lethal:

- Electrical shock hazard from TV, computer and other video monitors, microwave ovens, the switchmode power supplies in some VCRs and computer peripherals, electronic flash units, some parts of audio equipment, hand and stationary power tools, large appliances, and even many small line powered appliances.

- Mechanical hazards from the moving parts of various appliances, computer peripherals, hand and stationary power tools, and especially gasoline powered yard equipment.

- Risk of CRT implosion from equipment using large CRTs.

- Vision hazards from the lasers in CD players and CDROM drives, DVD players and DVDROM drives, other optical data storage devices, and laser disc players.

It is imperative that you understand and follow ALL safety recommendations while working inside whatever equipment.

See the document: Safety Guidelines for High Voltage and/or Line Powered Equipment for general safety information.

See the SAFETY sections of the documents dealing with your equipment for additional safety information for your equipment.

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Basic Troubleshooting

Some of My Rules of Troubleshooting

1. Safety first - know the hazards associated with the equipment you are troubleshooting. Take all safety precautions. Expect the unexpected. Take your time.

2. Always think 'what if'. This applies both to the analytic procedures as well as to precautions with respect to probing the equipment. When probing, insulate all but the last 1/8" of the probe tip to prevent costly shorts. (If I had a nickel for every time I have been screwed not following this advice...)

3. Learn from your mistakes. We all make mistakes - some of them can be quite costly. A simple problem can turn into an expensive one due to a slip of the probe or being over eager to try something before thinking it through. While stating that your experience in these endeavors is measured by the number of scars you have may be stretching the point, expect to screwup - we all can point to that disaster due to inexperience or carelessness. Just make it a point not to make the same mistake again.

4. Don't start with the electronic test equipment, start with some analytical thinking. Many problems associated with consumer electronic equipment do not require a schematic (though one may be useful). The majority of problems with VCRs, CD players, tape decks, and answering machines, are mechanical and can be dealt with using nothing more than a good set of precision hand tools; some alcohol, degreaser, contact cleaner, light oil and grease; and your powers of observation (and a little experience). Your built in senses and that stuff between your ears represents the most important test equipment you have.

5. If you get stuck, sleep on it. Sometimes, just letting the problem bounce around in your head will lead to a different more successful approach or solution. Don't work when you are really tired - it is both dangerous and mostly non-productive (or possibly destructive).

6. Many problems have simple solutions. Don't immediately assume that your problem is some combination of esoteric complex convoluted failures. For a TV, it may just be a bad connection or failed diode. For a VCR, it may just be a bad belt or idler tire - or an experiment in rock placement by your 3-year old. For a CD player, a dirty lens or need for lubrication. Try to remember that the problems with the most catastrophic impact on operation - a dead TV or a VCR that eats tapes - usually have the simplest solutions. The kind of problems we would like to avoid at all costs are the ones that are intermittent or difficult to reproduce: subtle color noise, the occasional interference, or the dreaded horizontal output transistor blowing out every 3 months syndrome.

7. Whenever possible, try to substitute a working unit. With modular systems like component stereos and computers, narrowing down a problem to a single unit should be the first priority. This is usually safe to do in such cases and will quickly identify which unit needs work. This same principle applies at the electronic or mechanical parts level. Note that there is the possibility of damaging the known good part by putting it into a non-working device or vice versa. This risk is most likely with the power circuitry in amplifiers, TVs and monitors, power supplies, etc. With appropriate precautions (like the series light bulb) the risk can be minimized.

8. Don't blindly trust your instruments. If your get readings that don't make sense, you may be using your equipment in a way which is confusing it. DMMs are not good at checking semiconductors in-circuit or the power transistor you are testing may have a built in damper diode and/or base resistor. Your scope may be picking up interference which is swamping the low level signal you are searching for (TVs and Monitors, or low level circuits in VCRs and CD players). Your frequency counter may be double triggering due to noise or imperfect signal shape.

9. Realize that coincidences do happen but are relatively rare. Usually, there is a common cause. For

example, if a TV has no vertical deflection and no picture, it is much more likely that a common power supply output has failed than for parts in both the deflection and video subsystems to be bad. In other words, first look for a common root cause rather than trying to locate bad parts in separate circuits.

Exceptions include lightning, power surge, dropped, water, or previous repair person damaged equipment. However, multiple electrolytic capacitors in older equipment may be degrading resulting in failures of unrelated circuits. Determine if all the problems you are troubleshooting have just appeared - see below. It is very common to be given a device to repair which has now died totally but prior to this had some behavior which you consider marginal but that was not noticed by the owner.

10. Confirm the problem before diving into the repair. It is amazing how many complaints turn out to be impossible to reproduce or are simple cockpit error. It also makes sense to identify exactly what is and is not working so that you will know whether some fault that just appeared was actually a preexisting problem or was caused by your poking. Try to get as much information as possible about the problem from the owner. If you are the owner, try to reconstruct the exact sequence of events that led to the failure. For example, did the TV just not work when turned on or were there some preliminary symptoms like a jittery or squished picture prior to total failure? Did the problem come and go before finally staying bad for good?

11. Get used to the idea of working without a schematic. While service info for TVs is nearly always available in the form of Sams' Photofacts, this is hardly ever true of other types of equipment. Sams VCRfacts exist for less than 10 percent of VCR models and only the older ones include anything beyond (obvious) mechanical information. While a service manual may be available from the manufacturer of your equipment or another Sams-like source, it may not include the information you really need. Furthermore, there may be no way to justify the cost for a one time repair. With a basic understanding of how the equipment works, many problems can be dealt with without a schematic. Not every one but quite a few.

12. Whenever working on precision equipment, make copious notes and diagrams. You will be eternally grateful when the time comes to reassemble the unit. Most connectors are keyed against incorrect insertion or interchange of cables, but not always. Apparently identical screws may be of differing lengths or have slightly different thread types. Little parts may fit in more than one place or orientation. Etc. Etc.

13. Pill bottles, film canisters, and plastic ice cube trays come in handy for sorting and storing screws and other small parts after disassembly. This is particularly true if you have repairs on multiple pieces of equipment under way simultaneously.

14. Select a work area which is wide open, well lighted, and where dropped parts can be located - not on a deep pile shag rug. The best location will also be relatively dust free and allow you to suspend your troubleshooting to eat or sleep or think without having to pile everything into a cardboard box for storage.

15. Understand the risk of ESD - Electro-Static Discharge. Some components (like ICs) in solid state electronic devices are vulnerable to ESD. There is no need to go overboard but taking reasonable precautions such as getting into the habit of touching a **safe** ground point first.

WARNING: even with an isolation transformer, a live chassis should **not** be considered a safe ground point. This applies mostly to TVs, computer and video monitors, some AC operated strobe lights, and other line connected devices. You shouldn't be touching components with the device powered and plugged in (at least, not until you really know what you are doing!). Once unplugged, sheet metal shields or other ground points should be safe and effective.

Some Quick Tips or Rules of Thumb

- Problems that are erratic or intermittent - that come and go suddenly - are almost always due to bad connections - cold solder joints or internal or external connectors that need to be cleaned and reseated. It is amazing what a large percentage of common problems fall into the category.

  Pay particular attention to areas of the circuit board where there are large and/or high power components, connectors, or evidence of discoloration or actual charring due to excessive heat. Your eyeballs, a bright light, and magnifier will be the most useful test equipment for this purpose!

- Problems that change gradually - usually they decrease or disappear - as the equipment warms up are often due to dried up electrolytic capacitors.

  While capacitors will occasionally leak making diagnosis easy, in most cases, there are no obvious signs of failure. (Note: Don't be misled into thinking that the adhesive often used to anchor large capacitors and other components to the circuit board is leakage.) The most useful testing device for electrolytic capacitors is an ESR meter. However, heating suspect caps with a hair dryer may get the equipment going for the purposes of making a diagnosis. See the document: Capacitor Testing, Safe Discharging and Other Related Information.

- Problems that result in a totally dead unit or affect multiple functions are generally power supply related. These are usually easy to fix.

  Common failure items are the large hybrid power regulator ICs used in many VCRs and TVs, diodes and transistors, and remarkably - high value resistors that open up.

- Catastrophic failures often result in burnt, scorched, cracked, exploded, or melted components, or similar catastrophic consequences. However, some components run hot by design and slight discoloration on the circuit board in their vicinity, while not desirable, may be normal.

  Use your senses of sight and smell for the preliminary search for such evidence.

- Listen for signs of arcing or corona - snapping or sizzling sounds. A component on the brink of failing due to overheating may provide similar audible clues.

  Some discharge sounds are normal for a TV or monitor when powered on or off and occasional sounds of thermal expansion are nothing to worry about. The flyback, yoke, or other (usually) magnetic component may also emit a buzz or while constantly or intermittently without any other symptoms or implication of impending doom. However, repeated loud snaps or a sizzling sounds accompanied by the smell of ozone should be dealt with immediately since they can lead to more serious and expensive consequences.

- Most VCR problems are mechanical in nature. Worn or deteriorated rubber parts, gummed up lubrication, or abuse (bad tapes or toy or penut butter and jelly sandwich storage.).

  For any problem but a totally dead VCR, a check should be made for dirty or worn mechanical parts before even thinking about electronic problems or trying to locate a schematic - especially if the unit hasn't been cleaned in a few years.

- Many CD player problems are mechanical - dirty lens, worn or oily drawer belts, dirt/gummed up grease on sled tracks/gears, bad/partially shorted spindle or sled motor. Power problems with portables seem to be common as well. No matter what the symptoms, always make it a habit to clean the lens first - many peculiar failure modes are simply due to a dirty lens. Actual laser failure is relatively uncommon despite what the typical service shop may claim. CD players are also remarkably robust. Optical alignment should never be needed under normal conditions of operation.

- TV and monitor problems are very often power supply or deflection related. These tend to have obvious causes - blown posistor, rectifier diodes, filter capacitor, HOT, or chopper. Flyback with shorted windings or shorts between windings or in the voltage multiplier (if used) or screen/focus divider network are also common. Where the HOT or chopper is involved, operation should be observed after the repair as components in the vicinity may cause the new parts to fail. HOTs should generally not run hot. If they do, check for weak drive, excess B+, etc.

- Microwave oven problems are almost always power related. Faulty components in the microwave generator - magnetron, HV diode, HV capacitor, HV transformer - are relatively easy to identify. Sometimes, components on the primary side can cause baffling symptoms like the misaligned interlock switches that blow fuses or the weak triac that causes the oven to blow the main fuse only when the cycle *ends*. Control problems may be due to a spill in the touchpad, dried up electrolytic capacitors in the low voltage power supply, or failure confused state due to a power surge.

- Ink-jet printers are extremely reliable electrically. Look for simple problems such as caked ink in the 'service station' area, misaligned print-head contacts, or a nearly empty cartridge when erratic printing problems develop.

- Laser printers tend to develop problems in the fuser, scanner, or power control modules. These are often simple like a burned out lamp, bad motor, or bad connections.

- Turntables or record changer problems are very likely to be due to gummed up grease.

- Problems with audio tape decks like VCRs are mostly mechanical. Similar solutions apply. Where one channel is out, suspect a broken wire at the tape head before a bad chip.

- Telephone line connected equipment like modems and phones are susceptible to phone like surges. Where a device seems to respond to user commands but does not dial or pickup, suspect a blown part near the phone line connector.

- Sam's Magic Spit(tm). This approach - using a moistened finger to probe LOW VOLTAGE CIRCUITS has come to the rescue many times. Touching various parts of a circuit from the solder side of the board in an attempt to evoke some sort of response can work wonders. Once an suspect area has been identified, use a metal probe or nail to narrow it down to a specific pin.

The reason this works is that the reduced resistance of your moist skin and your body capacitance will change the signal shape and/or introduce some slight signal of its own.

- Logic circuits - marginal timing or signal levels will result in a dramatic change in behavior with a slight 'body' load. It has been possible to locate a race condition or glitchy signal on a 305 pin PGA chip using this approach in less time than it would have taken to roll the logic analyzer over to the system under test. Signals which have proper levels and timing are gnerally remarkably immune to this sort of torture.

- Analog circuits - behavior can again be altered. In the case of audio amps, probing with a finger is just as effective as the use of a signal injector - which is what you are doing - and the equipment is always handy. By evoking hum, buzz, clicks, and pops, locating the live or dead parts of a circuit is rapid and effective.

- Unknown circuits - where no schematics are available, it may be possible to get the device to do something or locate an area that is sensitive to probing. The function of a section of circuitry can often be identified by observing the effects of touching the components in that area.

  For example, I was able to quickly identify the trigger transistor of in a wireless door bell by using my finger to locate the point that caused the chimes to sound. This quickly confirmed that the problem was in the RF front end or decoder and not the audio circuitry.

- Bad bypass capacitors - touching the power/signal side of a good bypass cap should result in little or no effect. However, a cap with high ESR and/or reduced uF will not be doing its job bypassing the pickup from your finger to ground - there will be a dramatic effect in audio or video systems.

Don't get carried away - too much moisture may have unforeseen consequences.

Depending on the condition of your skin, a tingle may be felt even on low voltage circuits under the right conditions. However, this is pretty safe for most battery operated devices, TTL/CMOS logic, audio equipment (not high power amps), CD players, VCRs (not switching power supply), etc.

WARNING: Make sure you do this only with LOW VOLTAGE circuitry. You can easily fry yourself if you attempt to troubleshoot your TV, computer monitor, photoflash, or microwave oven in this manner!

On-Line Tech-Tips Databases

A number of organizations have compiled databases covering thousands of common problems with VCRs, TVs, computer monitors, and other electronic equipment. Most charge for their information but a few, accessible via the Internet, are either free or have a very minimal monthly or per-case fee. In other cases, a limited but still useful subset of the for-fee database is freely available.

A tech-tips database is a collection of problems and solutions accumulated by the organization providing the information or other sources based on actual repair experiences and case histories. Since the identical failures often occur at some point in a large percentage of a given model or product line, checking out a tech-tips database may quickly identify your problem and solution.

In that case, you can greatly simplify your troubleshooting or at least confirm a diagnosis before ordering parts. My only reservation with respect to tech-tips databases in general - this has nothing to do with any one in particular - is that symptoms can sometimes be deceiving and a solution that works in one instance may not apply to your specific problem. Therefore, an understanding of the hows and whys of the equipment along with some good old fashioned testing is highly desirable to minimize the risk of replacing parts that turn out not to be bad.

The other disadvantage - at least from one point of view - is that you do not learn much by just following a procedure developed by others. There is no explanation of how the original diagnosis was determined or what may have caused the failure in the first place. Nor is there likely to be any list of other components that may have been affected by overstress and may fail in the future. Replacing Q701 and C725 may get your equipment going again but this will not help you to repair a different model in the future.

One alternative to tech-tips databases is to search via Google Groups (formerly Deja.com/Dejanews) for postings with keywords matching your model and problem and the newsgroup sci.electronics.repair. See the section: Searching for Information from USENET Newsgroups.

Please see the document: On-Line Tech-Tips Databases for the most up to date compilation of these resources for TVs, VCRs, computer monitors, and other consumer electronic equipment.

Getting Inside Consumer Electronic Equipment

Note: the documents on specific equipment has additional 'getting inside' info as well.

Yes, you will void the warranty, but you knew this already.

Hint: The crowbar and 12 pound hammer are *laset* resorts! Really :-).

Manufacturers seem to take great pride in being very mysterious as to how to open their equipment. Not always, but this is too common to just be a coincidence. Opening the equipment non-destructively may be the most difficult and challenging part of many repairs!

A variety of techniques are used to secure the covers on consumer electronic equipment:

1. Screws. Yes, many still use this somewhat antiquated technique. Sometimes, there are even embossed arrows on the case indicating which screws need to be removed to get at the guts. In addition to obvious screw holes, there may be some that are only accessible when a battery or cassette compartment is opened or a trim panel is popped off.

   These will often be of the Philips variety. (Strictly speaking, many of these are not actual Philips head screws but a slight variation. Nonetheless, a Philips screwdriver of suitable size will work on them.) A precision jeweler's screwdriver set including miniature Philips head drivers is a must for repair of miniature portable devices.

Sometimes, you will find Torx or a variety of security type fasteners. Suitable driver bits are available. Sometimes, you can improvise using regular tools. In the case of security Torx, the center post can usually be broken off with a pair of needlenose pliers allowing a normal Torx driver to be used. In a pinch, a suitable size hex wrench can substitute for a Torx driver. Places like MCM Electronics carry a variety of security bits.

2. Hidden screws. These will require prying up a plug or peeling off a decorative decal. It will be obvious that you were tinkering - it is virtually impossible to put a decal back in an undetectable way. Sometimes the rubber feet can be pryed out revealing screw holes. For a stick-on label, rubbing your finger over it may permit you to locate a hidden screw hole. Just puncture the label to access the screw as this may be less messy then attempting to peel it off.

3. Snaps. Look around the seam between the two halves. You may (if you are lucky) see points at which gently (or forcibly) pressing with a screwdriver will unlock the covers. Sometimes, just going around the seam with a butter knife will pop the cover at one location which will then reveal the locations of the other snaps.

4. Glue. Or more likely, the plastic is fused together. This is particularly common with AC adapters (wall warts). In this case, I usually carefully go around the seam with a hacksaw blade taking extreme care not to go through and damage internal components. Reassemble with plastic electrical tape.

5. It isn't designed for repair. Don't laugh. I feel we will see more and more of this in our disposable society. Some devices are totally potted in Epoxy and are throwaways. With others, the only way to open them non-destructively is from the inside.

Don't force anything unless you are sure there is no alternative - most of the time, once you determine the method of fastening, covers will come apart easily If they get hung up, there may be an undetected screw or snap still in place.

The most annoying (to be polite) situation is when after removing the 18 screws holding the case together (losing 3 of them entirely and mangling the heads on 2 others), removing three subassemblies, and two other circuit boards, you find that the adjustment you wanted was accessible through a hole in the case just by partially peeling back a rubber hand grip! Been there, done that. :(

And on the still lighter side, from an IBM maintenance manual, circa 1925 (displayed in the Chicago Museum of Science & Industry):

> "All parts should go together without forcing. You must remember that all the parts you are reassembling were disassembled by you. Therefore, if you can't get them together again, there must be a reason. By all means, do not use a hammer."

When reassembling the equipment make sure to route cables and other wiring such that they will not get pinched or snagged and possibly broken or have their insulation nicked or pierced and that they will not get caught in moving parts. Replace any cable ties that were cut or removed during disassembly and add additional ones of your own if needed. Some electrical tape may sometimes come in handy to provide insulation insurance as well.

For those hard-to-open LCD panels:

(From: Onat Ahmet (onat@turbine.kuee.kyoto-u.ac.jp))

The LCD display housings are usually secured by plastic catches built into the case. They still may have a couple of screws that are positioned in the most innovative places! Obvious places are sides of the display, and under stickers (rub your finger over a sticker and see if you can feel the hole for a screw). Also, try to look around the hinge connecting the LCD to the main housing. Look with the LCD closed, and also open; rotating open the housing might hide some screws from view. Expect it to be awkward! BTW, do not forget small hatches, that do not look like one!

After that, it is patience, and knowing the right place to twist the case to pop it open. Try not to use screwdrivers; they leave unsightly marks along the seam.

Also, if it is your own unit, and you break a few of the catches along the way, do not worry; you can put the housing back together with a few spots of adhesive.

How to Build Obsolescence In Before the Name Goes On

The following would belong more in the humor department if it weren't for the fact that much of it is true by accident or design with modern appliances and electronics! However, memorizing this list will go a long way toward helping to understand by the piece of !@#$ is such a pain to repair! I don't believe we are divulging any secrets here - the manufacturers already have this list in their "Corporate Operations Manual". :)

These are in no particular order.

(Portions from various people including Alan Liefting (aliefting@ihug.co.nz), Heath Young (heathryoung@hotmail.com), Craig Osborn (eelcr@worldnet.att.net), Phil Allison (bilup@bigpond.com), Franc Zabkar (franczabkar@dingoblue.net.au), and Sam.)

1. Place metal shields around the power supplies without holes for air circulation. This will ensure power supply capacitors will dry out and make the power supply fail prematurely. And make sure not to use high temperature capacitors. Keeping the electros hot makes the ESR lower so cheaper ones will do.

2. Push as many capacitors as possible into the sides of heatsinks, power transistors, regulators, and power resistors - anything hot!

3. Do not bother with putting thermal conducting paste between heat sink and transistor. It only oozes and dries out anyhow.

4. Do not bother to solder the heavy components or joints subject to thermal cycling. Touch up selected connections by hand? You have to be joking.

5. The following components can be left out during manufacture: protection zener diodes, VDR's, spark gaps, decoupling capacitors, ferrite beads etc. If it works most of the time without them, the expense can't be justified.

6. Keep all factory tests as short as possible. If there isn't a dirt cheap solution to any problems found, don't test for them.

7. Buy the cheapest components from manufacturers who cannot guarantee the longevity of their product. It is easy to have a CRT fail within three years by using impure materials. This will make the cathodes oxide and reduce the emissions giving a dull, hard to read picture. The customer won't realize their TV or monitor has deteriorated but will see newer models with bright vibrant colors and just have to buy one.

8. Fit the so-called head cleaning device to VCR's. This will ensure numerous service calls increasing the customer frustration which will lead them to buy a new product. There is one born every minute.

9. Dispense with EMI/RFI components in the power supplies. As well as producing unacceptable interference, this will also mean that the power supply is more prone to damage from voltage spikes. These problems are by definition the responsibility of the customer anyhow so the result will only be a positive effect on the bottom line.

10. Use the softer plastics rather than the more wear resistant phenolic for kettles and toasters. This will guarantee the consumer will purchase a new product to replace the shabby appliance.

11. Make the covers of heat generating appliances out of painted instead of chrome-plated sheet metal. The paint will darken unevenly with use resulting in an old looking appliance in need or replacement.

12. Do not use spot welding on your heating elements. Spot welding makes a reliable connection. Crimped connections will fail within a short period. This is good (for the manufacturer) since spare parts are not available. The consumer will have to buy a new product and have been conditioned to not expect appliances to be repairable. People like to buy new things anyhow.

13. Install an Appliance Leakage Circuit Interrupter (ALCI) on the cord of the appliance. This is a one time use GFCI (or what I call a GFCK - Ground Fault Circuit Killer). When constructed with suitably cheap parts, it, rather than the appliance will fail but the customer will be informed that they must have gotten the appliance wet.

14. Use the cheaper carbon film resistors instead of the more reliable metal film resistor with better voltage ratings. What the customers can't see won't bother them.

15. Fasten heavy (or just random) parts to the PCB with that white/beige glue that decays after awhile to brown and conductive causing all sorts of nasty problems.

16. Use a design style which will rapidly look dated. This is another ploy in order to have the consumer purchase the latest style regardless of whether the item is working or not. People are slaves to fashion - and they love slaves.

17. Reduce the number of service agencies and the number of products the service agencies will repair for you. This will increase the sale of new products by frustrating the consumers efforts in order to have their item repaired.

18. Fit fast blow fuses inside sealed double insulated appliances that will fail from metal fatigue. (Why did they do this??? - it was sealed with heatshrink onto one of the wires?!)

19. Manufacture equipment as a collection of modules - example. Optics train in certain models of projectors - instead of replacing just a hot mirror ($15 or so) you have to replace the lot! (All optics and LCD screen etc as a module) Now, try getting the poor serviceman to explain why the projector that cost the customer $5,000 costs $3,000 to fix.

20. Encourage consumers to purchase the cheapest items so when someone does make a good product, no one will buy it, and the company will go out of business.

21. Make your spare parts very expensive or do not bother with having spare parts available.

22. When the prototype has been built and working correctly, start removing components until it fails to work properly. Then manufacture it with the minimum parts required to make it work. In mid production run, change selected over designed components to their border line equivalents.

23. If a government regulating agency forces a major recall due to a severe fire hazard, close the current brand name, and start a new brand with a redesigned outside shell that emulates an ergonomic look but with the same internals as before. Add words like "New, Improved, Upgraded, and Leading Edge" to the new marketing slogan.

24. Don't make service manuals or circuit diagrams available. If you do, ensure that only your service agents get one, or price them so highly that the job becomes uneconomical. Think of it this way: Instead of buying the equipment which was the usual way of doing business in the past, the purchase price is now actually only a rental fee for the duration of the warranty. After that, the manufacturer may let the smoke out at any time without notice and thus there is no reason to support repairs. :)

25. Don't identify yourself as the manufacturer. Hide behind your OEM resellers who of course will have no facilities to repair anything except by total replacement.

26. Scrape the numbers off your IC's, or have them stamped with obscure in-house part numbers. You don't want to make repairs too easy for the end user or for a third party repairer who would otherwise be able to source these $1 garden variety parts from any electronics store.

27. Don't stock parts that could reasonably be expected to fail or wear out like battery contacts, flex PCBs, remote control keypads, curly cords. If you must supply them, then do so as part of a complete, uneconomically priced assembly.

28. Use flimsy non-standard (and hence unavailable) connectors for attaching expensive proprietary AC adaptors, chargers, and accessories.

29. Use expensive sealed units which cannot be opened for service without being damaged, and which are powered by an inexpensive internal battery.

30. Have a single solid wire between circuit boards and anything that moves, e.g. sockets at the back of VCRs, or almost any part of a remote control, especially the battery connection. This means that the

soldered connection will give up.

31. Have flimsy hinged flaps on a remote control that break after a short time.

32. On a remote control, have rows and rows of identical buttons that have functions that are almost never needed. Also omit functions that would be very handy.

33. Make sure the coax to the tuner of the VCR or TV has no proper mechanical anchorage to the chassis so it takes little more than the house cat to trip on the cable and yank the active innards from the tuner.

34. Make sure all large metal components (particularly the audio in/out sockets at the rear of amplifiers) are only soldered to the same degree as the flimsy IC pins - just soldered sufficiently to pass the production final test.

35. Don't use fiber reinforced plastic gears if you can use plain plastic types.

36. Never use keys to lock shafts to plastic pulleys.

37. Always use etched copper film thin ribbon board interconnects wherever there is maximum flexing such as in laptop screen hinges.

38. Never make rubber drive belts accessible by just removal of the back plate.

39. Use as many non-standard components as possible.

40. Don't use 2 boards if you can mount components on both sides of one board.

41. Always use the smallest possible wattage for a resistor: if the dissipation is 2 watts, then use a 2 watt resistor.

42. Take advantage of exciting new legislation in creative ways to make it illegal for others to make compatible user-replacable parts. No more third party batteries, inkjet cartridges, etc.

43. Add useless complexity to accessories like batteries and inkjet cartridges to make it more difficult for third parties to manufacture replacements. Include warnings about the risks of using third party accessories.

44. Shorten product introduction cycles so that by the time the end-user requires a repair to the item, it's already obsolete.

45. Set the cost of the repair to greatly exceed the cost of a new model of the same type of equipment, which, you just happen (surprise surprise) to have in stock and for sale.

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Tools, Test Equipment, and Other Stuff

Hand Tools

Invest in good tools. If you are into garage sales, you can often pick up excellent well maintained tools very inexpensively but be selective - there is a lot of junk out there. In the end, substandard tools will slow you down and prove extremely frustrating to use. Keep your tools healthy - learn to use a wetstone or grinding wheel where appropriate (screwdrivers, drill bits, etc.) and put a light film of oil (e.g., WD40) on steel tools to prevent rust.

Some basic hand tools.

- Screwdrivers of all types and sizes including straight, Philips, Torx. Security bits for some video games, PS2s, etc. Notched straight blade for VCR mechanical tracking adjustment - make or buy.

- Jewelers screwdrivers - both straight and philips. These are generally inexpensive but quality is also quite variable.

- Small socket driver set.

- Hex key wrenches or hex drivers. Miniature metric sizes for VCRs.

- Pliers - long nose, round nose, curved. Both smooth and serrated types are useful.

- Adjustable wrench (small).

- Cutters - diagonal and flush. Linesman's pliers.

- Wire strippers - fixed and adjustable. Crimp tool.

- Alignment tools - (at least a standard RCA type for coils).

- Files - small set of assorted types including flat, round, square, and triangular.

- Dental picks - maybe a reason to go to the dentist? :-) These are useful for poking and prodding in restricted areas (but you knew that).

- Locking clamps - hemostats - for securing small parts while soldering etc.

- Magnetic pickup tool - you can never tell when you will drop something deep inside a VCR. If you keep a strong magnet stuck to your workbench, you can use it to magnetize most steel tools such as screwdrivers. Just keep anything magnetized away from the tape path and magnetic heads.

- Hand drill, electric drill, drill press - one or all. A small benchtop drill press (e.g., 8") is invaluable for many tasks. A good set of high speed bits (not the 1000 bits for $9.95 variety). Also, miniature bits for

PCB and small plastic repairs.

- Soldering and desoldering equipment. An entire chapter is devoted to this topic with the name, you guessed it: "Soldering and Desoldering Equipment and Techniques".

Emergency Screw Removal

While a good quality selection of straight, Philips, Torx, and hex-head drivers should handle most screws found in consumer electronic equipment, a couple of other types do turn up and can really be a pain in the you-know-where to remove intact. See the section: About Those Other Funny-Headed Screws.

It may be possible to remove such screws even if nothing in your driver assortment quite fits (short of buying the proper tool, that is - what a concept!). There is also the situation (very common) where someone (we won't say who) has pre-mangled the screw head! Here are a few approaches to try when you are stuck at 2:00 AM on a Sunday morning with an uncooperative screw:

1. Select a driver type (usually Philips) and size that privides the best grip. Then apply as much pressure as is safely possible without destroying anything and attempt to turn the screw. What you want to avoid is slippage - once the blade slips, the head will be quickly destroyed and then you are left with options (2) or (3), below. For a jeweler's type screwdriver, clamping something larger to its shaft can provide valuable additional leverage.

2. Use a hand grinder (e.g., Dremel tool) or thin file to create a slot in the screw head which one of your straight-blade screwdrivers will fit. Obviously, take care to avoid damage to adjacent parts and dam off the area to prevent grinding chips from getting over everything.

3. Grab the center and edge of the screw with a pair of sharp diagonal cutters and turn it. This, of course, also damages the screw head and if you are too forceful, will break your cutters as well.

4. Drill out the screw using a bit just large enough to sever the head from the shank of the screw. Then, use a pair of needlenose pliers to unscrew what remains. For large screws, drill only part way and then use a screw extractor like Easy-Out(tm).

5. Superglue the screwdriver or some other suitable tool to what's left of the screw. Wait till it hardens and turn.

6. There are also products available for the purpose of improving the grip of screwdrivers. For example: ScrewGrab.

7. For screws into plastic holding metal covers, remove all other screws so the cover can be used to pull on the screw and heat the screw with a soldering iron. With care, it will melt its way out but the plastic will solidify to a smaller hole that can be used to install a new screw. Where the cover is also plastic, it may melt first so probably not a good idea.

Note: some of these screws have had some material like Lock-Tight(tm) (which looks like colored nail polish) applied to the top to prevent the screw from loosening on its own. This also prevents the blade of a screwdriver from properly seating, so removal is essential before attempting removal.

Plastic Screw Thread Repair

Where a screw no longer tightens into a threaded plastic hole, here are a few suggestions:

1. Install a larger screw in original worn hole. :) For repairs where the appearance isn't important, this may be the best solution.

2. Use a soldering iron from the hidden side to "adjust" the hole. Doing this with the screw in place will result in proper threads being preformed.

3. Fill the hole with a mixture of the same type of powdered plastic and solvent or other similar material. When dry, drill a pilot hole and then install the original screw.

4. Glue a metal nut to the underside of plastic and use a machine screw.

There are many other possibilities.

To avoid this problem in the future, realize that plastic is very soft and it is essential to gently start the screw into the hole to get a feel for it properly mating with the existing threads. The use of an undersized screwdriver to get the screw started may be helpful in that it won't accidentally apply too much torque and strip the threads. Something that is less obvious is that screws for plastic are often made with a wide thread and a narrow thread wound that alternate, sort of like a deformed hunk of DNA. :) With these, there is only one proper way for them to mate with an existing hole and forcing them is asking for stripped threads and a fine strand of plastic being pulled out along with the loose screw.

About Those Other Funny-Headed Screws

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

As well as Phillips, there are Pozidriv and JIS:

> Pozidriv screws can be recognized by the 'starburst' - the little lines on the head between the main slots. These are very common (certainly in Europe) in all sorts of equipment.

- There are also JIS (Japanese Industry Standard) heads. These _look_ just like Philips, but the screwdriver is a little flatter on the end. Not surprisingly these do turn up in Japanese stuff.

A Philips screwdriver won't even appear to fit a Pozidriv head. It will appear to fit a JIS head, but it will also damage it if it's at all tight. JIS screwdrivers are not easy to get, either. I think I have a small set made by Acu-Min (?).

It's not uncommon for all 3 to be used in the same equipment, especially if subassemblies were made by different companies.

(From: Robert McPherson (rm502@bellsouth.net).)

There is a type of screwdriver called a "Reed & Prince" which fits these screws which are similar in appearance to Phillips screws. Cooper tools makes them.

Workbench and AC Power

Perhaps this isn't as immediately essential as a pair of wire strippers but for any serious electronics - be it construction or repair - some dedicated place to do it is essential. It doesn't need to be a $2,000 professionally designed "work unit". Any large sturdy flat surface will suffice as long as it doesn't need to be cleared off for meals. :)

A size of 3 x 6 feet should be adequate, longer is better if you have the space. Workbench height is typically 36 inches. Make sure the legs are sturdy and rigid - some equipment can be quite heavy. Get yourself a comfortable stool to sit on for those marathon troubleshooting sessions.

The surface can be laminate, particle board, plywood, butcher block, or some other insulator. It shouldn't have a dramatic pattern though since small parts will be hard to find. Wood products should have multiple coats of varnish or polyurethane. Using a cheap material that can be replaced will enable the surface to be rejuvenated after it gets pitted and burnt - as it invariably will after awhile. An antistatic surface is desirable but probably expensive to put on the entire workbench so just get an antistatic matt for use when needed. (An antistatic surface isn't quite a perfect insulator but has just enough conductivity to minimize the buildup of static electricity, essential for any work with devices like CMOS ICs and laser diodes that can be destroyed by even a small static discharge.)

Install a shelf or shelves along the back that are about half the depth of the workbench surface to hold smaller pieces of test equipment, power supplies, parts cabinets, and other odds and ends. Add a shelf or shelves underneath for storage.

Install AC outlets along the rear edge, vertically so debris can't fall into the holes. How many? The more the merrier - they will all get filled no matter how many are there! At a minimum, one every 6 inches or a duplex every foot, double this won't hurt. Power the workbench from two branch circuits fed from opposite sides of the 115-0-115 VAC (in the U.S.A.) Consider including at least one 230 VAC outlet (in the U.S.A.). Providing some outlets that are switched with power indicator lamps and protected by fuses or circuit breakers. Most outlets, particularly those used to plug in equipment being worked on, should be GFCI (Ground Fault Circuit Interrupter) protected for safety. But a few - clearly marked "NOT GFCI PROTECTED" - should be available for equipment that will not function reliably on a GFCI with the understanding that these lack such protection. Most test equipment and power supplies with properly wired grounded power cords do not need to be GFCI protected but won't complain if they are. However, some equipment may nuisance trip (immediately or at random) GFCIs even if functioning properly.

The total cost can be well under $100 for all of this even if the materials and parts are purchased new. With some reasonable scrounging abilities, it can be a lot less.

Basic Test Equipment

Obviously, you can load up on exotic test equipment. What follows are those that are most used. You might at first not consider all of these to fit the category of test equipment but an old TV can provide as much or more useful information about a video signal than a fancy waveform analyzer in many cases. And, basic reliable easy-to-use test equipment is more important than sophisticated instrumentation laden with features you will never need.

- DMM and/or VOM. I prefer to have both. A good old Simpson 260 is better in many ways than a cheap digital multimeter. For most measurements, I still use a 25 year old Lafayette (remember them?) VOM. I only go for the DMM when I need to measure really low ohms or where better accuracy is needed (though this can be deceptive - just because a DMM has 3-1/2 digits does not mean it is that accurate - check you manual, it may prove enlightening). The Simpson 260 also has a nice 5000 V AC/DC scale which the others lack.

  A fancy expensive multimeter is not needed, at least not while you are just starting out (and likely to make some occasional mistakes like attempting to measure line voltage on the ohms scale.) However, if someone offers to give you a nice Fluke DMM, don't turn it down :-).

  Scales for transistor, capacitor, frequency counter, etc. are not really essential. A diode test function on a DMM is needed, however, to properly bias semiconductor junctions. Even this is not useful for in-circuit tests or for some power transistors or transistors with built in damper diodes and/or base resistors.

  Make sure you have a good well insulated set of test probes. This is for your own safety as you may be measuring relatively high voltages. Periodically inspect for damage and repair or replace as needed. If the ones that came with your multimeter are substandard - flimsy connectors or very thin insulation, replace them as well.

  A high impedance high voltage probe is sometimes useful for TVs and monitors. You can build one of these which will suffice for most consumer electronics work.

- AC clamp-on ammeter. This permits the measurement of currents in appliances or electrical wiring without having to cut any wires. At most, you will need an easily constructed adapter to permit access to a single conductor of a line cord. This may be an option for your multimeter.

- Oscilloscope - dual trace, 10 to 20 MHz minimum vertical bandwidth, delayed sweep desirable but not essential. A good set of proper 10x/1x probes. High vertical bandwidth is desirable but most consumer electronics work can be done with a 10 MHz scope. If you get into digital debugging, that is another story - 100 MHz and up will be required. If money is no object, get a good digital storage scope. You can even get relatively inexpensive scope cards for PCs, but unless you are into PC controlled instrumentation, a stand-alone scope is much more useful.

  I would recommend a good used Tektronix (Tek) or Hewlett Packard (HP) scope over a new scope of almost any other brand. You will usually get more scope for your money and these things last almost forever. Until recently, my 'good' scope was the militarized version (AN/USM-281A) of the HP180 lab scope. It has a dual channel 50 MHz vertical plugin and a delayed sweep horizontal plugin. I have seen these going for under $300 from surplus outfits. For a little more money, you can get a Tek 465 or 465B (slightly newer but mostly similar specifications) 100 Mhz scope ($200 to 600) which is what I use now. The HP-180 is still fine but I couldn't pass up a really good deal. :) The Tek 465/B or other similar model will suffice for all but the most demanding (read: RF or high speed digital) repairs. (See the additional comments below on the Tek 465 as well.) From my experience with this scope many years ago and now as well, I really do agree with some who say that this is the best scope Tektronix ever designed.

Auctions like eBay can sometimes be a source of good used Tek and other scopes at reasonable prices though sometimes the bid price goes way beyond what is reasonable. :) A search for "oscilloscope" will typically turn up several hundred hits. However, to have any confidence in the operational condition of a scope, the seller must be reputable and know something about testing them. A warranty may be of limited value since a major part of the cost of a used scope is likely to be the shipping and you'd end up having to pay that both ways. Check out Phil's Tek Scope Prices on eBay List as well as catalog pages of surplus test equipment dealers. A Web search (e.g., Google) will usually turn up enough sites for any specific model to provide both specifications and typical prices from surplus equipment dealers (which are usually high!).

My instant checklist for a used scope:

- Bright, sharp trace, no screen burns, short warmup time.
- Vertical amp(s) operational on all ranges.
- Horizontal timebase(s) operational on all ranges.
- Stable triggering at low and high end of frequency range.
- Switches and controls reasonably noise-free (may need cleaning though).
- Decent cosmetic condition, all knobs and buttons present, no signs of major trauma.

You don't absolutely need an oscilloscope when you are just starting out in electronics but it would help a great deal. It need not be a fancy one at first especially if you are not sure if electronics is for you. However, being able to see what is going on can make all the difference in your early understanding of much of what is being discussed in the textbooks and the newsgroups. You can probably find something used that will get you through a couple of years for less than $100. An oldie but goodie is much better than nothing at all even if it isn't dual channel or high bandwidth!

And a note about digital versus analog scopes: Analog scopes are what we used to think of as an oscilloscope: The CRT *is* the place where the waveform is generated. Digital scopes use a fast A/D converter to capture data in memory in the form of 1s and 0s and then display this on a raster-scan CRT (like a computer monitor screen). Digital scopes are automatically storage scopes and are great for analyzing waveforms. However, most older digital scopes are really poor at real time display and in addition, appear to have been designed by computer programmers, not test equipment engineers. Ever try to play a menu-driven piano? :) For general electronics and troubleshooting, I'd rather have a 20 year old Tek analog scope than a 5 year old digital scope costing 25 times as much. The inherent real-time presentation of an analog scope can be invaluable when attempting to observe the subtle characteristics of a waveform. Those who go through school never having touched a true analog scope have missed out on a great experience.

- Logic probe - for quick checks of digital circuitry for activity. A logic pulsar can be used to force a momentary 1 or 0. Some people swear by these. I consider them of marginal value at best.

- TV set (color is desirable) and/or video monitor for testing of video equipment like VCRs, camcorders, laserdisc players, etc. I have an old CGA monitor which includes an NTSC input as well.

A great deal of information can be gathered more quickly by examining the picture on a TV or monitor than can be learned from the video waveform on displayed on a scope.

- VCR or other video signal source for testing of video monitors and TVs. These will have both RF (F connector) and baseband (RCA jacks) outputs.

- Stereo tuner or other audio signal source for testing of audio equipment.

- Audio signal generator. A function generator (sine, square, triangle) is nice as well. The usual audio generator will output from a few Hz to about 1 MHz.

- Audio amp connected to a loudspeaker. The input should be selectable between line level and mic level and be brought out through a shielded cable to a test probe and ground clip. This is useful for tracing an audio circuit to determine where a signal is getting lost.

- Signal injector. A readily accessible portable source of a test tone or other signal (depending on application) that can be introduced into the intermediate or early stages of a multistage electronic system.

  For audio, a simple transistor or 555 timer based battery powered oscillator can be built into a hand held probe. Similar (but generally more specialized) devices can be constructed for RF or video testing.

- RF signal generator. For serious debugging of radio and tuner front-ends. These can get quite sophisticated (and expensive) with various modulation/sweep functions. For most work, such extravagance is unnecessary.

- LCR meter - a capacitor tester is desirable but I prefer to substitute a known good capacitor rather than trusting a meter which will not test under the same conditions as exist in-circuit.

- Adjustable power supplies. At least one of these should bo of the totally indestructable variety - one you can accidentally short out without fear of damage. Mine is a simple 1 amp 0-40 V transformer and rectifier/filter cap affair with a little Variac for adjustment.

- The following book has a number of simple test equipment projects you can build with readily available parts:

    - Test Equipment Projects You Can Build
      Delton T. Horn
      Tab Books, a division of McGraw-Hill, Inc., 1992
      Blue Ridge Summit, PA 17214
      ISBN 0-8306-4154-8 (hardcover), 0-8306-4155-6 (paperback)

Jerry's Comments on Used Scopes and the Tek 465

(From: Jerry Greenberg (jerryg50@hotmail.com).)

If you are buying a used 465, look for the 465B. It is a better unit, and is the same price most of the time. Take care that this scope is about 20 years old, and there is no support from Tek on it. The replacement parts are not available if something blows. I used to have a few of them. One needed a CRT, and the other I sold while it was still working. For consumer electronics, you will get by with a 100 MHz unit, but it is preferable to have over 200 MHz bandwidth if you want to do front end service on consumer FM radio receivers. Read up on Nyquist and you will see the answer.

If you also call Tektronix technical services, tell them that you are looking for a used Tek scope to be used for hobby purposes. They will be very helpful in giving you any information you require. They will even recommend models and what to look for. If you talk to their sales people, they will sometimes even give you their authorized dealers who handle used Tek equipment so that you can shop around.

If you go a bit more for your used scope you can get a 200 or 300 MHz unit that is a newer version of an analog scope. It will have improvements over the 465 series. Look at the 2000 analog series scopes. These have a lot of enhancements like on the screen display. This will be very handy for precise work. When buying any type of scope, I would stress that the Tektronix is the best. If you find a good working used one, you will have a very high quality product, and it should give you years of service. Most of the analog scope that they made include the TV sync options.

Even if you buy a used one, and the parts are not available, it pays then to buy a second used one and you will have spare parts. These scopes used to cost in the many thousands of dollars when new, and you are probably paying between eight hundred to fifteen hundred for a used one (somewhat cheaper now, even from surplus companies. --- Sam). These scopes will be far superior to even the newer ones from the consumer level scopes. In 1978 I believe my company paid over $8,000 for the 465B scope new. A new Chevy fully loaded was less!

Repairing Tectronix 400 Series Scopes

As noted above, the Tektronix 465 and 465B 100 MHz scopes are among Tek's best ever made, and very desirable and affordable for troubleshooting and general electronics work. The Tek 485 is a nice 350 MHz scope. There are many other 400 Series Tek scopes, almost any of which would make a fine service scope. However, they are showing their age dating from the '70s to the early '80s and many are appearing with power supply problems at even more affordable prices. :(While Tek custom parts are no longer available for these scopes (and you couldn't afford them anyhow!), many power supply problems which often result in a totally dead scope (but may also just cause specific sections like the timebase to be non-functional), can be repaired with readily available parts at little cost.

The most likely causes are shorted tantalum "dipped" capacitors dragging down one or more power supply rails. Apparently, Tek used a batch of unreliable caps on the some of the 400 Series scopes and while aluminum electrolytics usually just dry out with decreased capacitance and increased ESR, these dipped tantalums go short circuit. Fortunately, the design of the switching power supplies in these scopes is such that the controller shuts down from a serious overload or short rather than letting its smoke out. If the overload is on only one voltage rail and not severe (e.g., through a resistor), only that voltage may be low or absent resulting in loss of functionality but not a totally dead scope.

So, the first step is (WITH POWER OFF) to check the resistance of each voltage test point to ground with a multimeter. While the expected resistances may not be known except from a service manual (if that), anything very low (e.g., 10 ohms) is suspect. Here are typical values measured on a Tek 485 using a Fluke 87 DMM with the black lead on ground: +50 V, 2.1K ohms; +15 V, 89 ohms; +5 V, 70 ohms; -5 V, 222 ohms; -15 V, 152 ohms. The resistance for +5 V changes significantly depending on front panel settings and which incandescent indicator lamps should be lit and may go below 35 ohms. On this scope, the -15 V rail originally measured about 10 ohms due to a bad cap. Where one of these is found, attempt to determine the location of the short to a specific circuit board. Then, trace the wiring on that board to locate the possible bad caps. A good DMM or milliohmmeter can help to track down the cap since PCB foil resistance is high enough to be measured and the resistance to ground will be lowest at the location at the bad cap. At this point, unsoldering one lead of each cap and checking its resistance is the safest approach. With care, this can be done from the component side of the board which is fortunate since removing some of these large PCBs can be a royal pain. Heat the lead with a soldering iron and pull it free. Then, use a vacuum desoldering tool ("SoldaPullet") to clear the hole. Check the resistance of the cap and/or across the supply rail to determine if you found the correct one. The bad cap mentioned above was found in about 5 minutes in this manner. There are typically only a few of these caps on each board but it's possible for the bad one to be on a board that isn't easily accessible.

Where this approach doesn't work or for the lazy but daring among us, the alternative is to apply voltage from an external adjustable current limited supply to the bad power rail. If the bad part isn't a perfect short circuit, it will dissipate heat and let its smoke out or explode. Wear safety glasses! If this doesn't happen, it may actually be possible to power up the scope with the external voltage applied to determine functionality. In either case, I won't be responsible for any destroyed equipment should this be done.

So You Can't Afford a $20,000 Transient Event Recorder?

You know the situation - an intermittent that happens once an hour for 1/2 second! In industry, you would use a fancy logic analyzer with associated digital scope to capture the event.

However, there may be no need for such extravagance. If you have an oscilloscope and camcorder or video camera/VCR, you probably have all that is needed.

For a TV or monitor, point the camera at the CRT and the scope screen so that they are both in the picture and record on a 6 hour tape. Then, when your event takes place, you have a permanent record!

That old video camera will be perfectly adequate. It doesn't need a 100X digitally stabilized enhanced reprocessed zoom or 1/10,000th second shutter. It doesn't even need to be color!

Sure, this won't capture the 1 ns glitch. But, for the occasional flash in the picture, it is more than adequate to eliminate a video signal line as the source of the problem.

Extensions to more convoluted problems are left as an exercise for the student!

Transformers - Isolation and Variable

Isolation transformers are *essential* to safely work on many types of equipment with exposed AC line connections or live chassis. Variable transformers provide a convenient way to control the input voltage to equipment to determine whether a fault still exists or to evaluate performance at low or high line voltage.

Isolation Transformers

An isolation transformer is very important for safely when working on live chassis equipment. Make it a habit to use an isolation transformer whenever possible. Portions of TVs, monitors, switchmode power supplies, and many other types of equipment are generally fed from a direct connection to the AC line without a power transformer (which would provide the isolation function). The DC power rails will typically be between 150 and 300 V with momentary current availability of multiple amps!

Since Earth Ground and the Neutral of the power line are connected together at your service panel (fuse or circuit breaker box), grounds like cold water pipes, test equipment chassis, and even a damp concrete floor make suitable returns for the line voltage (Hot or live wire). Since this is just as true with the conductor being being a wire or your body, such a situation is very dangerous.

An isolation transformer as its name implies provides a barrier such that accidental contact with an earth ground results in negligible current flow (only due to the parasitic capacitance and inductance of the transformer) - a slight tingle at worst. This also protects your test equipment as well as the device you are troubleshooting since a similar accidental contact can result in a short circuit, sparks, smoke, and many destroyed parts.

The schematic for a typical isolation transformer is shown below:

```
                   _        1:1
    H o-----/ ----- _------+    +-----------o 115 V
           Power  Fuse      )||(
           Switch           )|| +-----------o 105 V
                            )||(
                            )||(
                    Primary )||( Secondary
Tied together at            )||(
service panel               )||(
|                           )||(
|                           )||(
+-> N o----------+---------+ |  +---+--------o Return
|                |  4.7 M*   |      |
|                +---/\/\----|------+
|                            |
+-> G o----------------------+--------------o Ground
```

Note: Ground is included on the secondary side. This is actually needed for safety with certain types of equipment like microwave ovens where the HV return is to the chassis. Most other consumer electronic equipment and appliances will only have a 2 wire cord and thus not use the Ground. However, a potential safety hazard can arise if some other piece of equipment develops a ground fault resulting in a live, non-isolated part being user-accessible so this must be taken into consideration in deciding whether to ground the secondary side.

The resistor (*) is desirable to permit any static charge to leak off to ground. Since it is quite large - 2 M ohms - no perceptible current will flow between the secondary and primary sides but this value is low enough to dissipate any static charge. CAUTION: The resistor must be a high voltage rated type (as in 4,200 V isolation, large size light blue color to assure that arc over will not result due to voltage differences that may be present when the isolation transformer is being used in its normal manner.

Although the power line Neutral and Ground wires are tied together at the main service panel (fuse or circuit breaker box), the transformer prevents any significant current flow between any of its outputs and earth ground should a fault occur.

Even if you were standing with bare feet in a puddle of salt water on a concrete floor (noting that this is definitely NOT recommended) and were to touch something connected to the secondary of the isolation transformer or its return, or equipment circuitry attached to these, there is no direct return path for current to flow through you.

However, this shouldn't encourage a false sense of security. If you were to touch two points at different potentials on the secondary side, you could still be fried! And some equipment like microwave ovens use their chassis, and thus ground, as the high voltage return so an isolation transformer is of limited value for these whether it passes ground through or not.

Isolation transformers can be purchased or constructed from a pair of similar power transformers connected back-to-back. I built mine from a couple of old tube-type TV power transformers mounted on a board with an outlet box including a fuse. Their high voltage secondary windings were connected together. The unused low voltage secondary windings can be put in series with the primary or output windings to adjust voltage. See the section: Typical Homemade Isolation Transformer.

For super critical applications like in hospitals where every microamp of leakage counts, special isolation transformers are available (no doubt at equally super cost) which have shielding between the primary and secondary to minimize the inter-winding capacitance and inductance as well. This should not really be necessary for general servicing.

Note: Not all definitions of the term 'isolation transformer' are created equal! For some purposes, this may mean just preventing line born electrical noise from passing to the equipment. So, if you acquire something called an 'isolation transformer' on its nameplate, confirm that the primary and secondary are indeed not tied together by a low resistance. If they are, it can probably be modified for service needs by disconnecting a jumper but it may not have the insulation ratings desirable for high voltage isolation.

(From: Filip "I'll buy a vowel" Gieszczykiewicz (filipg@repairfaq.org).)

Ever wonder how those guys repair HV transformers running 200 kV without shutting off the power lines feeding the city? They use *very well isolated* cherry pickers! The guy on that platform is working on ONE wire which - since he's not connected to the ground - is at ZERO potential! That wire has no reference at all so no current flows. And he prays each morning that it stays that way or he goes off with a flash! [ugh!].

You're doing something like that on a much safer level. :)

Typical Homemade Isolation Transformer

The schematic for a homemade isolation transformer a pair of back-to-back power transformers from ancient tube-type TVs is shown below:

```
                                +-------------------------o 109 V
                                |
                                |     +-------------------o 121 V
                                |     |
                                | +---------------+
                                | |   |           |
                   || +--o NC   | |   +---+ ||    |
                   ||(          | |        )||    |
                   ||(          | |  6.3 V )||    |
                   || +--o NC   | +-------+ ||    |
            _      ||(          |          )||    |
H o--/ ----- _---+ ||(          |    6.3 V )|| +--+-------o 115 V
    Power  Fuse   )|| +--o NC   +---------+ ||(
    Switch        )|| +-------------------+ ||(
            115 V )||(                     )||( 115 V
                  )||(                     )||(
                  )||( 350 V         350 V )||(
N o---------+----+ ||(                     )|| +----+-------o Return
            |      || +--o NC       NC o--+ ||      |
            |      ||(                     )||      |
            |      ||(                     )||      |
            |      ||( 350 V         350 V )||      |
            |      ||(                     )||      |
            |      |  +-------------------+  |      |
            | Pri1 |  Sec1              Sec2 | Pri2 |
G o----------------+-------------------------+-------------o Ground
            | Transformer 1    2M*    Transformer 2 |
            +------------------/\/\-----------------+
```

Note that there should be a fuse in the primary to protect against faults in the transformer as well as the load. A slow blow type should be used in the primary circuit. The inrush current of the transformer will depend on the part of the cycle when the switch is closed (worst is actually near the zero crossing) as well as the secondary load. To protect the load, a fast blow type in the secondary is recommended. However, the inrush current of the degauss coils in TV sets and monitors, for example, will often pop a normal or fast blow fuse when no actual problems exist. (It is probably a good idea to disconnect the degauss coils while testing unless they are suspected of being the source of the problem.)

The 2 M resistor (*) is to bleed away any static charge as described above.

The power/VA ratings of the transformers you use need to be greater than your expected load. And, since some equipment like TVs and computer monitors draw a lot of current at power-on (from the degauss circuit), the isolation transformer will limit the peak current and may cause problems during startup (though overall, the limited current may prevent some types of disasters!). In any case, don't expect a pair of 6.3 VAC, 1 A transformers wired back-to-back to be useful for testing much of anything!

Also see the section: Isolation Transformers from Dead Microwave Ovens.

(From: David Moisan (dmoisan@shore.net).)

It's not as hard as you think to find inexpensive isolation transformers. At the next hamfest, look for someone selling dead UPS's (Uninterruptible Power Sources) or other power conditioning equipment. Isolation transformers are often sold for use in the computer industry; that's how I got mine. 250 VA for $20, and I could have gotten 1000 VA for $50 if I wanted. Definitely increases my safety *and* confidence level!

Isolation Transformers from Dead Microwave Ovens

The high voltage transformers from dead microwave ovens (failures are rarely due to the transformers) can also be used. These are probably much easier to locate (try your local appliance repair shop or dump) and will have a nice high capacity - usually 5 to 10 A or more.

However, note that microwave oven transformers are usually designed with as little copper as possible in the primary winding and do go into core saturation at normal line voltage with no load. For example, measurements using a clamp-on AC ammeter of a transformer from a mid-size microwave oven shows:

```
  Input VAC   Input Amps
------------------------
     80           .3
     90           .6
    100          1.1
    110          2.0
    115          3.0
    120         >4.0
```

At 115 VAC input, that's about 350 VA - probably close to 350 W with nothing connected to its secondaries! It also had a very noticeable hum above about 100 VAC.

Thus, this sort of approach isn't recommended unless you really need the high capacity - testing of other microwave ovens or ion laser power supplies, for example!

A pair of these trnasformers can be connected in a similar manner to the tube-type TV power transformers described in the section: Typical Homemade Isolation Transformer, there are a few more things to keep in mind:

- These transformers are DANGEROUS. Their high voltage output is between 1,500 and 3,000 VRMS at AMPS - an instantly deadly combination. Therefore, thoroughly insulate the connections between the HV secondaries.
- The high voltage returns are connected to the cores so these must be tied together AND to earth ground for safety.
- These transformers may not be rated for continuous duty operation. So, they should probably not be left plugged in when not in use.
- The more limited capacity of a small isolation transformer can sometimes protect you from yourself -

preventing the burnout of a horizontal output transistor due to excessive load or carelessness. You will have no such guardian looking over your shoulder with a microwave oven monster!

A better way to use these is to take the primary (low voltage) windings from two similar transformers and mount them on a single core. Then, there is no high voltage to worry about, the unit is more compact and lighter in weight, and the performance is better (less voltage droop at high loads). Of course, disassembling the cores may prove interesting especially if they were originally welded!

How Safe is a Homemade Isolation Transformer?

Some people will claim that because it is homemade from salvaged parts, it *cannot* be as safe as a commercial unit.

Keep in mind that I am not talking about using something that has been rusting away in a damp basement for 20 years. The power transformers from tube-type TVs or audio amplifiers must have been designed with isolation requirements in mind to obtain regulatory approval in the first place since they are used in equipment where the user may come in contact with metal parts.

Also, the use of an isolation transformer is no excuse to ignore the other aspects of safe troubleshooting.

It is easy to test for AC and DC leakage - and this should be done - to be sure that your transformers are in good condition. With two transformers, the probability of a failure is even smaller - 1/(P*P). Personally, I would trust the homemade transformer over a cheap import any day!

Variable Autotransformers

A variable autotransformer (Variac is the trade-name of one popular brand) enable the AC input to an appliance or piece of electronic equipment to be easily varied from 0 to full (or greater than full) line voltage. Your first Variac doesn't need to be large - a 2 A unit mounted with a switch, outlet and fuse will suffice for most tasks. However, a 5 amp or larger Variac is desirable. If you will be troubleshooting 220 VAC equipment in the US, there are Variacs that will output 0 to 240 VAC from a 115 VAC line. **WARNING:** A Variac is NOT an isolation transformer!

The internal wiring of a typical Variac is shown below:

```
           _                1
    H o---- _-----/ ------>o--+     Tap 1: 0 to 115 VAC
         Fuse 1  Power      2  )||
        (Input)  Switch    o--+ ||  Tap 2: 0 to 140 VAC
                               )||
                               )||      _
Tied together at               )<------- _--------o Adjustable output
service panel           Power  )||     Fuse 2
|              220       LED   )||    (Output)
|          +--/\/\--|>|--|>|--+ ||
|          |                   )||
```

```
+-> N o----+-----------------+-|----------------o Return
|                              |
+-> G o------------------------+----------------o Ground
```

WARNING: Direct connection between input and output - no isolation since the power line Neutral and Ground are tied together at the main service panel (fuse or circuit breaker box)!

CAUTION: Keep any large transformer of this type well away from your monitor or TV. The magnetic field it produces may cause the picture to wiggle or the colors to become messed up - and you to think there is an additional problem!

Note: the 'Power LED' circuit is soldered directly to a winding location determined to produce about 6 VAC.

- Sam's Rule #61453: Your lab or shop can never have too many Variacs!
- Sam's Rule #61454: If you only have a single Variac, it should be LARGE!

Wiring a Variable Autotransformer

Typical variable autotransformers (e.g., Variacs) may be wired so that either clockwise or counterclockwise shaft rotation increases the output and for either 0 to 115 VAC or 0 to 140 VAC from a 115 VAC line (0 to 230 VAC or 0 to 280 VAC for units designed to operate on a 230 VAC line). There are also some Variacs that can produce 0 to 280 VAC from a 115 VAC line with the proper wiring (but they must have been designed for this!). Intermediate taps on the winding provide these options. The one for the LED, I add myself. :)

Wiring is straightforward if you have acquired a bare unit (the following assumes a 115 VAC line, the extension to 230 VAC should be obvious):

- Decide on the output voltage range and direction of rotation (clockwise should always be used to increase output as far as the user is concerned but depending on mounting, actual direction of the shaft with respect to the body of the unit may be either way):

  - For 0 to 115 VAC output, Hot and Neutral go between the ends of the winding with Neutral at the terminal where the wiper will be when you want the output to be 0 VAC; The output goes between Neutral and the wiper.

  - For 0 to 140 VAC output, Hot is moved to the tap about 20 percent away from the terminal where the wiper will be when the output is at 140 VAC; The output goes between Neutral and the wiper as above.

  - For some (mostly small) Variacs that do not have intermediate taps, it may still be possible to add a tap to permit 140 VAC operation. However, this will reduce the number of turns on the primary and could lead to overheating from core saturation if the design is marginal. Most of these are overdesigned and this shouldn't be an issue. But, nonetheless, if you try this, monitor the temperature of the *unloaded* Variac for, say, an hour to make sure it doesn't get excessively hot.

- Include a primary-side power switch and power-on indicator lamp. In the old days, a neon lamp would be used (e.g., NE2H with a 47K ohm resistor). Nowadays, neon lamps may be hard to find. An alternative as suggested above is to add a tap on the Variac winding at about 6 to 10 VAC and use an LED and current limiting resistor.

- Provide fuses for **both** input and output. They should be the same rating as the Variac. The fuse for the input protects against primary side shorts. The one for the output protects the Variac winding from excessive load. Commercial units may only have one fuse but fuses are inexpensive and the added protection won't hurt.

- Use an adequately rated grounded cordset and mount everything in a well insulated box. The Variac frame and box (if made of metal) should be grounded.

Variable Isolation Transformers

This should probably be your basic setup for troubleshooting. You don't need to buy a fancy combination unit. A Variac can be followed by a normal isolation transformer. (The opposite order also works. There may be some subtle differences in load capacity.)

Variac/Isolation Transformer with Current Limiting

For the well equipped troubleshooter, there are also devices (Variacs and/or isolation transformers or combos) with adjustable (electronic) current limiting. This is particularly useful to protect the equipment being tested from excessive current - somewhat like the series light bulb but easily settable for each particular situation.

Constant Voltage Ferroresonant Transformer

These provide very good line voltage regulation (typically +/-1% output change for a +10/-20% input change) without any active components. They also are very effective at suppressing line noise, spikes, and harmonics. SOLA is probably the most widely known manufacturer of these devices. A complete FAQ can be found at .

Note that while isolation may be provided, it is NOT inherent in this technology. Some types may use autotransformers and thus have no isolation.

(From: Dave Martindale (davem@cs.ubc.ca).)

The simplest version has fairly ordinary-looking primary and secondary windings wound on the centre leg of a shell-type transformer core. Unlike a normal transformer, where the primary is wound over the secondary (or vise versa), the primary and secondary windings are physically separated. Magnetic shunts (chunks of transformer steel) are inserted between the centre and outside legs of the core at a point between the primary and secondary winding. These magnetic shunts provide a flux path around the primary that bypasses the secondary winding, producing lots of leakage inductance. This is what limits the current when the secondary is shorted.

Meanwhile, the secondary winding is in parallel with a capacitor, chosen to make the secondary resonant at 60 Hz. The resonance drives the portion of the core inside the secondary winding into saturation, which limits the amplitude of the secondary voltage. Changes in primary voltage have almost no effect on secondary voltage over the regulating range.

Now, the above is actually a simplification. In real CV transformers, the secondary actually has enough turns to step up the voltage by a factor of several, so the capacitor is operating at several times line voltage. This allows the capacitor to be lower capacitance for resonance, which is physically smaller and cheaper than what you'd need at 115 V. The actual output voltage is obtained from a tap on the secondary where the voltage is 115 V or so.

Also, the transformer I've described so far outputs a pretty square waveform. That's great for the input stage of a DC power supply, but not for some AC loads. The commercial CV transformers I see use a "harmonic neutralized" design that gives an output closer to a sine wave. Instead of one secondary winding, there are two, with another pair of magnetic shunts between the two secondaries. The capacitor is connected across the two secondary windings in series. The output voltage is taken from just the "middle" secondary winding. In the Sola transformer, there's also an air gap in the centre leg of the core, at the end where the 3rd winding is. I don't understand how the extra winding and shunt cancel some of the 3rd harmonic output, but they do.

The Series Light Bulb Trick

When powering up a TV (or any other modern electronic devices with expensive power semiconductors) that has had work done on any power circuits, it is desirable to minimize the chance of blowing your newly installed parts should there still be a fault. There are two ways of doing this: use of a Variac to bring up the AC line voltage gradually and the use of a series load to limit current to power semiconductors.

Actually using a series load - a light bulb is just a readily available cheap load - is better than a Variac (well both might be better still) since it will limit current to (hopefully) non-destructive levels.

What you want to do is limit current to the critical parts - usually the horizontal output transistor (HOT). Most of the time you will get away with putting it in series with the AC line. However, sometimes, putting a light bulb directly in the B+ circuit will be needed to provide adequate protection. In that location, it will limit the current to the HOT from the main filter capacitors of line connected power supplies. This may also be required with some switchmode power supplies as they can still supply bursts of full (or excessive) current even if there is a light bulb in series with the AC line.

Actually, an actual power resistor is probably better as its resistance is constant as opposed to a light bulb which will vary by 1:10 from cold to hot. The light bulb, however, provides a nice visual indication of the current drawn by the circuit under test. For example:

- **Full brightness:** Short circuit or extremely heavy load - a fault probably is still present.
- **Initially bright but then settles at reduced brightness:** Filter capacitors charge, then lower current to rest of circuit. This is what is expected when the equipment is operating normally. There could still be a problem with the power circuits but it will probably not result in an immediate catastrophic failure.
- **Pulsating:** power supply is trying to come up but shutting down due to overcurrent or overvoltage

condition. This could be due to a continuing fault or the light bulb may be too small for the equipment.

Note: for a TV or monitor, it may be necessary (and desirable) to unplug the degauss coil as this represents a heavy initial load which may prevent the unit from starting up with the light bulb in the circuit.

The following are suggested starting wattages:

- 40 W bulb for VCR or laptop computer switching power supplies.
- 100 W bulb for small (i.e., B/W or 13 inch color) TVs.
- 150-200 W bulb for large color or projection TVs.

A 50/100/150 W (or similar) 3-way bulb in an appropriate socket comes in handy for this but mark the switch so that you know which setting is which! Or, for the ultimate in troubleshooting convenience, see the section: Combination Variable Isolation Transformer and Series Light Bulb Unit.

Depending on the power rating of the equipment, these wattages may need to be increased. However, start low. If the bulb lights at full brightness, you know there is still a major fault. If it flickers or the TV (or other device) does not quite come fully up, then it should be safe to go to a larger bulb. Resist the temptation to immediately remove the series light bulb totally from the circuit at this point - I have been screwed by doing this. Try a larger one first. The behavior should improve. If it does not, there is still a fault present.

Note that some TVs and monitors simply will not power up at all with any kind of series load - at least not with one small enough (in terms of wattage) to provide any real protection. The microcontroller apparently senses the drop in voltage and shuts the unit down or continuously cycles power. Fortunately, these seem to be the exceptions.

Combination Variable Isolation Transformer and Series Light Bulb Unit

If you plan on doing a lot of electronics troubleshooting consider building a box which includes:

- A Variac and isolation transformer or variable isolation transformer. Include a power switch and BIG RED power-on indicator as well as primary and secondary fuses or circuit breakers.

- A series light bulb bank consisting of 25, 50, 100, and 200 W light bulbs in parallel with individual switches for each. By selecting an appropriate combination of switch positions, any wattage from 25 to 375 W can be set up in 25 W increments. An additional switch in parallel with the light bulbs can be used to bypass them entirely. The light bulbs should be outside any enclosure so (1) they are clearly visible and (2) their heat won't cook the components inside the case!

- AC voltmeters on the isolation transformer output and final output; AC ammeter in series with the load.

Using a Light Dimmer or Similar Device as a Variac?

The quick answer is: No, get a proper Variac!

The behavior of a phase control device like a light dimmer depends critically on what sort of load it sees. If the dimmer sees mostly a resistive load, it will work reasonably well and survive. However, most electronic equipment doesn't fall into this category. If the dimmer is attempting to drive a piece of equipment with a lot of capacitance or inductance, at the very least it will behave strangely with the control range squashed to one end or the other, or the output voltage will change suddenly rather than smoothly. But more likely, it will self destruct and/or damage the equipment due to the strange waveform, which may result in a peak output voltage that approaches full line voltage even at relatively low settings. There's also usually a minimum load below which it won't do anything predictable. In short, get a proper Variac. You know my motto: "You can never have too many Variacs!". :) Surplus Variacs are readily available including on eBay.

What About the Scope Ground?

In general, scopes SHOULD be earth grounded. The only time this is not the case is if you are attempting to measure signals in a line-connected device such as found in many TVs and switching power supplies and are not using an isolation transformer. However, this is a very dangerous setup and should be avoided if at all possible. With line-connected equipment, the return or ground reference is not at earth ground potential due to the bridge rectifier or voltage doubler often used in the power supply front-end.

Without an isolation transformer, connecting the scope ground clip to the return will result in a short through the ground lead between the equipment and earth ground. There will be smoke and possibly blown components as well. Disconnecting the scope from ground allows its case to float which will prevent the melt-down but is EXTREMELY DANGEROUS since the entire scope cabinet is effectively connected to the power line. You (or someone else not familiar with your foolishness) may casually touch or lean against the scope cabinet and be thrown across the room if it is a lucky day or worse. Don't do it! Invest in an isolation transformer. It is very cost effective insurance.

Basic Ancillary Equipment

Various common items are useful for testing of the following consumer electronics and computer devices. These will normally be used before and during use of any actual test equipment. (Some of these were already listed under the heading of 'test equipment'). However, this is kind of inverted identifying what is needed for each type of equipment being repaired.

- TVs: VHF and UHF antennas and/or VCR or other video source with both RF and baseband (RCA plugs) outputs.

- VCRs: a small TV (preferably color but a monochrome TV will suffice for many tests) and/or NTSC/PAL video monitor, antenna, known good video tapes at both SP and SLP speeds. Also, a couple of blank cassettes for record tests.

- Camcorders: same as VCRs but in addition, a test chart, tripod, and lamps for indoor testing.

- CD and Laserdisc Players: - a garbage CD and test CD (or laserdiscs). A garbage disc is one you do not care about if it gets scratched. A test disc does not need to be an official (and expensive) test disc - any known good disc will do for most tests. The garbage CD can even be an outdated CDROM - an audio CD player will often read the directory of a CDROM just like an audio CD.

  Special cut-down miniature test CDs can be made to view the lens motion while focusing and to permit access to adjustments blocked by normal CDs in many portable players. See the document: [Notes on the Troubleshooting and Repair of CD Players and CDROM Drives] for details.

An IR detector will be needed to confirm laserdiode operation.

An audio amplifier with speakers or headphones will be needed for the audio tests, or headphones if the unit has a headphone jack. A TV or video monitor will be needed for Laserdisc video tests.

- Audio Equipment - a set of known working stereo components consisting of at least a tuner, amplifier, and speakers. Headphones are also useful. For most purposes, an inexpensive setup is preferred since there is no telling what kind of abuse it may need to endure during troubleshooting. I suppose that a turntable may even be needed occasionally. A couple of prerecorded audio cassettes are handy when testing tape decks. One of these should have a tone of known frequency recorded on an accurately calibrated deck for setting tape speed. Also, a couple of blank cassettes for record tests.

- Microwave Ovens - a cup of water for a load. You don't need special microwave approved water - tap water will do :-) A thermometer for power tests. Neon or incandescent bulbs with their leads shorted together can serve as microwave detectors inside the oven (though these may not always survive for very long).

- PCs and components - a working basic PC is useful to serve as a testbed for trying suspect components. I use an old 286 mainboard with just enough to boot from an old hard drive. A set of known working basic PC peripheral boards is useful - SA, IDE and MFM HD and FD controller, I/O ports, sound card and speakers, 5-1/4" and 3-1/2" floppy drives, etc. A spare power supply - even one that is not an exact mechanical match - is also handy for testing. An old laptop (commonly used as a door stop) is useful for testing printers on location.

- Computer Monitors - a test PC is useful as a video source. Of course, it will need to support whatever scan rates and video types the monitor is designed to accept. Programs are available to display purity, convergence, focus, color, and other test patterns.

- Telephones, answering machines, faxes - a phone line simulator is useful for initial tests. For many purposes, a DC power supply or battery and 600 ohm resistor will be all you need. A pair of normal phone lines will of course also work but you will need to provide jacks where you are working and access (which may be difficult with teens in the house).

Incredibly Handy Widgets(tm)

These are the little gadgets and homemade testers that are useful for many repair situations. Some of these can also be purchased if you are the lazy type. Here are just a few of the most basic:

- Series light bulb for current limiting during the testing of TV sets, monitors, switching power supplies, audio power amplifiers, etc. I built an outlet box with two outlets wired in series, switch, and indicator. A lamp or other load can be plugged into one outlet and the device under test into the other. Clearly label the special outlet box so you (or someone else) will not attempt to use it for other purposes!

  A typical schematic is shown below:

```
H o-------/ ---+-------+
       Power   |       | H     N
       Switch  /       +--|   |--+  Current limiting load
               \                 |
           47K /           o G   |
               \                 |
               |       +---------+
              +++      | H     N
         NE2H |o|      +--|   |--+  Device under test
        Power |o|                |
        Light +++          o G   |
               |           |     |
N o-----------+----------------+
                           |
G o------------------------+
```

Note: Ground connections normally not used for equipment likely to be tested using this device.

See the repair guides for specific equipment for more details on the use of the series light bulb.

- Capacitor discharge tool. This device provides a safe and low stress (for your spouse - no zap) way of discharging the capacitors found in TV sets, monitors, microwave ovens, electronic flash units, etc. An indicator can easily be built in as well to provide a visual confirmation as the voltage decays.

  Safety note: always double check that capacitors are fully discharged with a voltmeter before touching any high voltage terminals!

  See the document: Capacitor Testing, Safe Discharging and Other Related Information for additional information.

- Video cassette cheater. This is the shell of a VHS or Beta cassette with all of the innards removed and most of the top and bottom cut out to permit access to the reel spindles and other rotating components of a VCR during operation. You can also purchase these at grossly inflated prices.

  See the document: Notes on the Troubleshooting and Repair of Video Cassette Recorders for additional construction details.

- Degaussing coil. Make or buy. The internal degaussing coil salvaged from a defunct TV doubled over to half it original diameter to increase its strength in series with a 200 W light bulb for current limiting, (use the series light bulb widget for this), fuse, and momentary switch will work just fine.

  See the document: TV and Monitor CRT (Picture Tube) Information for additional information on CRT magnetization and degaussing techniques.

- Tape head demagnetizer. This could just be a coil wrapped around a common nail with its end protected with tape. Connect to low voltage AC. However, these are so inexpensive that you should just buy one.

  See the documents: "Notes on Troubleshooting and Repair of Audio Equipment and other Miscellaneous Stuff" and "Notes on Troubleshooting and Repair of Video Cassette Recorder (VCR)" for additional information on tape head demagnetizing.

  Caution: do not use a demagnetizer on video heads unless specifically designed for them. Some are strong enough to damage the fragile ferrite cores. Video heads generally do not require demagnetizing anyhow.

- IR detector. This can be a photodiode/LED circuit or IR sensitive card. Use for testing remote controls, IR LEDs in photosensors, and CD laserdiodes.

  See the document: Notes on the Troubleshooting and Repair of Hand Held Remote Controls for construction details.

- Flyback tester. I use a 12 V chopper with a 10 turn coil to excite the flyback under test. This will identify most primary and secondary short type faults under near-operating conditions.

  See the document: Testing of Flyback (LOPT) Transformers for additional information.

- High voltage probe for your multimeter. This will come in handy when testing the high voltage circuits of TVs, monitors, and microwave ovens (though extreme care will be needed, particularly with the latter). See the document: Simple High Voltage Probe Design for details on basic high voltage probes you can construct from (relatively) readily available parts. These will be satisfactory for DC voltages but compensation to get any kind of high frequency response can be tricky. However, that will handle most consumer electronics needs.

- Not-so-fantastic current probe. When diagnosing TV and monitor deflection problems, a current probe may be desirable to view the current waveforms in the yoke and flyback. You cannot view the high voltage signals without a high frequency high voltage probe.

  If you have a current probe for your scope, this can be used to monitor the various current waveforms. I have used my Tektronix current probe to view the yoke current on TVs. The rendition of the horizontal deflection current waveform is quite good. However, the vertical suffers from severe distortion due to the low frequency cutoff of this probe.

  You can build a not-very-fantastic (but quite usable) current probe using a split ferrite core of the type used on keyboard and monitor cables (preferably one that snaps together). The following will work:

  - Wrap seven turns of insulated wire around one half of the core.
  - Solder a 2.2 ohm resistor across the two leads to act as a load.
  - Connect to the vertical input of your scope via a coaxial cable or probe.

  You can experiment with the number of turns and load resistor value for best results.

To use your fabulous device, insert one and only one of the current carrying wires inside the ferrite core and clamp the two halves together.

For a typical TV horizontal deflection yoke, this results in about a .3 V p-p signal. The shape was similar to that from my (originally) expensive Tektronix current probe. Enjoy the show! Due to its uncompensated design, this simple probe will not work well for low frequency signals.

- Quick and dirty curve tracer. A curve tracer is useful for displaying the I-V characteristics of semiconductor and other devices. See the sections on curve tracer design in the document: Basic Testing of Semiconductor Devices.

  There is info on useful devices for your scope that you can construct in about 10 minutes. These won't replace a fancy Tek 576 but may be all you need (or at least can justify on a finite budget).

- Handy-dandy phone line tester. The inexpensive variety is just a pair of LEDs in series with a resistor for each line attached to an RJ11 connector. However, this is much more convenient than fumbling with a multimeter! You can buy one at Radio Shack (about $7) or easily build your own. See the document: Notes on the Troubleshooting and Repair of Audio Equipment and Other Miscellaneous Stuff, specifically the section: "Handy-dandy phone line tester" for details.

- High voltage diode and neon bulb tester. This is a line powered low current voltage doubler producing up to about 300 VDC to test (in conjunction with a Variac and multimeter) for reverse blocking of high voltage rectifiers, diodes, and ratings of high voltage zeners, neon and other small discharge lamp characteristics, and so forth.

  WARNING: Use an isolation transformer with this device since it is line connected without isolation. The maximum sustained (short circuit) current is only 4 or 5 mA but this is still enough to be dangerous so respect it even with the isolation transformer!

```
          C1                    D2
AC H o----||-------------+----|>|----+-----+----o +DC
         .2uF            |  1N4007   |     |
         250V      D1    |           |     /
              +---|>|---+       C2 _|_    \ R2
              | 1N4007         .5uF ---    / 5M
              |                400V  |     \
          R1  |                      |     |
AC N o---/\/\---+--------------------+-----+----o -DC
         3.3K
```

Cheater Cords

In the good old days, before VCRs, before most solid state TVs, before the Net, and before newsgroups, most electronic equipment had a sort of interlock to prevent operation when the cover was removed. Normally this consisted of the line cord plugging into the chassis via a plug fixed to the cover. Then, emoving the cover automatically disconnected power to the equipment. So, a cheater cord was needed for testing and had an AC plug at one end and this special plug at the other to bypass the interlock and allow you to get a shocking experience. :)

Exactly why this is no longer done except to save money isn't quite clear. Chassis of modern equipment like TVs, computer monitors, microwave ovens (especially microwave ovens) are very dangerous. Perhaps the manufacturers figure that at least for the first two, not using vacuum tubes, most of their voltages are lower. More likely, since they provide the warning "no user serviceable parts inside", they figure that they can't be sued and it is isn't worth spending the 10 cents for the extra plug. :)

Where your equipment actually has this sort of interlock, it is usually possible to pop off a retaining clip and use the original cord for this purpose. Just make sure you understand the safety issues. Modern devices may not have several hundred volts sprinkled all over the chassis like those using vacuum tubes, but there may be non-isolated line voltage, 25 kV or more for the CRT, or 5,000 V at AMPs in a microwave oven. You can be just as dead from these!

Monitoring Current Consumption from Batteries

When a problem develops in a battery powered deviced - it might be totally dead or drain batteries too quickly - it is desirable to be able to measure the current from the batteries. A simple way to do this is to construct a gadget that can be inserted between two cells or between a cell and the battery holder terminal so that a multimeter can be installed in series with the battery output.

(Portions from: Raydon Berry (rayberry@pt.lu).)

Take a small piece of stiff plastic (e.g., as used in blister packs) and attach strips of self adhesive copper or aluminum foil to both sides. Shape one end of the strip into a sort of finger, narrow enough to slip between the AA or AAA batteries or batteries and the contact when they are installed in the holder. If the foil is copper, wires can be soldered to each side at the other end. If aluminum, cut away a portion of the foil in opposite locations on both sides so clip leads from a multimeter can be attached without shorting.

This device is used (frequently by me) for checking the current consumption of all battery powered equipment - it's very simple and very cheap.

For example, with remote controls, insert between batteries and put the multimeter on a range of about 25 mA and when you press each button, the code being sent will show up as a wagging needle on a VOM or an average current for a DMM. If the ceramic filter or the IR diodes have failed, the current remains very low, but if OK, you should see pulses of 5 to 10 mA.

For other devices, select an appropriate range. It might not be a bad idea to check new/working equipment as well to obtain a "signature" of health which is recorded on a slip of paper glued inside the battery compartment. Then, if the device should fail, a comparison can easily be made.

Miscellaneous

- Clip leads. Like woodworking clamps, you can never have too many of these.

- Patch cords for audio, video, and telephone interconnection.

- Parallel (Centronics) printer, serial (breakout box desirable), other computer cables.

- Insulating sheets - for separating circuit boards when removed from the chassis. These can be cardboard, fiberglas, plastic, etc.

- Insulating sticks - for prodding to locate intermittents.

- Small parts tray and container. I always use a film canister or pill bottle for storing the screws, washers, and springs removed during disassembly. An icecube tray or egg carton makes a handy parts bin for temporary storage of small parts while you are working.

Making a Bench Power Supply from a PC Power Supply

The power supply from a long obsolete PC can be the basis for a low cost unit useful for a variety of design and troubleshooting applications. The typical 200 W PC power supply will provide +5 V at 20 A, +12 at 8 A, and low current -5 V and -12 V outputs. However, these are not that well filtered - at least not where low noise analog circuits are concerned. They are fine for digital and power circuits as is. For analog work, additional post regulation (e.g., LM317s) and filtering may be needed.

- Typical (but not always) color codes for PC power supplies:

  Red: +5, Yellow: +12, Black: Gnd (Probably case as well).
  White: -5, Blue: -12, Orange: Power_good (output).

  (Some newer supplies may have a +3.3 output as well which may be green).

- PC power supplies (as well as most other switchers) need a minimum load on +5 and possibly on +12 as well. An amp (e.g., 5 ohms on +5) should be enough.

  I use an old dual beam auto headlight. It adds a touch of class as well to an otherwise totally boring setup :-). You can also use auto tail light bulbs or suitable power resistors or old disk drives you don't really care about (you know, those boat anchors).

- There are no sense lines. There is a 'Power_Good' line which is an output from the power supply to the mainboard and can be ignored unless you want to connect it to an indicator to let you know all the outputs are within specs (it may need a pullup and I don't know its drive capability).

- Pinout for the standard PC and clone connector (some companies like Compaq do NOT use this type of connector, however.). Black (Gnd) wires together for the P8 and P9 connectors when installed to mainboard.

```
    J8: Pin 1 = Power_Good   J9: Pin 1 = Gnd
    Pin 2 = +5               Pin 2 = Gnd
```

```
Pin 3 = +12                 Pin 3 = -5
Pin 4 = -12                 Pin 4 = +5
Pin 5 = Gnd                 Pin 5 = +5
Pin 6 = Gnd                 Pin 6 = +5
```

Note: for an XT only, J8-Pin 1 is Gnd, J8-Pin 2 is no connect.

- The peripheral connectors are: Pin 1: +12, Pin 2 and 3: Gnd, Pin 4 = +5.

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Soldering and Desoldering Equipment and Techniques

Solder is Not Glue

The ease and quality of your work will depend both on proper soldering as well as desoldering (often called rework) equipment.

However, the purpose of solder is not to physically anchor connections - they must be mechanically secure first to assure reliability. When properly done, solder actually combines with the clean metal surface of the wires, pins, and terminals assuring a low resistance connection.

While there are several conditions must be satisfied to achiev good reliable solder connections, with a little practice, soldering will become essentially automatic and you will know immediately when the results are satisfactory.

There have been entire handbooks written on proper soldering technique. Organizations like NASA take this seriously - after all, a service call to the one of Jupiter's moons would be quite costly!

Aditional information on soldering techniques and equipment can be found at:

- The Basic Soldering Guide

CAUTION: You can easily turn a simple repair (e.g., bad solder connections) into an expensive mess if you use inappropriate soldering equipment and/or lack the soldering skills to go along with it. If in doubt, find someone else to do the soldering or at least practice, practice, practice, soldering and desoldering on a junk unit first!

Soldering Equipment

- A low wattage (25 W) iron for delicate components including discrete semiconductors, ICs, other small parts).

- A medium wattage (40-50W) iron for heavy duty circuit board work including power components, power plane connections, and large transformers).

- A 100-140 W soldering gun for chassis connections.

Three wire grounded soldering equipment is recommended but I do not consider it essential for this type of repair work. However, a temperature regulated soldering station is a really nice piece of equipment if you can afford it or happen on a really good deal.

I consider fine gauge rosin core solder (.030 or less) to be best for most applications (e.g., Ersin Multicore).

- Desoldering pump - SoldaPullit or similar 'solder sucker' for removing components easily and usually nondestructively. SolderWick is also handy for cleaning up desoldered connections.

A vacuum rework station is not needed unless you are removing your soldered in 500 pin Intel P6!

Soldering Techniques

Soldering is a skill that is handy to know for many types of construction and repair. For modern small appliances, it is less important than it once was as solderless connectors have virtually replaced solder for internal wiring.

However, there are times where soldering is more convenient. Use of the proper technique is critical to reliability and safety. A good solder connection is not just a bunch of wires and terminals with solder dribbled over them. When done correctly, the solder actually bonds to the surface of the metal (usually copper) parts.

Effective soldering is by no means difficult but some practice may be needed to perfect your technique.

The following guidelines will assure reliable solder joints:

- Only use rosin core solder (e.g., 60/40 tin/lead) for electronics work. A 1 pound spool will last a long time and costs about $10. Suggested diameter is .030 to .060 inches for appliances. The smaller size is preferred as it will be useful for other types of precision electronics repairs or construction as well. The rosin is used as a flux to clean the metal surface to assure a secure bond. NEVER use acid core solder or the stuff used to sweat copper pipes! The flux is corrosive and it is not possible to adequately clean up the connections afterward to remove all residue.

- Keep the tip of the soldering iron or gun clean and tinned. Buy tips that are permanently tinned - they are coated and will outlast countless normal copper tips. A quick wipe on a wet sponge when hot and a bit of solder and they will be as good as new for a long time. (These should never be filed or sanded).

- Make sure every part to be soldered - terminal, wire, component leads - is free of any surface film, insulation, or oxidation. Fine sandpaper or an Xacto knife may be used, for example, to clean the surfaces. The secret to a good solder joint is to make sure everything is perfectly clean and shiny and not depend on the flux alone to accomplish this. Just make sure the scrapings are cleared away so they don't cause short circuits.

- Start with a strong mechanical joint. Don't depend on the solder to hold the connection together. If possible, loop each wire or component lead through the hole in the terminal. If there is no hole, wrap them once around the terminal. Gently anchor them with a pair of needlenose pliers.

- Use a properly sized soldering iron or gun: 20-25 W iron for fine circuit board work; 25-50 W iron for general soldering of terminals and wires and power circuit boards; 100-200 W soldering gun for chassis and large area circuit planes. With a properly sized iron or gun, the task will be fast - 1 to 2 seconds for a typical connection - and will result in little or no damage to the circuit board, plastic switch housings, insulation, etc. Large soldering jobs will take longer but no more than 5 to 10 seconds for a large expanse of copper. If it is taking too long, your iron is undersized for the task, is dirty, or has not reached operating temperature. For appliance work there is no need for a fancy soldering station - a less than $10 soldering iron or $25 soldering gun as appropriate will be all that is required.

- Heat the parts to be soldered, not the solder. Touch the end of the solder to the parts, not the soldering iron or gun. Once the terminal, wires, or component leads are hot, the solder will flow via capillary action, fill all voids, and make a secure mechanical and electrical bond. Sometimes, applying a little from each side will more effectively reach all nooks and crannies.

- Don't overdo it. Only enough solder is needed to fill all voids. The resulting surface should be concave between the wires and terminal, not bulging with excess solder.

- Keep everything absolutely still for the few seconds it takes the solder to solidify. Otherwise, you will end up with a bad connection - what is called a 'cold solder joint'.

- A good solder connection will be quite shiny - not dull gray or granular. If your result is less than perfect reheat it and add a bit of new solder with flux to help it reflow.

Practice on some scrap wire and electronic parts. It should take you about 3 minutes to master the technique!

Desoldering Techniques

Occasionally, it will be necessary to remove solder - either excess or to replace wires or components. A variety of tools are available for this purpose. The one I recommend is a vacuum solder pump called 'SoldaPullet' (about $20). Cock the pump, heat the joint to be cleared, and press the trigger. Molten solder is sucked up into the barrel of the device leaving the terminal nearly free of solder. Then use a pair of needlenose pliers and a dental pick to gently free the wires or component.

For stubborn joints or those connecting to the power planes (surface or multilayer boards), you may need to add some fresh solder and/or flux and then try again. Generally, if you only get part of the solder off the first time, repeated attempts will fail unless you add some fresh solder.

Other approaches that may be used in place of or in addition to this: Solder Wick which is a copper braid that absorbs solder via capillary action; rubber bulb type solder pumps, and motor driven vacuum solder rework stations (pricey).

(Portions from: Pat Brunner (Brunner@ieee.org).)

I have used a SoldaPullet for 30 years but found an inexpensive improvement. Add a 1 inch length of silicone tubing (or something else that won't be damaged by the heat, 1/8" ID x 1/4"OD) over the SoldaPullet tip leaving 3/16" to 1/4" extending past the tip. This absorbs the downward force when the SoldaPullet is fired reducing damage to the PCB, provides a better seal around the component lead so it's often possible to clear a hole in one operation that might otherwise require several, and it prevents the plastic tip of the SoldaPullet from being damaged.

Nick's Comments on Successful Desoldering Techniques

These directly apply to the destructive (i.e., you don't care about saving the part) removal of IC chips. However, the basic techniques work for discrete parts as well.

(From: Nicholas Bodley (nbodley@tiac.net).)

A few points to keep in mind...

Try to get cutters that will let you snip individual leads on the IC. Get tool catalogs! I like Contact East, in the USA; not sure about Canada. Jensen, in Arizona, I think, tends to be costly.

If you snip all the leads on one side, you can bend the IC back and forth to break the other side free, but be sure to do the bending next to the plastic (it's harder to do there).

When you cut the IC leads, do your best to leave most of each lead sticking up above the surface of the board.

Set your iron to about 770 deg. F (400 deg. C). (This assumes a modern soldering station with a temperature control, and a relatively-slender tip.) Be sure that the tip is clean and shiny and properly tinned. Any oxidation is just no good. (DON'T file modern plated tips! You'll remove the plating!). Be fanatical about ensuring that the tip always idles with a decent coating of solder.

Hotter temps run a real risk of spoiling the adhesive bond that holds the copper foil to the board. DO NOT use a higher temp to make up for an improperly-tinned tip!! (You might need a higher temp for holes in the middle of ground planes, however. These will sink the heat away effectively; but do those separately.)

You must get each pad hot enough to be well above the melting point, so that the cold air won't make the solder resolidify when you slurp it up.

To transfer enough heat, you must have a fillet of solder between the tip and the pad. If necessary, add a bit of solder to ensure this!

After hitting these points so hard, I'll relax and say that you'll really do better if you remove each lead stub individually with assembly tweezers (AA style are good) or thin needle-nose pliers.

Once they're all out, then you need to be concerned about heating the pads enough. Now you can desolder. The other messages in this post have good advice on that.

You need to maintain your desoldering tool, too. It might not have good vacuum if ignored.

It's tricky to hold the iron on the pad while getting the nozzle close enough, but a decent desoldering tool will work if tilted somewhat to let the tip contact the pad.

If a hole doesn't open, but some solder has been slurped up, you could try good solder wick (Solder-Wick (Soder-Wik?) brand is good); it can sometimes pull up solder from underneath by capillary action. (I didn't believe this until it happened!) Poor solder wick isn't fluxed sufficiently, or might be subtly corroded. It should soak up solder like a sponge.

It might be quicker to refill the hole with a bit of solder and repeat; there could be a good blob of it on the other side, which you might, or might not, be able to get to.

(If you can get to both sides, and have five hands, you could apply heat to one side, let the tip dwell for a few seconds to melt all the solder, and slurp from the other side.)

If things become messy, apply liquid flux (seems not to be too easy to find in small quantities; I use a flux pen, which seems not overpriced). Reheat the pad, and the flux should do a great job of tidying things up. It tends to let capillary action make the holes open wider, when most of the solder has been picked up.

I think it's well worth the effort to cut the leads free from the IC body and remove them one at a time, then go over the pads a second time to remove the solder.

I have very recently removed a 16-pin DIP twice from a location without damaging the pads at all by these principles.

It's much harder, or impossible, to do good work with poor tools. Do try to get good tools, and learn to take care of them.

Soldering Pins in Plastic Connectors

The thermoplastic used to mold many common cheap connectors softens or melts at relatively low temperatures. This can result in the pins popping out or shifting position (even shorting) as you attempt to solder to them to replace a bad connection, for example.

One approach that works in some cases is to use the mating socket to stabilize the pins so they remain in position as you solder. The plastic will still melt - not as much if you use an adequately sized iron since the socket will act as a heat sink - but will not move.

An important consideration is using the proper soldering iron. In some cases, a larger iron is better - you get in and out more quickly without heating up everything in the neighborhood.

Comments on Repairing Damage to Printed Circuit Boards

Two common problems are discussed here: damaged traces and damage from overheated components.

- Traces may be damaged due to poor soldering or desoldering techniques or by acting as fuses due to short circuits. Where there is just a gap in a trace, it may be possible to scrape off any protective coating (the solder mask) and then soldering a bare jumper wire to bridge the gap. DO NOT just put a blob of solder there - it won't last. However, it is often better to remove the remains of the trace entirely and solder a wire between the two end-points.

- When components overheat, they can also damage the PCB material underneath them. If the PCB is just slightly discolored, then probably it can be cleaned up and reused. This will often happen under hot components even with properly functioning equipment after many years of operation and doesn't cause problems.

  But if there is actual damage to the board material itself, then the carbon that is present and can't be removed will result in a conductive path which may result in circuit failure or erratic behavior. It would be best to replace the entire PCB if possible. But a more realistic alternative is to cut out the bad section and build the missing circuitry on a separate prototyping board.

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Supplies and Parts

Lubricants, Cleaning Agents, and Other Liquidy or Slimy Stuff

- Light oil such as electric motor oil or 3-In-One. WD40 may be useful for cleaning or freeing rusted screws but it is not a general purpose lubricant despite what is claimed on the label.

- Light grease suitable for fine electronics - must be plastic-safe.

- Isopropyl alcohol (91 % medicinal or better preferred though rubbing alcohol (70 percent) can be used in a pinch as long as it doesn't contain any additives).

  - Q-tip swabs (you may know them as cotton buds) for cleaning of everything BUT the video heads on VCRs and other helical scan tape transports.

  - Chamois covered head cleaning sticks for video heads.

  Note that sometimes plain water will work better for sugar based coatings. Tape head cleaner can be used for head cleaning as well.

- Contact cleaner in spray can. This is used for switches and relays.

- Control cleaner in spray can. This is used for potentiometers and will probably include some type of non-drying lubricant.

- Tuner cleaner and lubricant in spray can. The stuff sold by Radio Shack works fine.

- Degreaser in spray can. Use with care around plastics.

* WD40 in spray can. NOT for lubrication in most cases. However, WD40 is an intermediate strength solvent that comes in handy for cleaning, removing labels and label goo, coating tools to prevent rust, etc.

* Liquid flux for helping in tough soldering and desoldering jobs.

* Flux remover. Isopropyl alcohol will work but there are also spray cans of this stuff.

* Silicone heat sink compound. A little goes a long way. You don't need to goop it on - just the thinnest film to fill voids. Here are some numbers:

  (From: Asimov.)

  Thermal resistance (°C/W) for silicone heatsink compound:

```
 Insulator           Without   With
------------------------------------
 None                  0.20     0.10
 Anodized Aluminum     0.40     0.35
 Mica                  0.80     0.40
 Teflon                1.45     0.80
```

Note that using no insulator is always better than one with heatsink compound for these materials (no data on BeO which may be the exception).

(From: Gavin Parrish (the_big_geez@ameritech.net).)

Kano Labs makes a number of exceptional products which are only available directly through them. They are not cheap, but all that I have tried have met or exceeded my expectations. Their premier product is "KROIL" a penetrating oil that breaches a space as small as one millionth inch. No fooling! Throw away that WD whatever-its-called stuff. If it's stuck, this will unstick it.

While they have a lot of really big industrial customers, they give attentive service even if you only buy 1 can. The only drawback is they keep sending you somewhat amusing flyers every month or so. You already get a lot of this so it's no big deal.

For info or ordering contact: (what? no URL?!): Kano Laboratories, 1000 Thompson Ln., Nashville, TN 37211-2627. Phone: 1-615-833-4101, Fax: 1-615-833-5790.

(The above is not a paid promotion, merely data I hope you find useful.)

(From: Rich Grise (richardgrise@yahoo.com).)

Which solvent to use depends on what you're trying to dissolve. For a something like a cruddy motor, I'd try, in order from least aggressive up:

1. Isopropyl alcohol - good on most oils and greases, fairly innocuous chemically.

2. Ethyl alcohol - as good a solvent, or better than isopropyl, but much too valuable as a beverage.

3. Methyl alcohol - don't even touch this crap - if you even just get it on bare skin, it can blind you. (Actually, this is an extreme position, methyl alcohol is mainly dangerous if ingested. --- Sam.)

4. Naphtha (lighter fluid) - the only solvent I've ever seen that can get chewing gum out of your hair. Not too good on aliphatic greases, however.

5. Mineral spirits or turpentine - still flammable, makes good paint thinner, but seems to leave a greasy residue when used for cleaning.

6. Toluene/xylene - excellent cleaner, but it could attack the insulation on the windings. Breathing the fumes can cause a sort of intoxication that I think isn't very good for you.

7. Acetone/MEK - MEK is less volatile, but still quite aggressive. Very flammable, but evaporates completely without residue. Acetone is the only thing I've ever seen that can dissolve acrylic plastics like Plexiglas.

The chlorinated/fluorinated solvents sit somewhere in the middle of the range - someone else pointed out the difference between trichloroethylene and trichloroethane; I guess TCA is much friendlier than TCE - but we used them in the Airforce to clean up hydraulic fluids that nothing else would even touch.

I've heard that Vaseline makes a superb lubricant for bike bearings; it also makes a reasonable vacuum seal, and it's incredibly tenacious - one day, I used it on a gasket, and when I needed to make a change, I couldn't find anything in the shop that would clean it up completely.

Don't use WD-40 as a cleaner; it gums everything up. I inherited an old Baudot teletype once and thought I'd clean it with a WD-40 spray. HAH! Spent the next week disassembling the thing and cleaning all the gunk off the intricate little parts with TCA or something. WD-40 is good for door hinges.

Carburetor cleaner is a mixture of solvents in a spray can which may include acetone, toluene and methanol but it's extremely flammable and it seems to wash greasy dirt away as if it weren't even there.

Adhesives

- Two part Epoxy. Epoxy is one of the strongest and most versatile all around adhesive and bonds well to most materials except some plastics. I recommend separate tubes, not the combined syringe type. With tubes, it's much easier to get exactly what is needed. The syringes invariably dispense about 10 times the desired quantity and then last for only a few uses.

    - Fast curing (5 minute) Epoxy is most convenient for quick repairs but may not be as strong as the slow curing (1/2 to 1 hour) type.

    - It is generally easier to do a neat job with clear Epoxy but white or metal types work as well.

    - Conductive (silver filled) Epoxy may be useful for repairing printed circuit board traces and remote control pads but is no substitute for metal wires.

    - There is also special Epoxy for plastics which may form a stronger bond to certain types of plastics than normal Epoxy.

- Industrial quality cyanoacrylate like Loctite 401. The common types (Crazyglue, Superglue) work but stick to everything you don't want stuck together and the tubes never seem to keep the unused portion in decent condition. Loctite 401 comes in a nice bottle with applicator and proper recloseable top. This is probably best for instant repairs.

- General purpose adhesive like Duco Cement.

- Semi-flexible adhesive like windshield sealer.

- Flexible adhesive like weather strip cement or silicone sealer or RTV. Note: some types may be corrosive to metals upon curing - test first. One example of a suitable product would be Dow Corning #736 RTV though I don't know first hand if it is acid-free.

- Solvent type plastic cement or plastic model cement.

- Rubber cement.

- Plastic electrical tape.

- Masking tape.

- Clear plastic tape.

Electronic Sealers and Potting Compounds

These may be needed to insulate a high voltage connection or to encapsulate a circuit for reliability (or to keep it from prying eyes!).

Ordinary silicone window and bathtub caulk has the right mechanical and electrical properties (tough, flexible, excellent insulator especially for high voltage), but it secretes acetic acid upon curing and this may damage the electronic circuitry (but not always the case). Some types claim to be safe for this or that (e.g., aluminum) but unless it states specifically that it is safe for electronics, use at your own risk.

(From: Ralph L. (ralphl@keycomp.net).)

You can also use an RTV that is safe for oxygen sensors that are used on most computer controlled cars. It does not produce that acetic acid (vinegar smell) during the curing process and will not harm electronics.

(From: Greg Szekeres (gjs@prophet.pharm.pitt.edu).)

Yes, Permatex Ultra Blue is safe, available at most auto parts stores. I have also been using polyurethane instead of silicone, although is has problems with some materials.

(From: RadMan (radcom@comnet.ca)).

Some agents require UV to cure, some need heat. You can also try Miller-Stevensen 907 available at Future/Active, and it pots with a heat gun very fast (30 minutess).

(From: Bob Wilson (rfwilson@intergate.bc.ca).)

Dexter makes Hysol Epoxy which is a potting compound that totally encapsulates the circuits. There are easily available commercial coloring compounds intended for this purpose, and are available from the supplier of the Epoxy. An alternative is to mix some laser copier toner (dry powder) with the epoxy if making it opaque is desired.

Mind you, all that potting does as a means of security, is to keep he amateurs out. Depotting an electronic assembly is pretty easy. All that is needed is judicious application of a small welding torch flame to locally heat the epoxy above its glass temperature (whereupon it becomes rather "crunchy" and easy to remove), and a little patience.

(From: Brian Symons (brians@mackay.net.au).)

The products normally safe to use are labeled "neutral cure" or at least they are here in Australia.

Any acid cure product is certainly dangerous around electronics. I cam across some PCB's that had had the wires glued in place by a run of acid cure silastic across the board.

When looking for the fault, I peeled up the silastic and found every track under the silastic was completely eaten away.

BTW. Over here, It is quite common for ovens to have a from glass viewing window that is glued in position with a silastic material that can handle the high temps.

When a warrantee guy ordered in a tube of the silastic, they supplied a tube of the silastic that is available here at car parts suppliers and service stations to repair windscreen seals. They were only charging about eight times the price though. This silastic is a black product. I have used it successfully for oven glass repairs for several years.

Electronic Parts

I was going to attempt to make a basic list of recommended parts but this quickly got out of hand. The list below is just a start. The idea is to have enough parts available so that you do not need to raid the local electronics store every time you want to try something.

A good source for many of the basic parts is dead equipment - their organs can live on at your workbench. Parts like small resistors are so inexpensive that this doesn't warrant a lot of time. However, power resistors, potentiometers, power semiconductors, some ICs, etc. are well worth saving. Used electrolytic capacitors will generally still be functional but these do deteriorate with time and heat so testing them first and avoiding the use of really old ones for the permanent repair is probably wise. The majority of my parts inventory is from salvage. Think of them as 'pre-owned burned in components' :-).

- Resistor assortment. A variety of resistor packs for digital termination.
- Potentiometers (variable resistors), assorted values.
- Capacitor assortment - ceramic and electrolytic. Large high voltage electrolytics for power supplies.
- Rectifiers - 1N4007s for primaries of power supplies. Microwave oven rectifier. Fast recovery rectifiers - for switching supplies.
- Diodes - 1N4148 signal diodes.
- Transistors (bipolar): small signal, medium power, high power audio, and horizontal output transistors. Obviously, this list could get quite long. A few basic types will suffice in a pinch.
- Fuses - 3AG size (1-1/4"x1/4") - .5, 1, 2, 3, 5, 10 amp. You can always solder these across the smaller 5x20 mm fuses often found in consumer equipment these days.
- LEDs and indicator lamps.
- Wire: assorted colors of #24, #18, and #14 stranded and solid insulated wire. 75 ohm coax for video. Shielded cable for audio. Fine wire (e.g., #30, bare and insulated) for PCB repairs.
- Assorted small switches - toggle, pushbutton, etc.
- Line cords, plugs, and other electrical components.
- Lamp sockets, single and three-way switch/sockets, plugs, etc. for small appliance repair.
- Various jacks and plugs such as RCA, phono, F, BNC, etc.
- Small loudspeakers, headphones.
- etc., etc., etc.

Mechanical Parts

- Hardware assortment including English machine screws and nuts, Metric machine screws (mostly for replacement use, and Metric nuts are rare), and flat and lock washers.

- Plastic split washer assortment. Despite dire warnings to the contrary, these can often be reused. However, they are easily lost.
- E-clip and C-clip assortment. These can be reused but very often go 'pling' into never-never land when removed.
- Spring assortment.
- Several thicknesses of steel wire.
- Various bits of plastic, wood, and metal to fabricate splints or other emergency repairs.
- Dial cord material.

Plastic Parts Repair

When a little plastic part breaks, repair can be a time consuming, frustrating, and ultimately futile task unless the failure was from abuse. The reason is that when a part breaks under normal operating conditions, the plastic gives way at the areas of maximum stress. Simply gluing the part won't work because the strength after the repair will probably not be as great as it was originally even if the proper adhesive is used.

Note that there are quite a variety of what we call "plastics". An adhesive that bonds with extreme strength to one may not even stick at all to another. (Nylon and polyethylene are difficult to glue; styrene is easy.) This is especially true of the 'welding' adhesives like MEK.

However, using the most appropriate glue can make a very significant difference:

- MEK (Methyl Ethyl Ketone) is the stuff in plastic solvent used for 'welding' styrenes. This results in a truly adequate repair only under very special conditions (which I've yet to encounter).
- Plastic model cement contains allyl Isothiocyanate (oil of mustard, huh?), and is good for styrene and acrylic plastics. Not recommended for polyethylene or phenolic plastics or for styrofoam (which it will eat).
- Duco Cement(tm) and similar all purpose glues are decent for many plastics including phenolics. Windshield sealer is similar but results in a semi-flexible repair.
- Tenex 7R is recommended for joining dissimilar plastics.
- SuperGlue(tm) and its clones (Cyano-acrylics) are only good on some plastics and only where the fracture is clean with a perfect fit upon reassembly. However, they are excellent for sticking thumbs to foreheads. :)

WARNING: The vapors from all of these adhesives are harmful to health if inhaled. Work only in a well ventilated area.

CAUTION: Spills from some of these will also damage paint and other plastic surfaces (including eyegless lenses!) even if wiped up immediately.

- RTV Silicon works well on a variety of plastics where a flexible repair is acceptable.
- Epoxies, wood glues, white Elmers glue, and library paste :) in general **do not** work well for plastics.

Where possible, I add reinforcement to plastic parts - either with plastic or metal. Or, fabricate all metal replacements. I've heard of people successfully adding bits of metal to replace plastic gear teeth. I have several clock radios with a mechanical clock where the little plastic pin in the number changing mechanism invariably broke after 5 years or so on all similar models. I replace them with a piece of steel wire (from a large paper clip) glued in place. This repair has worked for over 20 years. I bet the manufacturer saved a fraction of cent on each unit though! And, when someone forebly removed a paper jam on an HP DJ1000 printer and broke several pressure roller spring levers, stiff steel wire came to the rescue once again.

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Sources of Information and General Comments

This set of sections deals with ways of locating general electronics repair information as well as problem specific specifications, datasheets, manuals, and tech-tips. Since we first presented this set of topics several years ago, there have been two major trends which are worth noting, one good, one bad:

- The Internet, specifically the World Wide Web, has become THE preferred avenue for obtaining device datasheets and related information. While it may still be possible to obtain printed databooks, the convenience of typing in the part number to a search engine like Google and having its datasheet link appear almost instantly as one of the top 3 results cannot be overemphasized. This applies to virtually any widely used commercial discrete semiconductor or IC. Unfortunately, those with "house numbers" and more specialized ICs found in consumer electronics will probably not yield with this ease.

  For those of you without Web access at home or work, this may not sound like good news. However, libraries and other institutions are increasingly providing this service, and one can't hide from the future forever!

- The number and type of equipment that can be effectively and economically repaired is dwindling. VCRs, CD and DVD players, cell phones, pagers, and much other newer equipment is simply not designed to be repaired by anyone but the authorized service company - or not at all. Much A/V equipment is constructed so cheaply that it's lucky to last the warranty period. Compact high-tech devices are put together using surface-mount technology (SMT) and ICs that simply cannot be identified so anything beyond an obvious bad connection probably means it is junk. Absolutely NO service information is available in any form and the manufacturer, assuming they can be identified, couldn't care less about helping.

  PCs have been of this type for many years where anything beyond swapping modules is probably a futile exercise. Well, guess what? Devices lie digital set-top boxes, digital video recorders, video game consoles, and digital flat-screen TVs can be added to this list. Except, that they aren't going to use anything resembling standard modules like PCs still do to some extent. So, forget about achieving any significant success rate repairing this and similar equipment.

References

Each of the repair guides in the "Notes on the Troubleshooting and Repair of" series includes a list of relevant links and books on the technology and servicing. Also check out:

- Electronic Troubleshooting
  Don Matsuda, 1992
  ISBN 0-13-248055-7

Manufacturer's Service Literature

Service manuals are still available for a great deal of consumer electronics. Once you have exhausted the obvious possibilities or mechanical problems, the cost may be well worth it. Depending on the type of equipment, these can range in price from $10 to 50 or more. Some are more useful than others. However, not all include the schematics so if you are hoping to repair an electronic problem try to check before buying.

Identifying OEM Manufacturer - FCC Numbers

Only a few manufacturers actually produce the vast majority of consumer electronic equipment. For example, Radio Shack, Magnavox, and Emerson do not make their own VCRs (I can tell you are not really surprised!). House brands are nearly always the products of well known manufacturers identical or very nearly identical to their standard models but repackaged or at least relabeled to reflect the store chain's name and logo. This is one reason why such lower cost products may be a good deal (but not always).

How do you determine the actual manufacturer? For most types of consumer electronic equipment, there is something called an 'FCC ID' or 'FCC number'. Any type of equipment that may produce RF interference or be affected by this is required to be registered with the FCC. This number can be used to identify the actual manufacturer of the equipment.

A cross reference and other links can be found at:

- FCC ID Numbers Cross Reference

Sams' Photofacts

Sams' (no relation) is Sams Technical Publishing (formerly Howard Sams & Company) who publishes circuit diagrams and service info for just about every TV sold on this planet since the 1940s.

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5436 W. 78th St.
Indianapolis, IN 46268-3910
Phone: 1-800-428-SAMS
Fax: 1-800-552-3910
Email customercare1@samswebsite.com or customercare2@samswebsite.com
Web: http://www.samswebsite.com/

You can search the Web site to determine if they have a folder for your model. Service info (EFacts) for most models manufactured after 1992 is available in electronic form (currently) about $11. These are similar to the print PhotoFacts but may be ordered on-line and will arrive via email within 1 business day.

These folders of service information have been published for over 45 years (I don't know for how long but I have a set for a 1949 portable 3 inch Pilot TV - about as portable as an office typewriter if you remember what one of those was like) and are generally the best most consistent source of service info for TVs, radios, some VCRs and other consumer electronics. There are some Computerfacts but the number of these is very limited. The VCRfacts are also somewhat limited and the newer ones tend to have strictly mechanical information.

Even if they don't list your model, they may have a folder for one using the same chassis so search by chassis number as well. Even if this doesn't help, there still may be a folder for models that are similar enough to be of value (though you really have to be in the library to be able to determine this by looking at the circuit diagrams or photos) so check out folders for other model numbers that are close to the one you really want.

Sams' Photofacts are often available (for photocopy costs) from you local large public library which may subscribe to the complete series. If not, a large electronic distributor can order the selected folder for you.

One advantage of the Sams' info is that it is compiled in a very consistent format so that once you are familiar with one model TV, it is easy to transfer that knowledge to any other. They provide waveforms at key locations and DC voltage measurements almost everywhere. Additional info such as IC pin to ground and coil resistances are often provided as well. The manufacturer's service manuals are generally not nearly as complete.

Note: I have heard that some of the Photofacts recently purchased directly from Sams Technical Publishing/Howard Sams have been poor photocopies with illegible scope waveforms rather than original printings. If this is the case, it is truly the end of an era and too bad. In any case, try to confirm the quality before you buy or get your info from the library.

Inside Cover of the Equipment

Television sets and even old radio often have some kind of circuit diagram pasted inside the back cover. In the old days, this was a complete schematic. Now, if one exists at all, it just shows part numbers and location for key components, occasionally some test points and voltages - still very useful. Some TVs - as late as 10 years ago, maybe even now - included a complete schematic with the product information and owner's manual. I have a 1984 Mitsubishi which came with a very nice high quality multi-page schematic. However, this is the very occasional exception rather than the rule anymore for A/V equipment.

Microwave ovens do almost always have a schematic diagram of the microwave power generation circuitry pasted inside the sheetmetal cover. This will generally include at least the high voltage transformer, interlocks, rectifier, capacitor, and magnetron. Since most microwave oven problems are in these areas, this is all you are likely to need. The controller, especially electronic units, is often omitted or only covered superficially.

Additional Sources for Service Information and Manuals

Where service information on your equipment isn't available as a Sams' Photofact (or even if it is), NAP is another possibility. They aren't that expensive, Maybe $25 for a set of 6 microfiches (well, you can't have everything!) that covers a variety of models including the one you are specifically interested. NAP's phone number for parts is 1-800-851-8885. They will look up your model in their database and identify the microfiche set(s).

As of Winter, 2002, I have confirmed that all the following Web sites for manuals and schematics are active. However, I have NOT checked email or snail mail addresses. Note that since these sorts of sites come and go, I'd advise downloading and archiving whatever you might possibly need when you find them - don't just save the links. You may be sorry later!

Listed in more or less alphabetical order:

- AA4DF Test Equipment/Consumer Electronics/Other Service Manuals
- Anatekcorp
- Braun service manuals (Courtesy of The Mending Shed).
- Bomarc Services (Reverse engineered schematics)
- Consolidated Surplus (Test equipment service, calibration, and user manual sales and rentals)
- Cooke International (Test Equipment Manuals)
- Datasouth Services, Inc. (Free test equipment manual downloads but requires signup)
- Diverse Devices (UK) (Manuals for test equipment, consumer electronics, etc.)
- David DiGiacomo's Test Equipment Manuals Trading List (Many popular models)
- Eagan Technical Services (Reverse engineered schematics)
- Electronicsrepair.Net (Schematics, some reference info, a few free tips)
- Electronictrader (Australia - Loans of test and other electronic equipment manuals)
- Electronix (Some TV, VCR, monitor schematics)
- Harman-Karden (Manuals for Out-of-Warranty products only may be available if you ask)
- Hitachi Service Manauls (Requires registration but should be free)
- Mark Hughes Copies of Vintage Manuals/Schematics/Catalogs
- EServiceInfo.com Schematics, Datasheets, and Service Manuals Exchange (Growing collection of free info, requires registration)
- Infotronix (Hard to find and out of print manuals, schematics, and other information)
- K4XL's Boat Anchor Manual Archive (Tube and test equipment manuals)
- KDTV (Service manuals)
- Manuals 4 You (User and service manuals on CD or for download)
- Manual Man (Vintage manuals for amateur, audio, and radio-related equipment)
- Manual Merchant (Test equipment manuals)
- Manuals Plus (Test equipment manuals)
- Manufacturer's Service Manuals
- Mauritron Technical Services (UK) (Manuals, publications, CDROMs)

- William E. Miller (Used Sams' Photofact TV repair manuals)
- GetManual.com (Consumer and professional eqiupment user and service manuals)
- Microtech - John Gallawa (Microwave oven manuals)
- Monitorss' Monitor Schematics and Links Page
- Monitory (Monitor schematics, change "s" in "s.htm" to appropriate your monitor)
- NAP, 1-800-851-8885 (Alternative to Sams)
- Panasonic Manuals (Probably mostly non-USA models though)
- Pepper Systems, 1-214-353-0257
- Ramond Sarrio Co. (Amateur radio equipment manuals)
- SBC Manual and Schematics Downloads
- SBC Manual and Schematics Downloads Mirror Site
- Schematics for Free (Various consumer electronics and test equipment schematics for download)
- Sears Parts (Includes exploded diagrams and other info for Sears appliances, power tools, and electronics)
- Sencore Service Page (Includes some Sencore test equipment schematics)
- ServiceManuals.Net (Consumer electronics service manuals)
- Simpson Electric Manuals (Simpson test equipment manuals)
- Synergetics Surplus, 1-520-428-4073
- A. G. Tannenbaum (Parts and service Data, 1920s to the present)
- TekNet Electronics (Downloadable test equipment manuals)
- Tech Systems, 1-800-435-1516
- Tektronics PDF Service Manuals (Manuals for most popular scopes on CD or via download)
- Tom's Service Manuals on CD (Operation and service manuals for Tektronix, HP, and other test equipment)
- Treasure Chest Corporation (Owner's and service manuals for many brands)
- Triplanetary Diagrams
- Michelle Troutman (Sams' Photofacts and service manuals for older equipment, more)
- Vinyl Engine (Turntable manuals and other info)
- US Surplus, 1-410-750-1083
- W7FG Vintage Manuals (Manuals for ham radio and test equipment)
- Wizards Electronic Repair Center (Over 85,000 manuals)
- W.J. Ford Surplus Enterprises (Test equipment manuals)

For Heathkit manuals specifically:

- The Heathkit Virtual Museum
- Heathkit Downloads

- DP's Heathkit Manuals

- Ed Mosher
921 Wisconsin Ave.
St. Joseph, MI 49085

(From: William E. Miller (eagle@trader.com).)

Besides the used Sams TV Repair Manuals I sell, here are a few good sources for various flavors of service manuals.

- A.G. Tannenbaum
  Electronic Service Data
  P.O. Box 386, Ambler, PA 19002
  Phone: (215) 540-8055
  Fax: (215) 540-8327
  E-Mail: k2bn@agtannenbaum.com
  Web: http://www.agtannenbaum.com/

  "Parts and Service Data, 1920s to the present". Lotsa stuff!

- Michelle Troutman
  47 No. Bain Street, Brewer, ME 04412-2007
  Email: mtroutm@michelletroutman.com
  Web: http://www.michelletroutman.com/

  Sams Photofacts and service manuals for older TVs, stereos, and radios, as well as test equipment, vacuum tubes, electronics books, and magazines.

  (From: Mike Kaufman (makaufman@jps.net).)

  > "This is an excellent source for very reasonably priced repair manuals, especially out-of-date manuals,. Michelle's prices are on the order of $2.50 per manual plus $1.50 shipping - hard to beat."

- Marty Gasman
  Email: mgasman@tiac.net
  Web: http://www.tiac.net/users/mgasman

  He has a LOT of AUDIO service manuals for sale. Check his full list at his web site.

- Microtech - John Gallawa
  Email: microtech@gallawa.com
  Web: http://www.gallawa.com/microtech/

  "We will be happy to help anyone who needs a schematic or parts breakdown for virtually any make and model (commercial or residential) microwave oven."

- Mauritron Technical Services
  Phone: 01844-351694
  Email: mauritron@dial.pipex.com Web: http://dialspace.dial.pipex.com/mauritron/

  "Suppliers of Technical Books and Servicing Information to the television, video and computer repair trade"

- Manuals sometimes turn up at auctions - on-line (e.g., eBay) and others, as well as estate sales and the like, though these would hardly be regarded as a way of finding exactly what you want!

The U.S. Military has an extensive library of test equipment and related manuals, some of which are in the public domain:

(From: Dino (kl0s@cox.net).)

Go to: U.S. Army Logistics Support Activity. Select "Publications and Forms" which should get you to LOGSA Publications and Forums. Then select "Electronic Technical Manuals Online" which will roll you down to "Go to Electronic Technical Manuals Online". Click on this link which takes you to http://www.logsa.army.mil/etms/online.htm. If you accept their terms, click on "I accept" which takes you to http://www.logsa.army.mil/etms/welcom1.htm Choose "Enter the Site" [Note the disclaimer that you have to login if accessing anything but public release manuals and that you have to have 128 bit encryption engaged. That should bring you to: http://www.logsa.army.mil/etms/find_etm.cfm. which is the search page; click on "TM Title Text" and enter, for example, "Tektronix" and scroll down to hit "Search" which should get you to: http://www.logsa.army.mil/etms/show_etm.cfm where if you scroll down and look CAREFULLY you'll find lots of material in .PDF format which you can then download.

You may have to go through this entire process to establish the fact that you accept their terms. There's probably a cookie in my system that lets me go straight to the search page. I've found a number of good references here for text equipment.

Canadian Schematics Source

(From: John R. Hepburn (jhepburn@recorder.ca).)

I use a source in Canada for cheap schematics. I have to mention that they have limited coverage in the last while due to some O.E.M. holdbacks. There is nothing at all on monitors. It is:

- R.C.C. (Radio College of Canada)
  Lewcor Communications
  Phone: 1-416-971-4170
  Fax: 1-416-971-4173
  Email: lewcor@hookup.net

What they do cover is inexpensive, typically 5 schematics + data in one $19.50 manual ($14.00 U.S.). An example, I just received a manual the other day that I ordered to service a Sony VCR. It contained the following.

1. Citizen TV model JCTV-0204/JCTV-3097
2. Citizen VCR model JVHS-3931
3. Hitachi TV model CY07 C#G9LXU1M
4. Hitachi VCR model VT-M262A

5. Sony VCR models SLV-340/380/440/441

I suggest ordering their master index. They have 2 of them, pre-1973 and 1973 to present. You will need it for crossing anyway and it will give you a better idea what value their resources will be to you. Cost for an index is $5.00 (Can).

Reverse Engineered Schematics

A number of companies are in the business of generating schematics either from samples of the equipment or by 'other means' (which we won't go into). One such company that claims to have over 3,000 such schematics is:

- Bomarc Services
  P.O. Box 1113 Casper, Wyoming 82602
  Phone: 307-234-3488
  Email: rollo@trib.com
  Web: http://w3.trib.com/~rollo/bomcat.htm

I have no idea of their cost, reliability, quality, or accuracy but this type of source may be worth checking if you are desperate! One risk is that he wants $5 for catalogs of at most 3 categories from the following before you can order: audio, auto/air/marine, computer, detection, industrial, lighting, medical, phone, power supplies, radar, radio, security, tape/disk, telemetry, television, test equipment, time, toys & games, video, potpourri (misc).

Here is another company which has some reverse engineered schematics:

- Eagan Technical Services
  408 Northland Drive #304
  Mendota Heights, MN 55120
  Phone: 1-651-688-0098
  Web: http://www.eagantech.com/
  Email: dcarlson@eagantech.com

They have some PS/2 and other PC and monitor related schematics but not nearly the selections it would seem as Bomarc, above. I do not know anything more about this company.

Reverse Engineering Your Own Schematics

Of course, most of us have had need to reverse engineer equipment. This is probably not realistic for a multilayer PC mainboard. But for even something as complex as a TV or computer monitor, it may not be that difficult - and in some cases, the only option. I generally do this by going component by component and determining all connections to each one. The initial drawing will be a total mess - a spaghetti diagram. :) Once the wiring has been determined, I redraw the circuit (you've seen enough of them in these pages!). Everyone who does this more than once probably has their favorite technique to make the task easier.

(From: Jeff Zurkow (jeff@atrox.com).)

Here's a trick I'm using for reverse engineering: Put the board on a color photocopier, set the copier for "mirror image", and make a copy. This gets you a top view of the underside, as if the board were transparent. You can tape a piece of drafting mylar over the copy, and draw in the topside components and traces with colored pencils. In fact, I sometimes use multiple mylars: top traces on one, components on another, component values on a third, and a final one on which I check off components and solder joints as I draw them on the schematic. It helps to have a light box :)

The layered drawing can also serve as a component-location key for future troubleshooting. Just assign new component identifiers (the ones silk-screened on the board are often obscured by the components), and draw them in on both the mylar and the schematic. Makes it real easy go from the schematic back to the circuit board.

Mark's Approach to Finding Information

The first skill you need when you want to design something is digging up the databooks. This applies to troubleshooting and repair as well. A well stocked literature shelf (f cabinet) is an invaluable time saver. Don't assume you can get EVERYTHING on the net just yet!

Take the lowly 2N3055 power transistor, for example.... (Most of us have its specs engraved on some radiation-hardened neurons safely tucked away in a forgotten part of our brains but for the freshly minted EE or technician....

(From: Mark Zenier (mzenier@netcom.com).)

Places to look:

The web, at sites for companies that make power transistors.

Good bets would be Motorola (http://www.motorola.com/), Philips (http://www.semiconductors.philips.com/) Note: only 1 'L' in Philips, and SGS-Thomson (http://www.st.com/). (A whole bunch more people make 2N3055s, down to some little 50 employee companies that you've never heard of, but they may not have a web site yet). Or start with one of the web directories like http://www.xs4all.nl/~ganswijk/chipdir or Grey Creagers pages on http://www.scruznet.com/~gcreager. (Hope I got my spelling right on all those URLs).

The sales rep, sales office, or company literature department. Look in the phone book or on the web page for the phone number of a company or their local or regional sale representative or office. Call them up and ask. It's their job to provide customer support and if you sound like you halfway know what you're doing (saying you're a student works, too) AND it doesn't cost them much (don't get greedy) they'll often be more than willing to send you information. (These days, it might be a CD-ROM of their whole product line. Cheap, but not that easy to use, IMHO.) If they won't help you, ask them where there is someone who can. Like the nearest distributor.

Electronics distributors. Larger ones often fill the same literature distribution role as the sales rep. Other distributors like Jameco, JDR Microdevices, Future Active sell databooks as a catalog item. Or a local distributor that caters to the walk in trade will have a databook shelf and allow (or have a nominal fee for) photocopies. (The big distributors are closed operations, mostly using phone salesmen and UPS for distribution, visitors aren't necessarily welcome.)

A good library. Like one at a university with an electrical engineering program, or a large city library.

Used book stores, a big unselective 'book dump' often will have a good stock of old databooks. Ones that you can't get from the manufacturer and more. Likewise, electronics surplus stores (most big cities should still have one or two) often have them.

Parts Information and Cross References

I have found that one of the most useful single sources for information on semiconductors, especially for troubleshooting and repair, to be the ECG Semiconductors Master Replacement Guide. (ECG is now merged with NTE.) It used to be about $6 and may possibly be available for download free now from the NTE Web site (but it's huge). SK and others have similar manuals but NTE, especially with its acquisition of ECG, now appears to dominate the industry. The manual will enable you to look up U.S., foreign, and many manufacturer's 'house' numbers to identify device type, pinout, and other specifications.

Also see the section: House Numbers.

Here is the current Web site for NTE:

- NTE (NTE Electronics, Inc)

(From: Gregg (greggIns@ix.netcom.com).)

> "NTE's device numbers are the same as ECG's, and their cross-ref guide can be downloaded from http://www.nteinc.com/.
>
> It's free but they do want you to register. If you want to bypass this, go to ftp://nteinc.com/pub/ and download the windows version of the guide, ntesetup.exe. Don't bother with the dos version; the file named dosdisk2.exe is bad, and won't unzip."

I am not necessarily recommending using NTE (or other generic) replacements if the original replacements are (1) readily available and (2) reasonably priced. (Note that very often the original replacement part will be less expensive than the equivalent from NTE. Therefore, it should be used if available.) However, the cross reference can save countless hours searching through databooks, seaching the Web, or contacting the manufacturers. Even if you have a wall of databooks, this source is invaluable. However, there are a couple of caveats:

1. Some crosses have been known to be incorrect - the specifications of the generic replacement part were inferior to the original or totally wrong with different pinout or even function!

2. Don't assume that the specifications provided for the generic part are identical to the original. Since a single NTE part may replace multiple standard parts, it may actually be better in some ways. Thus, using one of these cross references to determine the specifications of the parts in your junk bin can be risky.

I often use the replacement guide to determine upper bound specs but as noted above, rarely buy any generic parts (sorry NTE). Then I find industry standard parts that have equal or better specs. Dalbani's catalog (see the section: Mail Order Parts Sources) has a sort of inverse cross-reference from NTE to 2S/2N/BU/whatever that isn't a bad starting point (though probably not to be trusted without confirmation of actual specs). Of course, this doesn't necessarily help with some tricky HOTs and choppers....

Note that while Howard Sams of Sams' Photofact fame publishes a semiconductor cross reference manual (or used to), it would appear to just be a compilation of the ECG, NTE, SK, and Radio Shack manuals - and much more expensive ($25 or so).

For standard ICs, IC Master can often provide quick access to complete data. Full access to their Web site is currently free but they do require registration. However, with their print version, ICs no longer manufactured were not listed. I assume the on-line version will be similar. Thus, it may be of only limited value for older equipment.

Transistor Designations

Unfortunately, there is no such thing as a universal part number!

- U.S. made semiconductors used to be mostly of the 'nN' variety - 2N with a 3 or 4 digit number for bipolar transistor, for example. This is called the Joint Electron Device Engineering Council (JEDEC) standard numbering but seems to have been replaced by letter prefixes which may be manufacturer dependent although the same part may be available from multiple sources. These numbers are becoming less common and are rare in consumer electronics.

    - 1N: diodes.
    - 2N, 3N: bipolar transistors.
    - 4N, 5N: optocouplers.

- Many devices in consumer electronic equipment are marked with a letter (A, B, C, D, F, J, K) and a 3 or 4 digit number. Add a '2S' in front of this and the result is likely to be the complete (Japanese) part number (the '2S' is nearly always absent from the package label). You can often use this number to find a suitable cross from NTE. However, most of the common '2S' devices are available from places like MCM Electronics and Dalbani.

    - 2SA, 2SB: PNP bipolar.
    - 2SC, 2SD: NPN bipolar.
    - 2SF: thyristor.
    - 2SJ, 2SK: FET/MOSFET.

    There are many other '2S' prefixes but these are by far the most common.

    Suffixes may denote package type or some special feature like an internal damper diode (D, for horizontal output deflection transistors), enhanced gain, special speed sort, etc.

    A cross reference of sorts is availabe at Transistors Japonais (French). Don't worry, the device numbers are the same in French and English. :)

- Less common are designations which look similar to the Japanese 2S numbers (a capital letter followed by a 3 or 4 digit number and optional suffix) but are actually Korean part numbers to which you add a 'KT' (Korean Transistor or Type?) instead of a '2S'. So D998 becomes KTD998. These components typically have a capital 'K' on top in addition to the part number starting with the letter (e.g., A,B,C,D). However, sometimes the only way you will know is that ordering the 2S version gets you a device that isn't even close (like a tiny TO92 small signal transistor rather than the 200 W, TO3 type you expected)!

There may be other examples but these are the exceptions (at least for now).

- Note that some components (usually ICs) may be labeled in a similar manner (like C4558C which is actually a dual op-amp) but this IS the complete part number - just something else to confuse you! Some of these such as one labeled C1003 may actually be a uPC1003 so if what you find in a datasheet doesn't make sense, try these other possibilities!

Aside from the VERY expensive D.A.T.A. semiconductor reference series (don't even ask), which includes virtually all types and flavors of devices, there are various Japanese Semiconductor Reference manuals available through places like MCM Electronics for around $20. Some of the text may be in Japanese but the relevant data is in English so these are handy if you want more detailed or precise specifications for these devices than provided by cross references such as NTE.

More on Transistor Designations

A common labeling scheme for MOSFETs consists of a 2 digit number followed by "N" or "P" followed by another 2 digit number: II T VV. This may be embedded in a much longer part number.

- II denotes the current rating in amps.
- T will be either N for N-channel or P for P-channel.
- VV denotes the D-S voltage rating in V/10.

(From: Mark Robinson (mark-r@snow_white.ee.man.ac.uk).)

We are lucky with transistors that, apart from a few oddities which I'll talk about later, most markings follow one of these codes. ICs are more tricky as you're often dealing with custom chips or mask programmed devices with manufacturers individual codes. A quick hint though: always look for known numbers (e.g., 723, 6502, 2764) etc. between the suffix and prefix, and beware of the date code.

Right... Back to transistors. The three standard transistor marking schemes are:

1. **Joint Electron Device Engineering Council (JEDEC).**

   These take the form:

   Digit, letter, serial number, [suffix]

   where the letter is always 'N'.

   The first digit is one less than the number of legs, (2 for transistors unless they're crippled although I'm not sure about 4 legged transistors maybe they get a 3) except for 4N and 5N which are reserved for optocouplers.

The serial number runs from 100 to 9999 and tell nothing about the transistor except its approximate time of introduction.

The (optional) suffix indicates the gain (hfe) group of the device:

A = low gain
B = medium gain
C = high gain
No suffix = ungrouped (any gain)

See the data sheet for the actual gain spread and groupings. The reason for gain grouping is that the low gain devices are fractionally cheaper than the high gain devices, resulting in savings for high volume users.

Examples: 2N3819, 2N2221A, 2N904.

2. **Japanese Industrial Standard (JIS).**

These take the form:

Digit, two letters, serial number, [suffix]

Again, the digit is one less than the number of legs.

The letters indicate the application area and flavour of the device according to the following code:

SA: PNP HF transistor
SB: PNP AF transistor
SC: NPN HF transistor
SD: NPN AF transistor
SE: Diodes
SF: Thyristors
SG: Gunn devices
SH: Unijunction transistor
SJ: P-channel FET/MOSFET
SK: N-channel FET/MOSFET
SM: Triac
SQ: LED
SR: Rectifier
SS: Signal diodes
ST: Avalanche diodes
SV: Varicaps
SZ: Zener diodes

The serial number runs from 10 to 9999.

The (optional) suffix indicates that the type is approved for use by various Japanese organizations.

NOTE. since the code for transistors always begins with 2S, it is sometimes (more often than not is seems) omitted so, for example, a 2SC733 would be marked C733.

Examples: 2SA1187, 2SB646, 2SC733.

3. **Pro-Electron.**

These take the form:

Two letters, [letter], serial number, [suffix]

The first letter indicates the material:

A = Ge
B = Si
C = GaAs
R = compound materials

Needless to say the biggest majority of transistors begin with a B.

The second letter indicates the device application:

A: Diode RF
B: Variac
C: Transistor, AF, small signal
D: Transistor, AF, power
E: Tunnel diode
F: transistor, HF, small signal
K: Hall effect device
L: Transistor, HF, power
N: Optocoupler
P: Radiation sensitive device
Q: Radiation producing device
R: Thyristor, Low power
T: Thyristor, Power
U: Transistor, power, switching
Y: Rectifier
Z: Zener, or voltage regulator diode

The third letter indicates that the device is intended for industrial or professional rather than commercial applications. It is usually a W,X,Y or Z.

The serial number runs from 100-9999.

The suffix indicates the gain grouping, as for JEDEC.

Examples: BC108A, BAW68, BF239, BFY51.

Apart from JEDEC, JIS and Pro-electron, manufacturers often introduce their own types, for commercial reasons (ie to get their name into the code) or to emphasize that the range belongs to a specialist application.

Some common brand specific prefixes are:

MJ: Motorola power, metal case
MJE: Motorola power, plastic case
MPS: Motorola low power, plastic case
MRF: Motorola HF, VHF and microwave transistor
RCA: RCA
RCS: RCS
TIP: Texas Instruments power transistor (plastic case)
TIPL: TI planar power transistor
TIS: TI small signal transistor (plastic case)
ZT: Ferranti
ZTX: Ferranti

Examples: ZTX302, TIP31A, MJE3055, TIS43.

Many manufacturers also make custom parts for large volume OEM use. These parts are optimized for use in a given part of a given circuit. They usually just have a manufacturers stamp and an untraceable number. Often when a company goes bankrupt, or has surplus at the end of a production run, these transistors find their way into hobbyist bargain packs. There is no way that you can trace data on these devices, so they are only suitable as LED drivers, buffers, etc, where the actual parameters are not important. Check carefully before buying.

Once you have identified your part, a trip to the data sheet or equivalents book is called for (anyone know of an on-line equivalents list?).

Surface Mount Parts

Due to their small size, very little information is printed on the actual package for diodes, transistors, capacitors, and other discrete devices.

- Resistors are often labeled with 3 or 4 itty-bitty digits where the last one is the multiplier (10 to the Nth power).

- Capacitors are often totally unlabeled but larger electrolytics may have both capacitance and voltage rating. Non-electrolytic types often have a brown body. Electrolytics may be black, yellow (tantalum), or some other color.

- Discrete semiconductors can often be identified by the number of pins using an ohmmeter at least in a rough sort of way. However, the only way to determine their specifications (and often even the type) or to find a cross reference for the abbreviated markings like 1A, B2, 2J, is to look them up since there is no logical relationship between the marking and the actual part number (unlike the 2S discrete parts, for example). This can be done if you have the manufacturers databooks or possibly even their abbreviated catalog (e.g., Motorola's "Master Semiconductor Selection Guide". NTE does cross a few of these SMT parts but their coverage is not nearly as comprehensive as for normal (through-hole) counterparts.

  The Web sites of semiconductor manufacturers may also have some information but this varies widely from company to company.

  There is an on-line list at:

  - Surface Mount (SMD) Transistors/Diode FAQ

  This is also somewhat incomplete. And, a very nice one at:

  - The SMD Code Book

  There used to be SMT marking codes info at:

  - Siemans Semiconductors

  However, since the semiconductor division changed their name to Infineon, I haven't been able to locate the page if it exists.

- ICs. The only option for many of these is to locate the databook or Web site with the datasheet. Even if the part number is similar to a through-hole version, the pinout may differ. However, common TTL/logic chips and op-amps will usually have identical pinouts and specifications. It is often possible to partially confirm this by checking the location of the power pins or known signal connections.

House Numbers

These are the cryptic numbering like 121-1025 or 113234 that may be the only marking on that critical part you need to replace or identify.

Are house numbers used just to make life difficult?

It certainly seems that way from the perspective of repair. Give me industry standard numbers anyday. However, house numbers are a fact of life.

The house number is what you need to order a replacement from the original manufacturer of the equipment but that may not always be desirable due to the likely high cost and possible difficulty in locating a suitable distributor that carries the manufacturer's replacement parts.

As noted in the section: "Parts information and cross references", a Master Selection Guide like NTE may be able to give you some idea of the specifications even if you don't want to use their generic replacement semiconductors. Their web sites have (or should have in the future) some amount of cross reference information for industry standard and house numbers. However, don't expect to detailed IC specifications or even pinouts in most cases there or from the disks they may also offer. The hard-copy Master Selection Guides which these companies sell have been better in the past (though this may be changing) but even these won't give you all the details. However, if you do repair work regularly, these 'telephone book' thickness guides worth the few bucks that is charged.

Also see the section: Parts Information and Cross References.

Generic Parts (Mostly Semiconductors)

NTE (which now includes ECG) offers an extensive selection of discrete devices and integrated circuits which are replacements for thousands of industry standard as well an house numbered semiconductors. Should you consider them? My general feeling is: not unless you have to. They are often more expensive than the parts they replace and quality is not always quite as high as an original standard part. However, in most cases, these parts will work just fine.

Other common components including flyback transformers, belts and other rubber parts, and RF modulators may also be available from these sources but they tend to be used less often and quality may vary even more.

There are some other similar companies like SK (part of Thomson Consumer Electronics) but NTE now appears to dominate the industry for these generic replacement semiconductor and other electronics components.

HP-to-Industry Standard Semiconductor Cross Reference

(From: Walter Shawlee 2 (walter2@sphere.bc.ca).)

This will help decode all those odd 1820-xxx numbers!

http://www.sphere.bc.ca/test

Also HP and Tek repair parts and equipment on line, plus helpful FAQs and links to all kinds of test gear sites.

We also have a big used equipment site on line for Canadians.

Internet Sources of Information

Most manufacturers of electronic equipment are now providing info via the World Wide Web. The answer to you question may be a mouse click away. Perform a net search or just try to guess the manufacturer's home page address. The most obvious is often correct. It will usually be of the form "http://www.xxx.com" where xxx is the manufacturers' name, abbreviation, or acronym. For example, Hewlett Packard is hp, Sun Microsystems is sun, Western Digital Corp. is wdc. It is amazing what is appearing freely accessible via the WWW. For example, disk drive manufacturers often have product information including detailed specifications as well as complete jumper and switch settings for all current and older harddrives.

Tandy (Radio Shack) has a nice web resource and fax-back service. This is mostly for their equipment but some of it applies to other brands and there are diagrams which may be useful for other manufacturers' VCRs, TVs, CD players, camcorders, remote controls, and other devices. The Tandy Product Support Page has links to each type of equipment.

In addition to Tandy products, there are a couple Sony models. Furthermore, since Tandy does not manufacture its own TVs, VCRs or camcorders - they are other brands with Realistic or other Radio Shack logos - your model may actually be covered. It may just take a little searching to find it.

Are There Schematics of Consumer Electronic Equipment on the Web?

Well, yes and no.

You are searching for the Holy Grail. Everyone is, but it isn't going to happen on a large scale - at least not for free. Schematics are copyrighted by the equipment manufacturers who sell them as part of their service manuals or license them to organizations like Sams Technical Publishing (Sams' Photofacts) and others.

- If you reverse engineer - trace - the schematic of a piece of equipment from the unit itself - and can prove it - and then make it available at your Web site, that is probably legal. You'll have a hard time proving it though for something like a TV or VCR.

- However, if you scan a service manual or Sams' Photofact and make that available at your web site, you may eventually find yourself in court. For schematics from original service literature of obsolete equipment, the chances of the manufacturer wanting to spend a lot of money on lawyers is small but for newer equipment, they may indeed - or just to make an example at your expense. A scanned Photofact is likely to be a problem regardless of age.

That is my take, at least.

Having said that, there are many Web sites with schematics that may or may not have been legally copied and made publicly available. See the section: Additional Sources for Service Information and Manuals.

Taking the Unit to a Repair Shop

As with medical problems, an accurate diagnosis can only be made with good complete information. Use your senses to their fullest. If you do decide to have the unit professionally repaired - and depending on your level of experience and confidence, this may be the wisest choice - the more complete your description of the problem the easier (and cheaper) it will be to locate the problem. Include functional behavior or lack thereof, mechanical and electronic sounds it makes, anything that is related at all to the operation of the unit. Sometimes seemingly unrelated factors can be important. For example, the fact that your officemate rearranged their desk and you monitor's image is now shaking. Don't omit anything - even what you feel is inconsequential - leave that judgement to the repair person. Also, what may have changed in your setup, did you move the equipment recently or add a component? What about your cable connections? Did you rearrange the furniture? When was the last time you know it worked properly? What were you trying to do at the time of the failure?

To paraphrase a famous quote: 'The only stupid or useless information is that which is not provided'. However, unless you really are sure of what you are talking about, don't try to tell the repair person what you think the problem is likely to be. Don't bombard them with technobabble full of buzzwords - any competent tech will see right through that. You can be sure that if you mention that you suspect the expensive flyback is toast, it will be diagnosed as bad. Let them do their job. Listen carefully to their diagnosis. You should be able to tell if it makes sense.

Searching for Information from USENET Newsgroups

USENET newsgroups are on-line bulletin boards or discussion groups that cater to every interest from soup to nuts and beyond. There are over 20,000 active newsgroups in existence though for our purposes one is of most interest: sci.electronics.repair.

There is an excellent chance that your question has come up and resulted in information being passed back and forth on sci.electronics.repair (or other appropriate newsgroup). For example, if you have had problems with a late model RCA/GE television, there have been dozens if not hundreds of postings on this subject over the last couple of years. There is no need to add to the clutter.

Google Groups (formerly Deja.com/DejaNews) includes a USENET newsgroup searching facility. It has been archiving newsgroup articles since March, 1995. By going to their web site, you can invoke a search of over 45,000 newsgroups (hundreds of GB of data!) for any set of words, names, or email addresses. Within *seconds*, they will provide a list of postings that satisfy your search criteria. Try using Google Groups at least once - you will be instantly hooked. :(Some of the relevant site URLs are:

- Google Groups Homepage
- Usenet Advanced Search

Specifically for the sci.electronics.repair newsgroup:

- Articles on Sci.Electronics.Repair

This results in listing of threads by date. However, going through the Search page provides many many options to locate specific articles relevant to your problem or just your curiosity.

While postings typically drop off of your local server in a few days or less, Googlegroups maintains them *forever* so that locating an entire thread becomes a trivial exercise in identifying a search string that will narrow down the postings to those relevant to your needs.

There are many other services available via Google Groups including newsgroup posting (under constructio apparently during the transition from Deja.com).

Speaking of posting:

Posting to the Sci.Electronics.Repair Newsgroup

This is a bit different than attempting to tell the tech at a repair shop how to do their job - speculation is safer. There is enough cross- checking such that any gross errors in analysis will be uncovered. There is also generally no profit motive. If your speculation is totally bogus, you will find out quickly enough, turn various shades of red - and learn from the responses.

Even if your ISP doesn't provide USENET newsgroups or allow posting for some reason, you can always access them (read, search, and post) via Google Groups. See the section: Searching for Information from USENET Newsgroups.

No matter how you do it, however, here are some tips that will get you what you want without unnecessary flame wars:

- Please read the on-line repair FAQs or repair guides first. Your problem may be covered. Even if an exact solution is not provided there, the additional information may allow you to ask your questions more concisely and intelligently and therefore arrive at a solution more quickly.

  The FAQs can be found at:

  - Sci.Electronics.Repair FAQ (RepairFAQ.org)

  and its mirror sites. First read the README and Mirrors links to identify the best way for you to access the information from your location.

- Put the type of device (i.e., VCR, CD player), manufacturer, and model number in the subject header as this will get the attention of the professionals. If you do not provide this info, the first reply you will receive will be to provide it. Avoid this waste of Net bandwidth. For general questions, such info may be unnecessary, but it will not hurt.

- As with professional repairs, provide as much relevant information as possible. Ambiguity can lead to totally bogus advice. For part identification, include both the designator (e.g., R324, Q1) and type (e.g., 330K, BU407D) if available.

- Don't just ask for repair tips - describe in chronological order what you have done so far in terms of troubleshooting approach and tests performed but don't fill screen upon screen with details. People don't want to read a lot of filler. Include only the essentials.

- Turn off any fancy formatting like HTML or WORD! Use plain ASCII text since everyone can read that, formatting adds NOTHING to the content, takes up space, and is very confusing for those people whose news readers cannot interpret it.

- Take a bit of time to make sure what you have typed is legible. Spell checking it won't hurt. DO NOT use ALL CAPS - that is like shouting in cyberspace and a good way to be ignored.

- A bit of courtesy won't hurt as well. Many people who reply won't care about the use of *please*, *thank you*, and *any help much appreciated*, but none of these will hurt and don't take much effort.

- If a little circuit diagram will help, provide it in ASCII if possible. ASCII takes up almost no space and everyone (with a fixed width font) can read it. Here are some basic guidelines for creating legible ASCII schematics:

1. Use a fixed-width font like Courier, Lucida Console, Quick Type Mono, etc.
2. Make sure your line length is set to 78 characters or less.
3. Use SPACES rather than TABs - TABs interpret differently depending on terminal or newsreader settings and the alignment gets messed up when text is included in a news posting.

For numerous examples of ASCII schematics that should look fine, see: Various Schematics and Diagrams.

Large binary files are not supposed to be posted on these newsgroups. In addition, you will upset people who are forced to download a 1 MB file they have no interest in but may not know it until they see the description. Some ISPs charge for connect time and bits transferred. If you have a large scanned schematic and you think it really will help with a diagnosis of or solution to your problem, offer it via email, upload it to your Web site, or post it to the newsgroup: alt.binaries.schematics.electronic (but not all news servers carry this group).

- You need to be patient. Not everyone sits at their computers all day. Some news servers may be days behind in their postings. If you truly get no replies of any kind (to the newsgroup or email) in a few days, repost your question with a note that it is a repeat. The net isn't perfect and due to finite disk space, many servers will miss postings or purge them after a day or less. Sometimes, your posting may not have made it out of the bowels of your computer system. You should be able to check this via - see below.

- Don't ask for help on 25 problems in the same posting - that is taking advantage of the generosity and time of others. Dribble them out and reciprocate by replying to other people's problems as well if you can but not to just say something. If you act immature, you will end up in everyone's kill file.

- Don't ask for help on problems that you could just as easily solve on your own by checking a databook you should have or a Web site that you should know about.

- Don't ask for an email response. First of all, it is very impolite. Sci.electronics.repair was not created for your benefit. We do this because we like to help people but at the same time do not want to feel like we are being taken advantage of or taken for granted. We are not your private consulting service. In addition, others will know when an adequate response to your query has been provided and will not need to waste their time repeating the same information. And, everyone will learn something in the process.

  More importantly for you, receiving replies via email will circumvent one of the most important functions of the newsgroup - cross-checking to locate errors in responses either because the responder didn't know what they were talking about or made an error in interpretation. Perhaps, they were just being a bozo and sent a totally bogus or even dangerous response. And, some people may have hidden agendas that aren't in your best interests. If that was the only reply, you would never know. While there is a lot of high quality information available via the Internet, there is also a lot of noise. Yes, you will need to read the newsgroup for a few days. That will be a small sacrifice and well worth the effort.

  If your news feed is indeed poor - as many are - and you are honestly afraid of missing the responses, then phrase your request for an email reply in such a way that it doesn't sound like you are totally immature and lazy.

Another alternative is to search for replies at:

  - Google Groups (formerly Deja.com/Dejanews.)

This service will enable you to search for only the postings you are interested in and seems to be pretty reliable. They subscribe to a half dozen news feeds just to avoid missing *your* postings!

Many people will send you a CC of their posting anyhow so avoid getting flamed for poor netiquette. However, take note below.

- Use your true full name and email address in the 'Reply-to' field of your posting. It is unreasonable to expect us to reformat a bogus email address that you might use to avoid SPAM. It is quite annoying to try to help people only to receive bounced mail. While the 'delete' key works quite well in dumping the returned message, you don't get your questions answered. The regulars on the sci.electronics.xxx newsgroup hierarchy all use their real names and email addresses. Please do us a favor by being mature and do the same. Spammers lurking around these sci newsgroups get pummeled anyhow and don't survive for long. :-)

- Don't accept the first response as the definitive word. Gather a few replies and followups and then you will be able to make an evaluation of which to believe and act upon. Post a question for clarification, if needed.

- If you do receive email responses, reply to the senders as well as posting to the newsgroup *and* indicate to the senders that you are posting a copy to the newsgroup.

  It is very annoying to reply via email only to find that the same question appears a little later on the newsgroup requiring a repeat response.

  In any case, once your problem has been resolved (or you have given up), it is polite to post a concise summary of the problem, suggestions, the solution or frustration, and appreciation to those who have helped you.

Private Discussion Groups and Email Listservers

In addition to USENET newsgroups, there are a number of private bulletin boards (may also be called forums) on repair related topics. These are accessible via the Web rather than through a News server. New ones come and old ones disappear regularly. :) I personally see little point in using these - traffic is usually very low, and the experts all hang out on the relevant USENET newsgroups anyhow! And, very often the private ones are related to a commercial enterprise as (1) you don't know how whether the replies are slanted toward selling something in some cases and (2) there is often objectionable (at least in my opinion) advertising on the site.

There are also a few repair related email listservers. These require that you subscribe by sending a special email message and/or filling out a form. Some may have merit in that experts are more likely to be subscribers and they are forced to at least receive all emails (even the next stop is the bit bucket!).

Sorry, given the relatively low interest in both private discussion groups and email listservers, I can't justify attempting to keep up with their arrivals and departures! :) Both of these can be found through the various tech-tips sites as well as by searching postings on the Sci.Electronics.Repair Newsgroup via Deja.com. A few may also be listed in my Bookmark File.

Having said that, popular services like Yahoo often host at least a few niche discussion groups that simply due to the number of users, have a volume of traffic worth noting. For example, go to Yahoo Groups and search for "Tektronix". Two groups for Tektronix oscilloscopes will pop up, one for general postings and the other for documentation like schematics.

Dealing with a Repair Shop in an Efficient and Professional manner

When all else fails and you are forced to admit defeat.... OK, I'll try that again: Should you end up taking the equipment to someone else for service, here are some tips for getting it fixed with minimal hassle.

(From: Rex (bopeep@prysm.net).)

I have been asked to give tips for dealing with repair shops. It is sometimes difficult for the average consumer to convey their needs to shops or technicians.

- Limit the scope of the problem to the actual problem you are having with your product.

  Avoid getting into dialog about children, grandchildren, holidays, bad mouthing other shops or manufactures, "I can get a new one for that", vacations, school functions, how seldom you have used the product or anything that that has nothing to do with you product's failure.

- Ask for an ESTIMATE, but realize that an ESTIMATE can and MAY be raised or lowered. You MUST be advised of any change to the estimate before you are billed for a unapproved amount.

- Avoid GUILT, RUSH (unless you are willing to pay for it), and pressure to the shop. Be polite and EXPECT to be treated politely and you should be given the respect that any business should give their customers.

- If the repair does not meet your standards:

  - Ask for and expect, that something will be done as quickly as possible.

  - If the shop fails in its obligation to you, call the BBB, consumer affairs agencies or any other place that can help you resolve the problem if the shop refuses to honor its warranty.

    CAUTION: Be VERY sure what the warranty is. Most repairs are covered for the work done, not the entire operation of the product. Read the shop warranty and ASK questions.

  - Do NOT expect a shop to clean up or repair problems from other repair attempts (including your own), or to be able to repair a product that has be abused.

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Parts Sources

Where to Go for Parts

Large electronics distributors like Allied, Digikey, Mouser, Newark, and others stock tens of thousands of types of electronic components. Even Radio Shack can be used in a pinch.

However, none of these places have even the most basic service parts for consumer electronic equipment. You won't find a single rubber belt, RF modulator, posistor, or video head, nor most Japanese semiconductors within their thick catalogs.

It may be possible to go direct to the manufacturer of the equipment but expect to spend many times the true price of a part to get it from the horses mouth. In most cases, a totally identical part - with the manufacturer's logo and everything - meeting identical specifications is available elsewhere at a fraction of this cost.

Web Parts Information and Ordering

Many manufacturers are now providing a great deal of *useful* information on the Web. For example, Panasonic has a web site you can enter your model number and get a parts list with list prices and part descriptions:

* Panasonic Parts & Service Online

This site includes support for Panasonic, Technics, and Quasar consumer electronics. However, my quick visit only showed accessory type items (e.g., replacement original remote controls, cables, etc.). Encrypted credit card protection presumably makes it possible to order parts directly.

Mail Order Parts Sources

See the document: "Major Service Parts Suppliers" for some companies that I have used in the past and others that have been recommended. (These lists have now been consolidated into that document.)

And, Don't Forget Radio Shack

Radio Shack may be the most abused chain on the sci.electronics.xxx newsgroup hierarchy but they ARE good when it is after business hours for your normal distributors, you need a resistor or capacitor, and just have to have it NOW!

In addition, Tandy, the parent company of Radio Shack is worldwide and may actually offer a USEFUL selection of components:

(From Ted Gondert (vcrepair@bbs.industrynet.net).)

Tandy (aka Radio Shack) has a new catalog available at your local Radio Shack; "Tech America" "Your Electronics Resource". This is special mail order catalog with many parts available from a different division of Tandy. There is no minimum order and parts are sent directly to your house. Shipping is $4.00 for components orders only or various rates up to $13 for orders of $500.

Call 1-800-877-0072 between 7 a.m. to 11 p.m. M-F Central Time, 9 a.m. to 8 p.m. Saturday, 11 a.m. to 7 p.m. Sunday. Fax 1 800 813-0087. Mail: Tech America, PO BOX 1981 Fort Worth, Texas 76101-1981.

This catalog, Sept 1997 has 546 pages with capacitors, resistors, transistors, IC, coils, wires, antennas, test equipment, tools, radios, security equipment, books, etc.

The capacitors include high temperature, 105C electrolytics. The integrated circuits and transistors are mostly American type part numbers, digital, op-amps, etc. not the Japanese type used in most consumer electronics today. But should be many parts that electronics techs can use.

For example; 1000ufd 16 volt 105C electrolytic capacitor is only 39 cents. (pg 14) That's popular size in use in Panasonic SMPS. Also has MJ15024 audio output transistor for $4.59 (pg 49) and surface mount transistors.

Radio Shack also has catalogs in stores for RSU, Radio Shack Unlimited. Those show Japanese semiconductors, special batteries, phono stylus, equipment, etc. that your local Radio Shack can order.

(I haven't ordered anything yet but after checking my inventory and budget will probably stock up on some capacitors, etc. Get most of my parts from MCM, MAT Electronics, etc and some local distributors.)

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Troubleshooting of Intermittent Problems

These are the ones everyone dreads - equipment that is tempermental, working or not working apparently depending only on its own mood. Behavior may appear to be totally random but in most cases, there will be some correlation with physical, environmental, or external interference. Careful observation and perhaps a bit of detective work will ultimately allow a repair to be successful. Troubleshooting such problems is a primary cause of hair loss in engineers and technicians. :) However, with a methodical approach and patience, it should be possible to identify the cause and repair misbehaving equipment. Here are some examples of intermittent problems:

- A computer monitor that erratically loses one of its primary colors (red, green, or blue).

- TV reception that turns to slow and then returns to normal apparently at random. Or one that turns itself on at maximum volume in the middle of the night.

- A car radio or tape deck that misbehaves on rough roads.
- A TV that turns itself on in the middle of the night.
- A CD player that is prone to aborting or skipping at random times
- A microwave oven that blows its main fuse once in 10 days.
- A TV that exhibits annoying herringbone patterns at certain times of day.

This section deals mostly with TVs and monitors since they appear to be most prone to these sorts of problems. This is partially due to the higher power levels and associated heat generation inside of them, and partially due to the cost pressures which result in manufacturing quality control problems. Other equipment like VCRs and CD players also may suffer from intermittent behavior, but it is usually not due to bad soldering (though there are exceptions) but rather due to mechanical problems or dirty or worn internal position sensing switch contacts.

TV and Monitor Manufacturing Quality and Cold Solder Joints

Low cost no-name (or unknown name) computer monitors tend to be particularly prone to bad solder connections. However, so are many models of name brand TVs including those from RCA/GE/Proscan and Sony. We'll touch on these at the end of this article.

Any intermittent problems with monitors that cause random sudden changes in the picture brightness, color, size, or position are often a result of bad connections. Strategically placed bad connections can also cause parts to blow. For example, a bad connection to the SCR anode in a phase controlled power supply can result in all the current passing through the startup resistor, blowing it as well as other components. I had a TV like this - the real problem was a bad solder joint at a pin on the flyback. Thus, erratic problems, especially where they are power or deflection related, should not be ignored!

Bad solder joints are very common in TVs and monitors due both to poor quality manufacturing as well as to deterioration of the solder bond after numerous thermal cycles and components running at high temperature. Without knowing anything about the circuitry, it is usually possible to cure these problems by locating all bad solder connections and cleaning and reseating internal connectors. The term 'cold solder joint' strictly refers to a solder connection that was either not heated enough during manufacturing, was cooled too quickly, or where part pins were moved before the solder had a chance to solidify. A similar situation can develop over time with thermal cycling where parts are not properly fastened and are essentially being held in by the solder alone. Both situations are most common with the pins of large components like transformers, power transistors and power resistors, and large connectors. The pins of the components have a large thermal mass and may not get hot enough during manufacturing. Also, they are relatively massive and may flex the connection due to vibration or thermal expansion and contraction.

Why Can't TV Manufacturers Learn to Solder Properly?

I can think of several potential reasons - all solvable but at higher manufacturing cost.

1. Mass of large component leads (like shields) does not get adequately heated during manufacture leading

to latent cold solder joints. While they may look OK, the solder never actually 'wetted' the heavy pins and therefore did not form a good mechanical or electrical bond.

2. Thermal cycles and differential thermal coefficients of circuit boards, traces, and solder. While it is not easy to do anything about the material properties, using plated through-holes or a similar mechanical via would greatly increase the surface area of the joint and prevent the formation of cracks.

3. Vibration. This is also directly related to the single sided circuit boards without plated through-holes to strengthen the joints.

4. Lack of adequate mechanical support (single sided circuit boards without plated through-holes (vias).

I believe that the single most significantimprovement would come about by using plated through-holes but this would add to the cost and apparently the consumer is not willing to pay more for better quality and reliability! Some designs have used rivlets - mechanical vias instead of plated ones. While this is good in principle, the execution has often been flawed where cold solder joints resulted between the rivlets and the circuit board traces due to lack of adequate process control.

The Sony and RCA/GE tuner shield problem is interesting because this could have been solved years ago at essentially no additional cost as other manufacturers - and their own repair procedures - have proven.

Attacking intermittents

First, determine whether the problem is internal or external.

The most common external causes would be electro-magnetic interference, either through the air or via the power line. For more on these in particalur, see information on interference in the documents on TV and monitor repair. But, suffice it to say, changing the location or electrical power source will usually help to narrow it down.

If internal, it may be physical, heat related, or mode related. Gentle whacking (yes, whacking is an acceptable diagnostic technique but don't go for the 12 pound hammer!), pressing, flexing, cable wiggling, etc., can and should be used in an attempt to confirm at least that there is a physical cause inside the unit. Doing these tests just as the problem comes or goes is the best time as whatever is marginal, will be most marginal then.

If the problem appears or disappears, or does both, over a period of time after the equipment is turned on, then temperature is almost certainly a factor as the circuit board and components expand.

The most common physical problems are bad (cold) solder joints, connectors that need to be cleaned and reseated, and bad cables or cable connections. Perhaps surprisingly, though components may fail internally and result in erratic behavior, this is probably lower on the list of likely causes than those listed above. Some exceptions would be mechanical relays in audio power amplifiers, phone equipment, and elsewhere; hybrid power amplifiers, and other power devices.

The whacking, etc., can be done without taking the cover off the equipment and may or may not reveal anything. In either case, you will have to go inside. But if there is an effect, then you will know that the problem IS inside and further tests will need to be done to identify the specific cause.

Once the cover is off, there still may be quite a challenge to find the specific solder connection or contact that needs attention. Knowing something about how the actual circuit area relates to the symptoms will help narrow it down. For example, if there is a loss of vertical deflection in a TV or computer monitor, the most likely areas to attack will be the vertical deflection output stage and its power supply feed.

For popular consumer electronic equipment, intermittent problems are often present in many (or even most) samples of a particular model over the course of its life. Therefore, checking a tech-tips database or asking on the USENET newsgroup sci.electronics.repair may reveal a common cause and an easy solution ("resolder the flyback pins"). There are a list of tech-tips databases at my Web site, www.repairfaq.org.

(From: Phil Buble N1GTZ (muttnik@ecr.net).)

A note on whacking as a troubleshooting technique, at home and in the shop.

I'm not what you would call a full time electronic repairman though I have made a living doing it commercially. I can be just helping a friend out at home but usually it's been an adjunct to my main work as assembler/post flow touch-up and I'm pretty good at it. Therefore most of my repair experience is with new equipment that doesn't work correctly the very first time it's powered on. (and yes when *will* that wave-solder machine learn to solder? :) Running that thing is a art-form I'm glad to avoid)

Naturally in such a situation I'm a great believer in "swap-out with NGP testing" since there's usually lots of them in an assembly shop but this cannot always be easily done. Especially at home, with obsolete units or those so small or cheaply made not a vacuum tube, IC or module is to be found in a socket. My funniest experiences with whacking regard these - one commercially and one at home. The commercial one first:

It involved a totally obsolete and smallish sensor board used in the ground-water monitoring industry to measure water pH deep down in wells. Even carefully sealed you can imagine the condition it was in after years of hard use. Only a few had ever been made by the company long before and the engineer who designed it equally long gone. A young, recently hired engineer was given the task of finding out what was wrong. It was giving rather useless and erratic readings and needed to be repaired in a hurry. I cleaned it and reflowed all joints, just in case, then turned it over to him since it still didn't work. After hours of frustration and attempts to get "into the head of the designer" he gave up and I asked to give it a try. By then I had a hunch. I made a routine test to make sure all was getting power - then gave the PCB a whack and a little twisting action. It began working perfectly as long as the PCB had a slight twist to the right. This literally took me all of about 5 minutes. You have never seen such a dumb-founded engineer! They do need to get out more! Even with the failure mode detected the cracked trace could not be found in a reasonable time so I had the honor of transferring all the parts to a new PCB. Amazing they even had one.

The second funny situation occurred many years before the above and happened at home. A neighbor brought over a old (even for the time) but nice condition 19" tube-type B/W TV hoping I could fix it. Fully half this set was point-to-point wiring, no PCBs at all. I'm old enough to have one foot in the all tube and "condenser" era and one foot in the transistorized world so it didn't matter to me that it was tubes. As long as my friends are willing to pay for the parts and hopefully locate a schematic I'm willing to at least try. It's all done in a casual sort of way. (Side note: You'll have to pry my Heathkit AA-100 Vacuum Tube Stereo Amp from my cold dead hands, it still sounds great 41 years after it was built)

This one located the Sam's Photofacts for it, complete with schematic and pin voltages. A resistor in the B+ line to the plate of the Horizontal output tube had burned out. That was replaced and all DC pin voltages then looked OK - yet no picture. Sure, the H Oscillator wasn't oscillating! The next logical thing to do was to swap-out the H output tube with another to see what happened. I told my neighbor we needed to locate a tube, and a rather expensive one, to go any further. He didn't bother, it wasn't worth the effort or expense. 5 *YEARS* later he trots out that same TV hoping, once again, I could get it to work. I tell him we still needed that tube. He shrugs, plugs it in, turns it on and gives it a good whack. It came on and worked perfectly! That's all it needed all along, my power-supply repair had fixed it 5 years before but no one ever whacked it to get it started again.

Selective circuit whacking's been one of my most productive and time saving

Inspection and Power Off Tests for Intermittents

Assuming these don't help (or you consider letting someone else solve your problem to be cheating), a detailed visual inspection is the next step. This may be all it takes. With the unit unplugged) and after confirming that power supply capacitors are discharged!), remove the cover.

- Start with the pins on devices like power transistors, transformers, and large or high current connectors. These are most likely to cause marginal solder connections to break apart due to thermal and physical stress. Hairline cracks at solder joints is a primary cause of intermittents, especially in TVs and monitors with their power supply, deflection, and video circuitry that may run hot.

  Make the inspection under a bright light. If your closeup vision isn't perfect, use a good magnifier - these may literally be hairline cracks and their visibility may be obscured by reflections from the solder joint. Use a pointed stick (not something metal if possible) to gently prod any suspicious looking pins to see if they move. Look for discolored patches on the circuit board. Such discoloration isn't in itself a problem unless it is severe but indicates that hot components live there or nearby and bad solder joints are very likely.

- Check for tan or brown glue on the top and bottom of the circuit boards. A rigid adhesive may be used to attach various components but some varieties decompose and become conductive with heat and age. Some very weird problems have been linked to decayed glue! So, carefully scraping it away and replacing it with non-acidic RTV Silicone or similar adhesive may be prudent. However, I don't know how to tell which types are a problem.

- Check for loose or damaged cables (particularly in user serviced equipment like PCs!).

- Remove, inspect, clean (if necessary), and reseat all internal connectors. Even if they don't seem to be in an area of the circuitry that is relevant, they could be feeding a power or control signal. Check for discolored or fatigued contacts as well as physical damage to the wires and improperly made crimps. If any components (like transistors or SIMM memory modules) plug in, do the same for them.

Where a problem is found, don't assume there is only one! In many cases, bad solder connections or bad crimps are caused by poor manufacturing process control and will be repeated in many locations. So, correct what was found and then continue to inspect the entire unit. Sometimes, manufacturing is so poor that resoldering the entire board is the only solution with any chance of long term success.

- If a suspicious area is located, it may be possible to use an ohmmeter between selected pins to determine if a connection is intermittent. To increase the chance of detecting a momentary change in resistance that may be too brief to register on a meter, connect the input of an amplified speaker (or audio amp and speaker) in parallel with the meter probes.

Power On Tests for Intermittents

If none of this produces a breakthrough, the next step is to power up the equipment. WARNING: Depending on the particular equipment, lethal voltages or other hazards may exist. Make sure you understand and follow what's in the document: Safety Guidelines for High Voltage and/or Line Powered Equipment.

- Using an insulated stick, start gently prodding likely areas of the circuitry in an attempt to make the problem come and go. If you are successful, don't assume the journey is over! Pressing at a corner of the board may have an effect at the opposite side. In fact, you may find that pressing *anywhere* appears to have about the same effect. It may take some vary very light tapping, flexing, etc., to locate the culprit. Until a physical cause if actually located (e.g., a visibly cracked solder joint where the pin can be see to move!), don't assume you're home free even if the problem appears to clear up. In fact, it is very common for an intermittent problem to go away as soon as troubleshooting begins not to reappear for several days or more - but it will reappear!

  Once a particularly sensitive area is located, use a stick thin enough to just touch a single pin at a time. Sometimes, a probe with a pointed metal tip, insulated for all but the last 1/16" or so, will be useful as it can get into the area between the pin and solder pad where cracks may have developed but are not visible. The metal tip will bridge the gap causing a change in behavior.

- If the cause is heat related, no amount of prodding (or cursing) may result in the problem occurring with the cover off. In this case, a heat gun (or blow dryer) may be needed to carefully warm up selected areas of the circuitry in an effort to identify the culprit. A blower with no heat may be used for cooling. Or, "circuit chiller" or "cold spray" may be used for more aggressive spot cooling. However, simply removing the cover may have altered something physical. For example, one of the cabinet screws may be to long and is shorting out something - this may be either from improper prior reassembly after repair or a manufacturing or design defect.

- The hardest intermittent problems to locate are those that occur infrequently and for only a short time with no chance of making a measurement. There are fancy and expensive recording analyzers for just such occasions (but you can buy a nice car for what one of these costs!). However, there may be no need for such extravagance. If you have an oscilloscope and camcorder or video camera/VCR, you probably have all that is needed.

  For a TV or monitor, point the camera at the CRT and the scope screen so that they are both in the picture and record on a 6 hour tape. Then, when your event takes place, you have a permanent record!

  That old video camera will be perfectly adequate. It doesn't need a 100X digitally stabilized enhanced reprocessed zoom or 1/10,000th second shutter. It doesn't even need to be color!

  Sure, this won't capture the 1 ns glitch. But, for the occasional flash in the picture, it is more than adequate to eliminate a video signal line as the source of the problem.

Don't rush this process. It may take several diagnostic sessions to finally resolve the problem. Even if one or more cracked solder joints are found and fixed, it may be worth waiting a few days to reinstall those 10 shields that had to be removed in order to access the underside of the main board! However, do replace the cover so that the internal temperature will be similar to normal during extended operation.

Now the question comes up: How can the re-occurrence of intermittents be prevented? For cracked solder joints, in addition to using proper soldering techniques for repair, it should be possible to add some "reinforcements" in the form of bare wire wrapped around the pin and extending out to the circuit board trace or even to an adjacent component pin. This will be better than just using more solder. For the CTC175 etc. cases discussed below, there is also special "elastic" solder that supposedly should be used. But, there are mixed reviews on whether this really helps.

Some equipment may also benefit from a small amount of additional cooling. A small fan can be added to draw air out of the cabinet. This will improve reliability since most components are happier being cool but will also reduce the extent of the thermal cycles reducing the likelihood of bad solder joints developing in the future.

RCA/GE/Proscan and Sony TVs

One of the classic examples of an intermittent problem that is present in an entire product line are the RCA/GE/Proscan TV chassis starting with CTC175 and running at least through CTC187, possibly beyond. A very large percentage of these TVs are destined to have cracked solder joints in the area of the tuner/controller resulting in erratic picture and sound. If not corrected, this eventually results in bad data being written into the EEPROM that stores the TV's parameters causing total failure to turn on. Until recently, Thomson Electronics was covering at least part of the repair costs. There may also be at least one class action lawsuit pending in regards to this problem.

Some Sony TVs suffered from a similar set of bad solder joints, usually in the tuner or IF (metal) boxes. The most common location for the problem for many of these was to one pin of a coil inside the IF box which always seemed to lack adequate solder.

Much more information on the RCA/GE/Proscan and Sony solder problems and solutions, see the documents: RCA/GE TV CTC175-187+ Solder Connection and EEPROM Problems and Sony TV Tuner and IF Solder Connection Problems.

Other makes and models of TVs have similar problems with solder joints but not to the extent of these.

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Perfecting Your Skills

Where to Find Equipment in Need of Repair or Abuse

Now that you have read all the previous sections, perhaps some of the Repair Briefs, followed the sci.electronics.repair newsgroup for a while, built your handy widgets(tm), and loaded up on test equipment, where should you go to find broken stuff to play with and practice on? Of course, you probably have closets bulging with broken VCRs, TVs, stereos, and small appliances. You may not may not want to practice on these just yet.

- One obvious source are accomodating relatives, spouses, and collegues. However, again, you will want to hold off on this until you have some success under your belt.

- Garage, yard, driveway, porch, etc. sales (also tag and house sales but this may be higher class more expensive junk) can be veritable bonanzas of dead appliances. With a little restraint (don't buy the first items you see until you have a feel for what the going rates are) you should be able to buy excellent dead items for next to nothing. For example, I usually don't pay more than $5 for a dead VCR - maybe $10 for a late model in excellent physical condition. I bought a 26" RCA Colortrak TV for $5 and a late model 20" color TV for $3. CD players with problems typically go for $2 to $7. Sometimes they will just give you the stuff so they do not have to haul it to the dump. Much of this can be repaired inexpensively once you have some experience. If you mess up some of the patients, so be it. You will have learned a great deal and sacrificed little.

  Always check to see that you got all the accessories - remote controls, cables, attachments, etc. Often, they will have long since disappeared but it won't hurt to ask.

  Try to find out what the symptoms were from the owner if possible. With a little knowledge, this could improve your bargening position as well - or make you decide to try for a lesser challenge:

  > "Jonny stuck a peanut-butter-and-jelly sandwich in the tape slot and when his pet hamster wen't to eat the sandwich it got stuck. They have both been there for a couple of years now. I put the VCR in this plastic bag to protect it from moisture. It really is a great VCR".

  or:

  > "Well, there was this lightning strike, the modem exploded and 6 foot flames leaped out of the monitor so I dumped a pitcher of lemonade on it to put out the fire. What is left of the PC is still melted to the floor but I figured someone could use the monitor."

  I would skip those.

  Another high risk would be a piece of equipment that had been worked on by someone not competent to change a light bulb:

  > "My VCR wouldn't play my Rambo tape so I opened it up and found this silver thing was out of line - you know, all cockeyed. So I tried to straighten it with a pair of Vise Grips(tm) but I must not have done it quite right as now all I get is snow and it makes these crunching noises. Maybe you will have more luck"

  or:

  > "I tried to repair this amplifier but while I was making some adjustments, my screwdriver

> slipped and there were these HUGE sparks and bubbles appeared on several of those black things that look like cochroaches and parts flew off of those clips glued to this plate at the back. You wanted a challenge, right?"

or:

> "Duh, I thought I would get cool music in my car but for some reason I cannot fathom, the jumper cables I used got really hot and my portable CD player now smells really bad and doesn't work on the normal transformer anymore. I will throw in the jumper cables for nothing."

I would pass on these as well.

In addition to melted or scorched cabinetry and the wonderful aroma of charred circuitry, look for the absense of cover screws and chisel or chainsaw marks!

- Moving sales are similar and better in some ways as the owners are usually very motivated to move out as much junk as possible.

- Flea markets may yield simliar types of items but expect to pay more. Where do you think they obtain all their merchandise?

- Thrift stores, Goodwill's, and similar outlets may also yield suitable candidates in some cases for free. Find out when their 'drop-off' days are and camp out. :)

- Auctions have potential as well but you better know even more about what you are bidding on, set a hard upper limit for you bids, and be prepared to spend the day.

  I like to swoop in and swoop out - thus my preference for garage sales.

- The curb, local dumpsters, and the town dump can also be sources but confirm that whatever you are taking is really up for grabs! One recommendation is to drive around a college campus at the end of the term when students are packing up and throwing away anything that they will not be taking home. There are even supposed to be USENET newsgroups on these topics. For example, alt.dumpster though I've not actually found it.

The most annoying situation is when after haggling over the price of a 'dead' VCR, you get it home with great expectations of the challenge ahead only to find that it works perfectly or your Mark-I thumb is all it takes to clean a supposedly trashed video head (but you do have to know the proper technique and incantations!) I ended up with a couple VCRs like that. A 'dead' CD player for $5 magically cured itself on the back of my 10 speed bicycle. Often problems are simple and easily remedied resulting in quick gratification. However, there will be real dogs which could more than make up for the easy fixes (like the GE TV with the never ending string of bad solder connections). At least, if you sell the easy ones, this will help pay for your 'habit'.

- Repair shops. They will literally have walls of beyond hope, dogs, or unclaimed equipment - TVs, VCRs, CD players, etc. It might be worth asking if you can buy some of these for a modest fee. While I am always tempted to save everything on the off chance that a part will be useful in the future, realiztically, this rarely turns out to be useful and they may be happy to part with what they consider junk especially if they have more than one of the same or similar model cluttering up their back wall.

I do not know how viable an option this typically is since I have never tried it. (However, I used to trash pick mostly replaced vacuum tubes - nearly always tested good - back in those days when such things were common.) If they consider you a threat to their business, you may get the cold shoulder. If they consider you a future employee - or suspect you will make whatever you are working on worse and increase their business that way, you may be forced to take a whole pallet load of stuff off their hands :-).

Note that this could turn out to be very frustrating if by chance you end up with partially cannibalized equipment without realizing it. "This VCR does not load the tape around the video drum. Come to think of it, what happened to the video drum...?" Or, "There seems to be a big hole in the front of the TV. Now, what could possibly be missing...?"

- (From: Jerry Penner (jpenner@sentex.net).)

  Make friends with several local apartment superintendants When they clean house after someone moves, they toss out all kinds of working/non-working stuff the folks left behind. Some supers make a little extra cash by fixing and reselling this stuff, some just give it the heave-ho.

One note: inspect whatever you take home. Cockroaches and other unwelcome visiters may have made a comfortable home in that old TV. I once picked up a nice toaster oven but found that I was baking more than I expected or desired and had to completely disassemble and clean it before the cockroaches stayed away permanently.

Paul's Comments on the 'Well Equipped Garage or Flea Market Sale-er'

Only read the following if you are serious about this! Note: these comments apply more to the electronic flea markets or ham fests found around high tech parts of the country but can be adapted for the back woods as well.

(From: Paul Grohe) grohe@galaxy.nsc.com).)

Ah! If you are really serious about buying equipment, carry one of those little 200W 120VAC inverter bricks *with you* in your backpack, along with a cigarette socket to car battery clip adapter. Keep a small marine or gel-cell battery in your car (or with a friend who has a table).

This way, when you "roll up" on a good deal, ask the seller if you can borrow his cigarette lighter, or car battery, for a few minutes. If you can't use his car (and if you have time), run back and get your battery.

If he refuses...There's your answer!

I keep an 8-cell "AA" battery holder and an assortment of pigtail power connectors in my backpack. This way, I have an adjustable 1.5 to 12V power source to test things there on the spot (I'm planning on making a complete test box, complete with ammeter and current limiting).

I also carry a bunch of "AAA" and "C" cells in my backpack ("C" cells can be shimmed into "D" holders with a few coins between the batteries).

The same rule applies, If they won't let you test it.....etc,etc,etc.

Will they give you their business card or phone number? Make it clear you will not bother them unless absolutely necessary (secretly write down their license plate number, for "Justin Case").

Also carry a pocket DMM (This is a *must* for any flea enthusiast - NEVER buy batteries w/o testing them first!) and a small, bright flashlight (for "inspections").

Smell the equipment too! This can be a big clue as to it's condition. Does it smell like something blew up? Does it smell musty or moldy?

Another clue I have found is the physical condition of the unit. Sometimes the "cleanest" unit of the bunch is the one that failed prematurely and got stuffed on a shelf or back in the box. Whereas the "used looking" units were just taken out of service.

More importantly than "functional", is "complete".

Nuthin' worse than getting something and finding out a piece, or a board, or a module, or an expensive or rare IC is missing. Now you know it's not functional, and there may be little chance of it even becoming functional again.

I always assume "dead" until happily proven otherwise. Follow your instincts! If you have doubts, there's a reason! I always consider the scrap value of the item also. Any expensive goodies in it? The power switch may be worth more than the item!

Some of my best deals were the "I don't know if it works...Oh,..five bucks" deals.

It's a gamble...Ya' win some, ya' loose some!

Caveat Emptor!!!!!

(Let duh buyer beware!)

Cheers.

And, How Paul Equipped His Home Lab

(From: Paul Grohe) grohe@galaxy.nsc.com).)

That's me! Flea Markets/Surplus Stores/Salvation Army/Goodwill/thrift stores/Garage-yard Sales/etc...And there is *lots* of good stuff around this area!

I call it "going' Junkin'".

I arrive at about 5:30 AM, so that requires a combo krypton spotlight/fluorescent lamp flashlight (a $3 Goodwill special :^).

I carry with me the aforementioned 8 cell battery pack, 8 "C" batteries, a bright krypton penlight, one of those all-in-one screwdriver/knife/pliers/scissors/bottle opener contraptions ("fishermans friend"?) and a small pocket DMM. All about 5-7 pounds total. I carry it all in a backpack that I wear "backwards" on my chest (for easy access). During the "lull" (around 9 AM), I go back and "load transfer" to the car.

I got it down to a science!! ;^)

After some lucky "scores", and a few *hundred* hours of troubleshooting, I have a *very* well stocked home lab... :^)

My home lab is graced with a Tek 576 Curve tracer (bad Xfmr), HP 5345 Freq cntr (bad NPN trannie), HP3456 DMM (bad ROM), Radiometer 106 RF Generator (stuck keys), Genrad 1688 Digital RCL meter (another bad ROM) and a "few" other assorted goodies...

The Tek 576 is my favorite. This unit was the one of the bunch that failed early and was shelved. It was dusty, dirty, full of spider webs, and missing one little knob, but in otherwise perfect shape. I got it for $200. Guys were offering me $750 for it "as-is" on the way back to the car! To top it off, two tables down from where I got the 576, someone was selling a *complete* set of the transistor/diode plug-in fixtures. Score #2!

It was a good day..... I used up all of my allocated "luck" for that year. :^)

The 576's collector supply transformers primary was dead-shorted. Eventually I was lead to Dean Kidd, who sold me a *brand new* one for $75! Tek even took the bad transformer back for failure analysis!

The HP frequency counter was the longest fix (~2 months). It's all jelly-bean TTL logic (some ECL), but no "brains" at all! Board swapping with a friends unit and some "shotgunning" brought it to back life. The eventual root failure was a single NPN transistor, in a buffer between two stages of the main 500MHz counters, whose beta had dropped significantly. I stuck a 2N2222 in there to check it out, and "there" it remains to this day!

> "If it's no longer broke, Quit fixin' it!" - Paul Grohe ;^)

The Genrad was the "hair-puller" (really made me begin to doubt my troubleshooting skills!). It would continually fail it's self check at the same step. The failure code indicated a certain section of the analog section, which I *knew* was okay. There is not much to the analog section anyways! It is mostly jelly-bean, off-the-shelf 74C series digital logic sitting around a 6502 uProc. After checking *every* analog part (most out-of-circuit), and swapping all of the digital chips, I concluded it *must* be the ROM. It was the only part left that had not been replaced! I posted for a "brain donor" and got a reply. He had two dead units and offered to send me the ROM's to compare and read. I took him up on his offer and copied the ROM, and then transferred it to an EPROM. Voila! The f#@&!#g thing worked! I chased my tail for weeks! It turns out that a few bits in the ROM were corrupted, and the error was subtle enough to cause it to just "trip-up" at that phase of the self-test, even though the hardware was fine. Arrrgghh!! I sent him his ROM's back, with a little "thank-you", and eventually helped him revive his two units. This was one of those "fun" repairs.

Everything else I have was dead, dying or crippled (er, "functionally challenged"). I even had to repair my 475A O'scope before I could use it! (It's a "P-I-T-A" to troubleshoot a scope w/o a scope!)

Too Bad About the Good Old Days

(From: Mike Diack (moby@kcbbs.gen.nz).)

In the days before 'Weirdstuff Warehouse' stopped being weird and simply became boring, a lot of the junkus electronicus they sold bore a sticker stating:

This equipment is guaranteed not to work - should you find that it does, we will be happy to exchange it for something that doesn't.

Treat fleas the same.

(From: Paul Grohe (grohe@galaxy.nsc.com).)

Yep! I bought a lot of "goodies" with that little orange and black sticker!! I resisted the temptation to take it back if it worked. If it did work, I broke it, then fixed it, so then I would not feel so "guilty". ;^)

Harrie's Notes on Repair

(From: Harrie Gulikers (hgu@oce.nl).)

Just want to share my experience on repairing electronic devices in general. After many (most successful) repairments I've concluded the following:

- If I need a schematic, then I'm really desperate, probably have spent too many hours by now on the device.
- Most of the problems were due to bad wiring between components. You must interpret this very general: bad solderdots (most common problem), bad contacts in connector, etc.
- 10 years ago and earlier, warm components were soldered with with straight leads to the solder-dots. After a few years these solder-dots come loose, or make bad contact because the leads vary in length due to temperature variations. Mostly you can see this with the bare eye. Just re-solder all big (warm) components, like transistors attached to heatsinks, big capacitors, coils etc. This works also preventive for future problems. Also, try to bend straight leads.

These bad contacts were the cause for, say 75% of all devices I have repaired for the past 16 years. If (and IF) a component was damaged, it was because of bad contacts.

Take this advice in mind and I hope you can profit from it. Repair shops probably will throw a stone towards my head ;-)

Roger's Comments on Troubleshooting

(From: Roger Pariseau (grinder@west.net).)

The closest I ever came to bench tekking was when I would service electronic organs at a dealer's warehouse. If I spent all day there I'd normally fix upwards of 20 instruments and "check out" several others. Normally I just "ran traps" at churches, auditoriums, schools and homes where I got to five or six instruments a day.

I dealt with intermittents via a little rubber mallet and a can of cold spray!

And, I learned a couple of things:

1. 'Shotgun' a bad circuit.
2. If an amp's outputs are blown, check/replace the speakers also
3. Digital circuits are *not* logical!
4. Never hurry.
5. Check *all* supply voltages first.
6. Check all signal generation and their paths (some organs derived their rhythm section's clock from a generated note - there are similar circuits in TVs).
7. Burn-in your work - it can go out the next day.

It was a great little business until the mid '80s when the Casios and the Yamahas became popular. Now I mostly repair computers with the occasional piece of HiFi gear hitting my bench. Like that damned Sony 100-disc CD player that I can't find parts values for!

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-- end V2.21 --

Safety Guidelines for High Voltage and/or Line Powered Equipment

Version 1.32

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Introduction

Consumer electronic equipment like TVs, computer monitors, microwave ovens, and electronic flash units, use voltages at power levels that are potentially lethal. Even more so for industrial equipment like lasers and anything else that is either connected to the power line, or uses or generates high voltage.

Normally, these devices are safely enclosed to prevent accidental contact. However, when troubleshooting, testing, making adjustments, and during repair procedures, the cabinet will likely be open and/or safety interlocks may be defeated. Home-built or modified equipment, despite all warnings and recommendations to the contrary - could exist in this state for extended periods of time - or indefinitely.

Depending on overall conditions and your general state of health, there is a wide variation of voltage, current, and total energy levels that can kill.

Microwave ovens in particular are probably THE most dangerous household appliance to service. There is high voltage - up to 5,000 V or more - at high current - more than an amp may be available momentarily. This is an instantly lethal combination.

TVs and monitors may have up to 35 kV on the CRT but the current is low - a couple of milliamps. However, the CRT capacitance can hold a painful charge for a long time. In addition, portions of the circuitry of TVs and monitors as well as all other devices that plug into the wall socket are line connected. This is actually more dangerous than the high voltage due to the greater current available - and a few hundred volts can make you just as dead as 35 kV!

Electronic flash units and strobe lights, and pulsed lasers have large energy storage capacitors which alone can deliver a lethal charge - long after the power has been removed. This applies to some extent even to those little disposable pocket cameras with flash which look so innocent being powered from a single 1.5 V AA battery. Don't be fooled - they are designed without any bleeder so the flash can be ready for use without draining the battery!

Even some portions of apparently harmless devices like VCRs and CD players - or vacuum cleaners and toasters - can be hazardous (though the live parts may be insulated or protected - but don't count on it!

This information also applies when working on other high voltage or line connected devices like Tesla Coils, Jacobs Ladders, plasma spheres, gigawatt lasers, hot and cold fusion generators, cyclotrons and other particle accelerators, as well as other popular hobby type projects. :-)

In addition, read the relevant sections of the document for your particular equipment for additional electrical safety considerations as well as non-electrical hazards like microwave radiation or laser light. Only the most common types of equipment are discussed in the safety guidelines, below.

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Safety Guidelines

These guidelines are to protect you from potentially deadly electrical shock hazards as well as the equipment from accidental damage.

Note that the danger to you is not only in your body providing a conducting path, particularly through your heart. Any involuntary muscle contractions caused by a shock, while perhaps harmless in themselves, may cause collateral damage. There are likely to be many sharp edges and points inside from various things like stamped sheet metal shields and and the cut ends of component leads on the solder side of printed wiring boards in this type of equipment. In addition, the reflex may result in contact with other electrically live parts and further unfortunately consequences.

The purpose of this set of guidelines is not to frighten you but rather to make you aware of the appropriate precautions. Repair of TVs, monitors, microwave ovens, and other consumer and industrial equipment can be both rewarding and economical. Just be sure that it is also safe!

- Don't work alone - in the event of an emergency another person's presence may be essential.

- Always keep one hand in your pocket when anywhere around a powered line-connected or high voltage system.

- Wear rubber bottom shoes or sneakers. An insulated floor is better than metal or bare concrete but this may be outside of your control. A rubber mat should be an acceptable substitute but a carpet, not matter how thick, may not be a particularly good insulator.

- Wear eye protection - large plastic lensed eyeglasses or safety goggles.

- Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current, or get caught in moving parts.

- Set up your work area away from possible grounds that you may accidentally contact.

- Have a fire extinguisher rated for electrical fires readily accessible in a location that won't get blocked should something burst into flames.

- Use a dust mask when cleaning inside electronic equipment and appliances, particularly TVs, monitors, vacuum cleaners, and other dust collectors.

- Know your equipment: TVs and monitors may use parts of the metal chassis as ground return yet the chassis may be electrically live with respect to the earth ground of the AC line. Microwave ovens use the chassis as ground return for the high voltage. In addition, do not assume that the chassis is a suitable ground for your test equipment!

- If circuit boards need to be removed from their mountings, put insulating material between the boards and anything they may short to. Hold them in place with string or electrical tape. Prop them up with insulation sticks - plastic or wood.

- If you need to probe, solder, or otherwise touch circuits with power off, discharge (across) large power supply filter capacitors with a 2 W or greater resistor of 100 to 500 ohms/V approximate value (e.g., for a 200 V capacitor, use a 20K to 100K ohm resistor). Monitor while discharging and/or verify that there is no residual charge with a suitable voltmeter. In a TV or monitor, if you are removing the high voltage connection to the CRT (to replace the flyback transformer for example) first discharge the CRT contact (under the insulating cup at the end of the fat red wire). Use a 1M to 10M ohm 1W or greater wattage resistor on the end of an insulating stick or the probe of a high voltage meter. Discharge to the metal frame which is connected to the outside of the CRT.

- For TVs and monitors in particular, there is the additional danger of CRT implosion - take care not to bang the CRT envelope with your tools. An implosion will scatter shards of glass at high velocity in every direction. There is several tons of force attempting to crush the typical CRT. Always wear eye protection. While the actual chance of a violent implosion is relatively small, why take chances? (However, breaking the relatively fragile neck off the CRT WILL be embarrassing at the very least.)

- Connect/disconnect any test leads with the equipment unpowered and unplugged. Use clip leads or solder temporary wires to reach cramped locations or difficult to access locations.

- If you must probe live, put electrical tape over all but the last 1/16" of the test probes to avoid the possibility of an accidental short which could cause damage to various components. Clip the reference end of the meter or scope to the appropriate ground return so that you need to only probe with one hand.

- Perform as many tests as possible with power off and the equipment unplugged. For example, the semiconductors in the power supply section of a TV or monitor can be tested for short circuits with an ohmmeter.

- Use an isolation transformer if there is any chance of contacting line connected circuits. A Variac(tm) (variable autotransformer) is not an isolation transformer! However, the combination of a Variac and isolation transformer maintains the safety benefits and is a very versatile device. See the document "Repair Briefs, An Introduction", available at this site, for more details.

- The use of a GFCI (Ground Fault Circuit Interrupter) protected outlet is a good idea but may not protect you from shock from many points in a line connected TV or monitor, or the high voltage side of a microwave oven, for example. (Note however, that, a GFCI may nuisance trip at power-on or at other random times due to leakage paths (like your scope probe ground) or the highly capacitive or inductive input characteristics of line powered equipment.) A GFCI is also a relatively complex active device which may not be designed for repeated tripping - you are depending on some action to be taken (and bad things happen if it doesn't!) - unlike the passive nature of an isolation transformer. A fuse or circuit breaker is too slow and insensitive to provide any protection for you or in many cases, your equipment. However, these devices may save your scope probe ground wire should you accidentally connect it to a live chassis.

- When handling static sensitive components, an anti-static wrist strap is recommended. However, it should be constructed of high resistance materials with a high resistance path between you and the chassis (greater than 100K ohms). Never use metallic conductors as you would then become an excellent path to ground for line current or risk amputating your hand at the wrist when you accidentally contacted that 1000 A welder supply!

- Don't attempt repair work when you are tired. Not only will you be more careless, but your primary diagnostic tool - deductive reasoning - will not be operating at full capacity.

- Finally, never assume anything without checking it out for yourself! Don't take shortcuts!

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Safety Tests for Leakage Current on Repaired Equipment

It is always essential to test AFTER any repairs to assure that no accessible parts of the equipment have inadvertently been shorted to a Hot wire or live point in the power supply. In addition to incorrect rewiring, this could result from a faulty part, solder splash, or kinked wire insulation.

There are two sets of tests:

- DC leakage: Use a multimeter on the highest OHMS range to measure the resistance between the Hot/Neutral prongs of the wall plug (shorted together and with the power switch on where one exists) to ALL exposed metal parts of the equipment including metallic trim, knobs, connector shells and shields, VHF and UHF antenna connections, etc.

  This resistance must not be less than 1 M ohm.

- AC leakage: Connect a 1.5K ohm, 10 Watt resistor in parallel with a 0.15 uF, 150 V capacitor to act as a load. Attach this combination between the probes of your multimeter. With the equipment powered up, check between a known earth ground and each exposed metal part of the equipment as above.

  WARNING: Take care not to touch anything until you have confirmed that the leakage is acceptable - you could have a shocking experience!

  The potential measured for any exposed metal surface must not exceed 0.75 V. This corresponds to a maximum leakage current of 0.5 mA.

  Note: A true RMS reading multimeter should be used for this test, especially where the equipment uses a switchmode power supply which may result in very non-sinusoidal leakage current.

If the equipment fails either of these tests, the fault MUST be found and corrected before putting it back in service (even if you are doing this for your in-laws!).

Checking for correct hookup of the Hot, Neutral, and Ground wires to the AC plug should also be standard procedure. There's no telling how it may have been scrambled during a previous attempt at repair by someone who didn't know any better or by accident. Unlike logic circuits, black is NOT the standard color for ground in electric wiring! :)

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-- end V1.32 --

Sam's Repair Briefs - Complete: 1 to 100

Version 2.00e

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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What are the Repair Briefs(c)?

This series presents case studies of selected repair problems from my archives. (Archives sounds more impressive than scribbled notes and schematics, doesn't it?). I hope that these summaries are useful for those of you are interested in tackling your own repairs. These will NOT be of the form: "replace C418 when vertical size is reduced on HyperTech TV chassis HT312". Rather, they will document specific but common problems with TVs, VCRs, CDs, computer peripherals, etc. The symptoms, testing, diagnostic procedure, repair procedure, and comments will be included so that you can learn from my approach (and my screwups). If you want specific solutions to well known or repeat problems with your RCA or Zenith, then the repair professionals who frequent this group will be in a better position to help since they work on many of the same line of equipment on a regular basis. However, if you want to develop a general diagnostic approach, then this series may provide some tips and insight based on theory and experience. Not all of these are exciting cast-of-thousands repairs. Many tend to be mundain but address common problems with consumer electronic equipment. You will no doubt recognize some as directly pertaining to some appliance or electronic device that you had repaired (or junked) in the past. There will probably even be some of those 'dogs' that we all hate - the problems that never seem to go away. In any case, these will all be based on my true experiences with minimal embellishment.

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Repair Brief #1: Daisy Wheel Printer - Carriage Gets Stuck

Patient: Panasonic KX-P3131 Daisy Wheel PC printer.

Symptoms: After some random amount of printing, the carriage would get stuck and just twitch instead of moving across the platen.

Testing: Using its internal test function, I let it print out until the problem ocurred.

Once the problem ocurred, the carriage would just kind of twitch back and forth. Grabbing it, it was obvious that the stepper motor was providing no effective power. Since this is usually indicative of a missing phase to the stepper motor, I immediately suspected either:

- Bad connection - cable or soldering.
- Bad driver.
- Bad motor.

Since it was intermittent with no relationship to time, heat, position, etc., this is most likely (1).

I then removed the cover to gain access to the circuit board and motor connections. It was necessary to defeat the cover interlock to get it to come one. Now, to get it to screw up again.

I left it printing out the ASCII character set and got a byte to eat. When I came back it was busy gouging a hole in the paper. So now for the critical test: Will pressing on the stepper motor connector cause a change? The answer is --- Yes! The carriage started moving again meaning that it is likely a bad connection.

Of course, to gain access to the underside of the circuit board required removing a zillion screws and the entire mechanical assembly. But once this was accomplished - immediate gratification. There were obvious bad solder joints around several pins of the stepper motor connector. I resoldered these and few others that were suspicious and inspected the rest of the board. If only I could remember which screws went where! Apparently, the continuous vibration of the assembly eventually caused the connections to fail. This is not likely a heat related problem though it could be just plain bad quality control.

Once reassembled, I left it happily printing out page after page of ACSII characters. Then, just to be sure, I connected an old laptop and printed a few pages of Repair Notes.

Comments: This is one of those dream problems since their solution is so obvious and so definitive. There is no doubt that the cure will last. Unfortunately, the tough 'dogs' are the ones you lose hair over.

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Repair Brief #2: Panasonic PV1461 VCR with Dead Power Supply

Patient: Garage Sale Panasonic PV1461 VCR (Asked $10, offered and accepted $5).

Symptoms: The power supply had been identified as being bad by the seller.

Testing: I plugged it in - nothing as expected. This was to verify that all functions and display were dead.

I removed cover and found that the main fuse had been removed. Hmmm, this usually means catastrophic power supply problem. This is the typical Panasonic switching power supply. Well, I have completely rebuilt these, so no biggie. (Of course, there was one I blew up, but that is another story).

The hardest part was removing the power supply. It is buried underneath the bottom circuit board necessitating the removal of this board and the front panel. Do you think they design these things this way to discourage tampering? There was plastic in specific places to prevent removal from the top even though it would have been trivial to design for easy removal. I disconnected power supply from VCR. Fortunately, this was just a connector.

I tested across switchmode power transistor with ohmmeter - dead short C-B-E.

I looked in ECG for 2SC3890 - ECG379 with that infamous # indicating an electrical but not mechanical match.. Since I had some BU406s, I looked this number up in ECG guessing that the BU406 would be have similar ratings and be usable in a small switcher - guess what, ECG379. The difference is that the 2SC3890 is totally plastic while the BU406 is a metal tab TO220. OK, so I cut out a bit of mica to serve as an insulator and used a nylon screw. This is temporary as I intend to get the proper replacement (2SC3890 - $2.15 from MCM Electronics).

I also checked continuity from the main filter cap to the C and E leads of the transistor to rule out a blown fusable emitter resistor. I checked other semiconductors as well - all fine as far as my VOM was concerned. Fortunately, the only casualty seems to have been the transistor and the fuse was fast enough to prevent any damage due to its shorting.

To power up the supply, I initially used a Variac with a 25 W light bulb in series with the line. Note that since I do not have any 1.6 A fuses, the fuse is shorted. The light bulb will provide the current limiting for now. I use my dual outlet widget box plugging in the supply to one outlet and a lamp with the 25W light bulb into the other (the outlets are wired in series for exactly this sort of application). This whole rig was plugged into an isolation trasformer for safety.

I then identified the primary output and connected my VOM to this. It would be in the range 5-15 V, probably 12 V based on the filter capacitors (16 V).

All set? Crank up power. Output comes up to about 13 V at around 50 VAC in. Light Bulb hardly flickered. If it had not stopped in the 12 V range, this would either indicate that there was a problem in the regulation or that a load was needed. Had this happened, I would have put a 22 ohm 5W resistor on this output and retested. Cranking up the Variac to full voltage causes no noticeable change to output.

OK, connect VCR. Lights, VCR, power! Nothing. Light bulb is now glowing but there is no indication of life from front panel and no action from motors.

Hmmmm.

Examining the nameplate, the expected power consumption is 29 W which is way more then one can get through a 25 W light bulb. (Expect to be able to draw maybe half of the bulb's ratings). So I go hunting for a 60 W light bulb.

This time the motors twitch and the front panel comes alive. Inserting a tape and holding my breath - tape starts to load but then aborts with poweroff. Go for it! The Variac had been set at about 90 VAC, so I crank it up to 120. Now everything works. I go dig up a TV and verify that the basic functions are ok. Doesn't appear to even need much cleaning. Even the idler tire appears to be in good condition.

Add a 2SC3890 and box of 1.6 A fuses to my next MCM order.

Comments: this is the sort of repair that might not pay for a professional shop to undertake. The time to disassemble the VCR, identify the problem, replace the transistor and fuse, and verify correct operation could be excessive, or at least has the potential to be excessive. If it turned out to be more than a transistor and fuse or was beyond repair, they might have to eat the cost in time and materials. In addition, there is no real way to guarantee that other marginal components won't cause the problem to repeat a week or month in the future. Upgrade/repair kits are available for these supplies and would probably represent the lowest risk investment for a permenant repair. No doubt, the previous owner had taken it in for repair and been quoted a rediculous price to replace the entire power supply module.

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Repair Brief #3: USR Data Modem Won't Dial

Patient: USR 14.4 K baud external data modem.

Symptoms: Modem works in most respects but when it goes to dial, the tones are superimposed on the dialtone which never goes away.

Testing: I plugged it into an old laptop kept for the specific purpose of testing of random external peripherals. Indeed, the AT commands worked just fine but tone dialing did not work. Interestingly, pulse dialing would work 90% of the time but a connection was never completely established.

At this point, I put a scope on each side of the 600 ohm coupling transformer. A normal 2 or 3 volt p-p signal was present on the logic side of the transformer during dialing. However, a much attenuated signal was present on the phone line side - probably .2 V p-p or so. I probably could have used a set of crystal headphones to just listen to the relative amplitudes of the logic and phone line side signals instead of a scope. (Magnetic headphones would have too low an input impedance.)

On a hunch, I did try replacing the transformer with one from my junkbox but as expected, this produced no change.

The phone line is a nasty place for electronic components - 90 V ringing signal, lightning strikes, pickup of EMPs (from nuclear bombs), etc. The first place to look for fried components is therefore the phone line circuitry. For a modem and no schematics, with the possible exception of the power supply, it is also probably the only place where there is any real chance of finding a problem.

Since there are a manageable number of discrete parts that connect the phone line to the transformer, an ohmmeter check was in order. Unfortunately, many of them were really itty bitty surface mount parts. After a couple of go-arounds, this proved to bear fruit as an SO23 device marked on the circuit board as a diode turned out to be shorted though I seem to have missed it on my first pass. Carefully unsoldering the almost microscopic part confirmed that it had turned into a dead short.

Note: markings for these devices were not always complete. Nonetheless, basic ohmmeter checks could be made with enough confidence to tentatively eliminate all except the single shorted diode.

Removing the diode and retesting proved that dialout was possible and that normal communications at 14.4 K baud was normal. The markings on the diode did not permit me to identify whether it was a simple diode or a zener. I still do not know what function the diode actually served.

I replaced it with a 1N4148. The modem has been tested to confirm that it is not damaged by the ringing voltage. Since the application does not require dial-in access, I do not know if there is still a problem with this mode.

Comments: Where a problem can be narrowed down to a small section of circuitry, ohmmeter tests can prove successful in identifying parts that have failed shorted or open. This may be the only option when confronted with a device for which obtaining a schematic would be difficult or impossible - or not worth the effort. While we might consider a modem to be a throwaway item these days, the time need to do basic testing of the phone line side components is minimal and, as in this case, may be all that is needed.

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Repair Brief #4: RCA 26" TV Very Dead

Patient: RCA 26" TV, Chassis CTC131A/M. Garage sale acquisition ($5). Previous owner explained that it failed to work after power was restored following a power outage due to a thunderstorm. They were more than happy to have me remove it from their garage.

Symptoms: Dead. Located fuse - blown due to short (not overload). Blackened inside glass. Note: appearance of blown fuses is very significant.

Testing: Replaced fuse. This was in hindsight a mistake without using a series light bulb to limit the current. The new fuse did not blow but the lights dimmed momentarily. Apparently a fusable resistor had sacrificed itself to protect the fuse.

Without schematics, I decided to trace the AC line circuits. These were partially buried inside a metal box with some big fat resistors on a separate board.

Measuring across the power resistors revealed that one 2.7 ohm resistor was now open. That explained the new failure. Some further searching located a TO3 power transistor inside the metal shield. Measuring C-E came up 0 ohms. This was not the horizontal output transistor but was rather in the power supply - a flyback switching supply separate from the deflection circuits.

The transistor was marked with an RCA part number. My handy dandy ECG Semiconductor Master Substitution guide listed it as a typical 350/800 volt switching transistor. I did not have an exact replacement but figured that a horizontal output transistor would probably work at least temporarily in this application, so I used my favorite BU208A in its place.

As a temporary substitute for the fusable 2.7 ohm resistor, I put in a regular power resistor with the understanding that a safe replacement would be installed before the TV was buttoned up.

Now for the test. This would be classic use for a series light bulb and/or variac for the initial power on. However, for whatever reasons, I did not bother - and lucked out in this case. The TV came on just fine. The only adjustments needed were to focus and horizontal position - totally unrelated to the original problem.

The recommended ECG replacement for the chopper transistor was an ECG385, a 350 V 10 A switching transistor. I elected to put in an ECG386 to give myself a little extra margin. The ECG386 is rated at 500 V and 20 A. Other specifications were similar or superior.

Comments: Since most modern consumer electronics are powered all the time even if the power switch is off, it is always a good idea to unplug everything during a lightning storm or if a blackout occurs. A nearby lightning strike can easily impose huge transients on the AC line. When power is restored following a failure, the initial power-on may not be clean including mini-brownouts, spikes, multiple cycles, etc. These are all hard on switching supply based equipment. Now, I fully realize that few of ua actually follow this advise. (Of course, other screwups can result in similar damage. I once was given a bag of dead stuff from a friend of a friend who had been doing a little wiring in his house. Somehow he managed to connect 240 V to a 120 V circuit - only for a second....)

This is one example where a failure with the most catastrophic impact on performance (it was dead, after all) has among a very simple solution (transistor, resistor, fuse). I much prefer these to the 'color noise on channels in the UHF band' variety.

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Repair Brief #5: Pioneer CD Changer will not Recognize Disc

Patient: Pioneer PDM601 6 Disc CD Changer rejects all CDs.

Symptoms: Disc is loaded from cassette, disc spins at various speeds for about 5 seconds, then it gives up, unloads this disc and loads next until there are no more.

Testing: Testing consisted of removing cover and observing behavior. Everything appears to happen normally except that disc directory is never read.

This is one of those problems that has an obvious cause and solution once experienced, diagnosed, and repaired the first time. I will outline my approach the first time I came across this one describing this particular case history from the perspective of the novice wannabe repair expert.

Since the disc is loaded and spins, it is likely that the laser and focus servo are functioning (though perhaps no guarantee, but I hope to get to that in another episode).

At first, I suspected (incorrectly) that an adjustment was needed, so I did what I always now warn against - turning any of the internal controls. I thought that they had been returned to the original settings but was not positive.

Pioneer CD players usually include a test function - a button on the main circuit board marked 'TEST'. Normally, test functions are invoked either by simply depressing the button or by holding it depressed when power is turned on. In this case I discovered that if this button were depressed when the unit was switched on, the display would change and certain front panel buttons would now function controlling the servo circuits directly.

(Note that the approximate duration of the previous paragraph was about 1 year as I put the thing aside unable to make any headway during the first go-around.)

After some experimentation with the front panel controls, I came to the conclusion that:

- STOP turns all servos OFF.

- TRACK FWD enable FOCUS servo (and loads disc 1 in changer).
- PLAY enables SPINDLE servo.
- PAUSE enables TRACKING servo (and PLAY mode).
- MANUAL SEARCH FWD or REV to move Laser head.

Playing with these for awhile revealed that it was possible to move the laser pickup, engage the focus servo, and make the disc rotate, Further experimentation confirmed that the internal controls were more or less in their correct positions - tracking offset could make the pickup slew from one end to the other, for example.

All this was leading nowhere until I accidentally happened to engage all servos in the middle of a CD - and the track display suddenly appeared. I reached for my headphones and confirmed that the CD was playing, just fine.

A little further investigation allowed me to determine that the CD would play fine from about the middle to the end but would get progressively noisier when moving toward the starting track and would be totally unplayable at the very start.

Now, what could depend so fundamentally on track position? Well, there are two possibilities: spindle motor speed and PLL frequency. A little careful tweaking of PLL center frequency had little effect.

One thing I noticed was that one of the servo driver ICs was running quite hot. This should have raised a red flag but again, this was the first time I had seen this problem. I also observed that putting a heatsink on the IC and blowing on this would permit the disc to play error free much closer to its start.

So now, you are saying, "what a moron, everyone knows that Pioneer CD spindle motors are crap". The confusing thing here was that the spindle motor was not dead, just marginal. So, all basic observations came up negative.

Anyway, back to the saga. Suspecting the driver IC, I obtained a replacement from MCM Electronics and swapped it. No change. Measuring motor voltage showed a maximum of 1.7 V or so at any time including startup. Since the driver is known now to be good and power was confirmed to be stable, I started to suspect the motor.

Disconnecting the spindle motor and cycling the player revealed that the driver was putting almost 10 V on the motor terminals but the motor was no doubt partially shorted and dropping this to less than 2 V with the consequential high power dissipation in the driver.

Now for the long shot. While the player was attempting to spin up and read the disc directory, I gave the motor a squirt of degreaser through its ventilation holes. The motor took off - went totally overspeed. Power off. Wait for degreaser to evaporate. Try again. Now, the directory came up the first time even though my internal controls were still no doubt not perfectly tweaked. All functions worked perfectly. For the first time is about 2 years, the player was producing music (without the help of TEST mode!

I then performed a normal alignment of the internal controls (but this is another story).

Measuring the motor voltage now showed greater than 5 V at spinup and a range of 2-.5 V between start and end of disc.

Comment: At this point the proper course of action would be to replace the spindle motor. However, since this is my CD player and replacing spindle motors is sometimes a pain, I will just keep an eye on performance. A pretty good indication of the motor's state is the time to spinup. If this deteriorates again I will be forced to replace the motor. For now, it continues to be satisfactory.

The initial confusion here was due to the fact that the motor was not totally dead, just weak enough to cause a problem with the inner tracks and more importantly, the directory. This is one of those cases where the old style turntable with a bad weak motor would have been much easier to troubleshoot,

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Repair Brief #6: Dead Power One 400 W Multiple Output Switcher

Patient: Power One multiple output 400 W switching power supply.

Symptoms: Totally dead. No schematics available.

Testing: Applying power produces no output. Only observation is that lights flicker indicating the input filter capacitors are charging so this eliminates a blown line fuse as a possibility.

Unfortunately, this unit is not what I would call a 'simple switcher'. In addition to the main switchmode transistor, there are 2 other power transistors, a uA723 IC regulator, countless discrete transistors, resistors, capacitors, some components I cannot identify. This is all on the primary side of the transformer. Tracing the circuit is virtually out of the question due to its complexity. The only good news is that I have several identical units so I can compare readings between the bad one and a working unit. Powering with a Variac produces similar lack of any output. This is not a case of the outputs shutting down - there is simply no startup.

First check: power to main filter caps, continuity of thermal protector, power to uA723, power to switchmode power transistor. These all are fine.

Next, checked components around input including power transistors, large resistors (suspecting a startup problem), capacitors, etc. All ok.

Finally, about to give up, I decide to just test resistance across a more or less random selection of components. Everything is identical until I put my meter across a 6.8 M ohm resistor. On the good unit, this measures above 1 M ohm. On the bad unit, it measures about 40 K ohms. I unsolder components around this resistor until I located a 2N4124 transistor that makes a difference when removed. Testing on the x1 range of my VOM it tests fine but on the x1K scale, there is significant leakage in the reverse biased junctions. Comparing with a nearby 2N4124, this is definitely not the normal characteristics of a 2N4124. The 2N4124 is a general purpose transistor so I replaced it with a handy 2N3904.

Powering with a Variac, the supply now comes up fine. I have no idea of the function of the bad transistor.

Comments: This might be called a blind repair. Like bad connections, the failure mechanism and function of the bad part will probably never be known. It is not known whether the transistor was marginal to begin with and ts characteristics just drifted over time, or whether it went bad.

The basic assumptions which permit this technique to work at all are that for a sudden change in behavior in a system with mostly discrete parts, one of these parts has changed its resistance enough that an ohmmeter check has a chance to find it and that the circuitry is interconnected enough that checking a relatively small subset of node combinations has a good chance of locating the bad part.

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Repair Brief #7: Goldstar CR820U TV with no Color

Patient: Goldstar model CR820U 19" color TV. Paid $1 at garage sale. If I can repair it cheaply, it will be given to someone in need free or for a nominal charge.

Symptoms: Basically operational except absolutely no color - not even any color noise between channels. Color and Tint knobs have no effect. In addition, brightness control has very limited range - brightness slightly too high. Several other minor problems including cracked tuner knob, dirty tuner, broken antenna wires.

Testing: This involved tuning local strong channels, adjusting fine tuning, tweaking AGC, etc. Under no circumstances was there any hint of color in the picture or between channels.

Fortunately, such symptoms narrow down the possible area of investigation to the chroma decoder circuitry. Searching the circuit board for a likely subsystem, I found that the set uses a TA7608P chroma chip. Fortunately, this chip is listed in my ECG Semiconductor Master Replacement Guide with a cross to ECG1532. Naturally, I suspect the IC at this point but know better than to just go out and find a replacement - I have been burned in this way with an RCA TV color problem - maybe I will say more on that in another Repair Brief. While the ECG does have a pinout, this does not really provide enough information to probe the circuit.

Off to the library to obtain the Sam's Photofact for this set. $0.75 poorer, I copied the complete schematic and another interesting page - a chart showing the resistances to ground for all pins on all of the intergrated circuits used in the TV. One item I forgot to look for was the block diagram that may have been included of the TA7608P chip. Oh well.

One thing I did try once armed with the Sam's was to attempt to tweak the subbrightness control. Even this had very little effect. OK, on to the fun stuff.

First test: confirm that the resistances of the circuit match those printed on the resistance chart. The chart specifies a DMM that applies less than .1 V on the ohms scales (to prevent forward biasing of any semiconductor junctions). Hopefully, my DMM satisfies this requirement. First step: make sure the main filter capacitor is discharged before making any resistance measurements. Done. Unfortunately. these tests do not reveal anything amiss.

Tests of this type are not guaranteed to find any problems. However, there is a fair chance that a shorted or open part would show up as a bad reading in the near that part. In my case, if there were any bad parts, the circuit topology prevented this simple resistance test from detecting them.

Now for the live tests. I don't have a color bar generator so I just have to hope that a broadcast channel will provide a signal that is close enough.

In the interest of safety, all the following tests are made with the set powered off of my isolation transformer.

Voltage measurements were inconclusive. Although some where off by 20%, this could be due to my non standard input signal. There did not appear to be any particular pattern.

Next, I used a scope to look at the testpoints for which Sam's supplied waveforms. Again, these will be different than the ones using a standard colorbar signal but the overall appearance should enable me to determine if a particular output is dead or the amplitude is way off.

All the waveforms looked reasonable except one - the output of what I deduce to be a gated chroma amplifier. Its output is almost dead. The color reference oscillator (3.58... MHz) looks fine as do the chroma input and color burst gating pulses. All the supply voltages and decoupling pins look fine as well. This doesn't look good for the chip. The signal seems to be getting in but the chroma amp would seem to be dead. Fortunately, I could not locate an inexpensive replacement from my usual sources. The TA7608P is probably obsolete. Even the ECG1532 is not available from MCM Electronics or Dalbani. I did not get to the point of trying ECG directly. You will see why I say 'fortunately' in a moment.

When confronted with a situation of this type, I usually try some experiments.

What would happen if I apply the chroma signal directly to the point in the circuit that is the output of that dead chroma amp? I take a 10K resistor and jump the input of the chip to the chroma amp output (and input to the chroma demodulator.) Now, I have colored stripes on the screen indicating that the chroma demodulator circuit is probably functioning. (Without the color burst to phase lock, I could not hope for anything more). So, it still looks like that bad amplifier. Well, one last desperate effort....

I use my Sam's patented magic spit. This has served in on numerous occasions mostly when locating clock noise, marginal timing, or glitches in high speed digital systems but hey, the world is really analog anyhow. I am not joking. Those who have done serious debugging know exactly what I am talking about. Moisten your finger. Run it up and down the pins on a suspect device. If something changes you have either (1) found a particularly critical or high impedance but normally behaving circuit (for example the frequency determining LC network of an oscillator) or (2) something that is open or on the edge.

Magic spit to the rescue: running my finger (one hand in my pocket, isolation transformer, etc.) over the two rows of pins on the chroma chip proved to yield immediate results. Around the low number pins, the color suddenly appeared grossly overloaded but with some indication of correlation with the picture. This is the first time I have seen any indication of picture related color. Hum.... OK, now to narrow it down. I take an insulated wire, and strip both ends. Holding one bare end with my fingers, I touch each of the pins in turn of the chip. Touching pin 6 has the most dramatic effect producing the distorted colors. What is connected to pin 6? According to the schematic, it is a 2.2 M ohm resistor to pin 3 and a decoupling capacitor to the power supply. It is unlikely that the capacitor would fail in such a way as to cause this behavior. So it must be the resistor. Rummaging around in my resistor cabinet I come up with a 2.2 M ohm resistor. and tack it across pins 3 and 6 (with power off!).

Now I get distorted color but this looks a lot more like a color TV than what I had before. Time for a better antenna. That helped a little but the picture is way too dark. Well, I did fiddle with the sub-brightness control back when it had minimal effect. Locating the sub-brightness control again, it now functions as expected having more than a sufficient range. When adjusted to produce a picture of normal brightness (with the user control mid-range), the color appears normal. Some additional fiddling with the Color and Tint controls yields a fine looking color picture.

Removing and testing the original 2.2 M ohm resistor confirms an open circuit. Soldering in my replacement completes the repair.

Now to clean the tuner, wipe down the case, repair the knob and antenna....

Total cost $1.77 including original purchase price (I threw in a hypothetical $.02 for the resistor).

As I am writing this, I am watching the Goldstar TV - my trusty RCA has just died after 14 years with no picture (raster and sound ok - that will be another Repair Brief).

Comments: It is always tempting to suspect the expensive or unavailable part first. Very often, as in this case, this proves to be erroneous. Had the TA7608P been readily available at reasonable cost, I would have probably replaced it only to find no change in behavior. This would, however, have saved time.

Be warned that the "Sam's Magic Spit(tm)" approach must be used with caution. You must understand the safety implications of touching *any* live circuit especially with moistened fingers. I use an isolation transformer for debugging. However, even with this precaution, I would think twice before doing this on a live chassis (the Goldstar signal circuits are isolated from the power line).

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Repair Brief #8: Panasonic PV3720 VCR with Erratic Horizontal Video Noise

Patient: Panasonic PV3720 3 head VCR.

Symptoms: Band of what looked like tracking noise would come and go depending on tape being played, speed of tape, whether at start or end, etc. The noise was confined to the top 1/3 of the picture. Its height could vary from just a couple of video lines to a band occupying 20 % of the screen.

Testing: Several tapes were played initially. Problem would be nearly absent with some but severe on others. It was generally worse with EP recorded tapes compared to SP tapes.

I generally do not like problems of this type because one of the more likely possibilities is of a worn video head. This is one of the classic symptoms yet it could have a number of other causes. The approach must be to eliminate as best as possible the alternative causes until the risk of purchasing a new video is minimized.

Alternate #1: dirty heads. Head cleaning with a wet cleaning tape followed by a manual cleaning had little effect.

Alternate #2: tape path alignment. Visual inspection of the tape movement showed nothing out of the ordinary. Tape motion was very smooth and uniform with no wiggling, wavering, or wondering. All tape guides were properly positioned, perfectly vertical (where appropriate) and the tape appeared to be riding at the correct height on the video head cylinder.

Alternate #3: backtension. Insufficient backtension could result in similar problems. Inspection seemed to indicate that backtension was normal. Manually increasing backtension by gently pressing the backtension level to the left made a slight improvement. Increasing the spring tension did the same. However, these were not dramatic effects and backtension is not a critical setting to obtain a clean picture (though it is important to be accurate to minimize head wear and clogging).

Alternate #4: roller guide height. Although visual inspection of the of the tape path alignment proved negative I decided to confirm roller guide height by careful adjustment of the supply side roller guide - carefully noting its original position. (Problems at the top of the picture would be related to the supply side roller guide.) Optimal position for both EP and SP was at the original setting.

This left the video head as a likely candidate and at this point based on the age of the machine, a new video head cylinder (MCM Electronics, ERH433) was ordered and installed. Success! There was no doubt about the improvement. The noise bards completely disappeared and the normal backtension provided more then adequate head-tape contact.

Comments: Subtle problems that eventually point to the video heads are among the more difficult to diagnose with enough confidence to risk ordering an expensive video head and find out that the problem was elsewhere. This was a case of video head wear (as opposed to a mechanical or electronic failure of the heads). The chance of having an identical video head available to swap - which is the best test - is quite small, especially for a 3 head type. If this were a 4 head machine, some meaningful comparisons could be made during playback since a different set of heads is often used depending on tape speed and mode.

Thus, unless there is visible damage to the video heads or something like an open winding that could be revealed by simple testing, it comes down to eliminating as best as possible the alternatives until only the head remains a likely possibility.

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Repair Brief #9: Original ATT Touch Tone Phone will not Dial

Patient: Classic ATT Touch Tone Wall Phone. 'Battlewagon' usually considered indestructible.

Symptoms: Everything worked fine except dialing. For some buttons, dial tone would not go away. For others, tones would be accepted but would be erratic and incorrect digits. Certain tones sounded weak or single frequency.

Testing: All buttons were tested. It was found that the problem was not even consistent as some buttons would not work all the time.

While the internal wiring of one of these old phones is intimidating, the basic tone dialing circuitry is an amazing example of simplicity. About the only things that fail yet still permit some tone generation are the pot core coils that determine tone frequency. Therefore, this is the first thing to check.

Sure enough, the core that deals with rows has split where the two halfs are joined. This seems to be a common problem due to both the age and brittle cement used on some revs of this model phone, and probably, as a result of rough treatment when hanging up the handset.

These cores must be aligned before being glued back together. In addition, there is an adjustment plug which may need to be tweaked. I align by ear as follows: Put a known good tone dialing phone and the bad phone on the same phone line. Depending on which core is bad, depress either an entire (same) row or column of buttons on both phones. (Adhesive tape is handy to hold down the buttons unless you have four hands.) By depressing the entire set of buttons, you are disabling the other tone generator so you hear a pure tone. Without turning the fine adjustment plug (assuming it was not disturbed; if it was, set it mid-range or the same as the one in the other core), rotate the loose core top until a zero beat is obtained. As your rotate the core, you will hear the tone change. As it approaches the correct setting, you will hear the tones beat against each other. When you are set correctly, the pitches will be equal and the beat frequency will go to zero. Mark the position of the core with a pen or pencil and then glue with Epoxy or other general purpose adhesive (around the outside - not on the mating surfaces as this will affect the tone frequencies). After the glue sets, confirm and adjust the plug core if needed. These cores use a strange triangular core tool - I made mine by filing down an aluminum roofing nail (do not use a ferrous material).

Comments: Those classic ATT touch tone phones are virtually indestructible. However, broken cores (or actually, just broken joints on the cores) are common but easily repaired once you know what to look for. Setting the tones by referencing a known good phone seems to be a very reliable technique as the zero beat permits an adjustment to better than .1%. Note that if the reference phone is a more modern (and flimsy digital one), then pushing multiple buttons may not work as it does with the old analog models. Setting the frequency using the normal dual tones will work - it is just not as easy.

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Repair Brief #10: Pioneer PD5100 CD Player Trashed

Patient: Pioneer PD5100 single disc CD player in really sad shape. Garage sale acquisition paid $2. Probably paid too much. This episode is more aptly called a restoration rather than a repair. Perhaps a feature length saga. The challenge was irresistible.

Symptoms: Tray wasn't even on track, just sitting inside; Flapper ripped off of mountings, electronic condition unknown. It is obvious that the owner had attempted something - it would be generous to call it a repair - and was unable or did not bother to get it back together.

Testing: Not applicable at this point. With loose parts removed, power was applied to determine if there was any hope at all. At least the front panel came alive and pressing Eject resulted in the tray loading motor spinning.

In order to attempt to play a disc, the controller needs to think that the tray is closed. It will then go through its startup cycle. In the case of this player, there is a limit switch - somewhere. Rather than trying to locate it, I decide to put the tray back on its tracks. This is easy but there is still something wrong as it jams when the Eject button is pressed. So be it, leave that for later. At least the limit switch will be activated. Rummaging around in the pile of lonely parts removed from the carcass, I locate the clamper cover with the magnet. I pop in a garbage CD, put the clamper cover on top (make a mental not to press Eject under any circumstances as the tray, disc, cover, and anything else that is not screwed down would probably fly across the room) and press the power button. Some success - the disc spins and the directory is correctly displayed. The display came up rather quickly indicating that most of the optics and servos cannot be far out of alignment. This is quite remarkable!

With mounting anticipation, I connect the audio outputs to my amplifier and press play. The disc spins and makes repeated attempts to start playing at track 1 but it is obvious that something is terribly wrong. Attempting to play other tracks results in similar behavior.

The pickup appears to actually move to the general vicinity of the correct track but is unable to locate and lock onto the time/track that is selected. Pioneer CD players perform a very audible search to home in on the correct disc location; there was no evidence of this search.

I next attempt careful adjustment of the servo controls. Note that I do not expect this to help the problem based on how quickly the directory was displayed. However, the tracking could still be off and with care, there should be little risk of making things worse. Who knows what controls the owner touched in a misguided hope of performing a miracle. First, I marked the *exact* position of each control with a felt tip pen. This will get me back to the supposedly good positions no matter what. The only controls that would likely have an effect are those related to tracking. Careful tweaking of tracking balance, tracking offset, and tracking gain have no detectable effect. I put them back in their original position and verify that the player still recognizes the disc. So far so good?

At least the moron who butchered this thing does not seem to have touched the electronic adjustments.

At this point what do we know? Well, we know that all of the major components of the optical deck work including the laser, photodiode array, fine focus and tracking voice coil actuators, and spindle motor. These are all needed to read the disc index. The spindle motor, a common problem in Pioneer CD players is fine as its toughest task is at disc startup where the speed is greatest. Since the disc index is located at the very inner extent of the disc, we do not know if the sled servo (coarse tracking) is working correctly, only that it is doing something - it resets to the inner track if manually moved away and it does move to the approximate position of the selected track.

Well, Pioneer CDs have a TEST mode. Where is the button? I hunt all over for the little button and am about to give up when there it is! Hidden by the cables to the front panel.

OK, press TEST while switching on power. Now I have control of the servos. A little experimentation confirms that focus and spindle rotation seem to be functional: (of course, we knew that, right?) With no disc in place, the focus search routine is initiated by pressing TRACK FWD. The disc will only spin if focus lock is achieved and this is confirmed with a disc in place. So far nothing new. I am able to move the pickup back and forth on its tracks by pressing SEARCH FWD and REV.

However, when entering the correct sequence to play at an arbitrary point on the disc, weird things happen. If I use the SEARCH FWD and REV buttons to move the pickup to a particular spot on the disc, press TRACK FWD to close the focus servo, PLAY to start spindle rotation, and then PAUSE to actually start playing, the track and time info is only displayed for an instant. Then, the pickup seems to move toward and bump against the inner limit. Sometimes, a couple of times are displayed in rapid succession which are not sequential as they should be. In fact, they nearly always are far apart and the second is usually a lower time than the first. Then the display is blank.

Hum, I don't have a schematic so this could be the end of the line. But, I do see one chip on the circuit board that is getting unusually hot and I know from past experience that it is a servo driver - TA8410K. I have absolutely no idea if it is related in any way to the problem or really, for that matter, what the problem is. I only know that (1) it has only 10 pins and is easy to replace, (2) I have a replacement in my parts box, and (3) it is getting hot (which may or may not be a fault since I know these type of chips to run at least warm).

Getting to the bottom of the circuit board proves to be a bit harder than anticipated requiring removal of most of the snap type connectors. I guess these are cheaper than real connectors for Pioneer but a pain for servicing (cables are terminated in tinned wires and placed in the connector housing, then a cover is pressed down to lock them in place). I manage to only mangle one of these (cosmetic damage only).

Replacement goes smoothly. Getting all the connectors back in place is loads of fun but the effort is worthwhile! Now, the disc plays on the first attempt. There are still some tracking problems but this is a distinct improvement. In all honesty, I am not sure that the chip made the difference - it could have been a bad connections at one of the connectors. The new chip runs warm, perhaps not quite as hot as the old one, I am really not positive. I put a heatsink on it in any case (as I always do with these chips - just for insurance.

Next I tackle the mechanical restoration. First step: get the tray to move smoothly. Without going into terrible detail, the tray consists of two parts whose relative motion raises and lowers the disc. There appears to be something missing which controls when this raising and lowering takes place as the disc is lowered even before the tray moves into the machine. Sometimes there is a ball that controls this and a little examination reveals a grease trail where such a ball could have been. A corresponding hole in the tray bottom confirms this. I didn't notice any such ball in the parts pile but it could have easily been lost (I later found it near a corner of my workbench) but for now, I located a similar sized steel ball in my steel ball collection. With the ball in place, the tray now moves smoothly in and out and the disc is raised and lowered at the proper time.

Now for the clamper.

This is a much sorrier affair as the clamper is mounted to the deck sheetmetal with a couple of plastic standoffs that have been totally snapped off at their bases. First I try simply glueing them but this does not appear to be solid enough. In addition to the glue, I am able to clamp one down with a metal scrap that I carefully shape and screw down. For the other, I made a splint using a screw through a drilled hole into a neighboring strut. Now the clamper moves up and down at the proper time but the cover disk with the magnet seems to hit the tray. The part that seems to help out has totally disappeared so I take a brass rod and mount it in its place. Even without the rest of the mechanism, this seems to work fine. This rod, wrapped with electrical tape to prevent damage to the disc, prevents the disc from flopping around too much. Disc loads; disc unloads; all is well.

I then went through the electrical servo adjustment procedure as outlined in the CD Player Notes, final tweaking by maximizing the amplitude and stability of the 'eye' pattern. I made the mistake of attempting to touch the 'tangential adjustment' (at least that is what I think it is - without a proper alignment disc, this appears to be very difficult) and spent some frantic minutes until I was able to restore it to its original position. Beethoven's Ninth Symphony comes in handy as it runs almost to the edge of the disc (74 minutes) necessary to access the tangential adjustment. I even risked careful adjustments of the LD - laser power just to determine that it was not at the limit of its power. It was not. I am fairly confident at this point that the adjustments are pretty much where they should be - and they are very close to their original position.

Now the CD player works fairly well though it does not seem to have as much disc defect tolerance as I would expect. I do not know if there is still a fault either optical, mechanical, or electronic as all tests that I can perform without service info seem satisfactory. Considering what the player went through, this has still been a rewarding experience.

Comments: I consider this to be more of a learning experience than a repair. At the outset, I did not expect to be able to get nearly as far as I did. It was fun as such things go.

While I am in favor of home repairs, this is an example of a situation where whoever attempted the repair of a problem due most likely to the bad servo driver IC, totally destroyed any possibility of a professional even going beyond looking at the unit and stating: "Yup, that was a CD player once upon a time long long ago. To whom should I send the flowers?"

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Repair Brief #11: Yamaha R8 Receiver with AM/FM Tuning Problems

Patient: Yamaha R8 stereo receiver, about 4 years old at the time of the failure.

Symptoms: Fm reception is totally dead. Station numbers change erratically, not possible to save presets. Some AM stations work but most do not. This happened without warning - turned it on one day and it was sick.

Testing: This involved methodically checking to see what functions are operational. Incrementing and decrementing of FM station frequencies is not operational in seek mode, only in manual. There is not reception on any FM station frequencies. Incrementing or decrementing AM station numbers across certain boundaries (I forget the exact locations) causes a sudden jump of 800 kHz and may actually jump to an illegal station frequency. Various other modes are non functional including saving of memory presets. Even the hard reset does not store the factory presets.

I purchased the service manual for this unit - a nice piece of documentation and very reasonable - about $12. However, this is an example of modern technology where even schematics, pin descriptions of the various LSI chips, parts lists, etc. are not really adequate when so much depends on firmware (in 3 microcontrollers) which is not provided. It turned out to be difficult to even determine where each function is centered.

Some electrical tests that were performed:

Power supply voltages were verified.

Waveforms were checked on frequency synthesizer chip (LC7210).

Function of PLL charge pump was verified in both AM and FM. Output (VCO control voltage) was consistent with frequency display when reception was possible but not at other times. However, this could not be a problem with the charge pump, only the digital control.

Intermediate 4 bit busses were checked for stuck-at faults - there were none.

The first real clue is that since even some manual tuning functions are faulty, this is probably a digital fault. Presumably in manual, the station display is driven by the microcontroller that drives the synthesizer chip rather than being returned by that chip after a station search. Even in this mode (for AM), there is the issue of the 800 kHz jump. This is not approximate but exact and probably due to a stuck bit representing the 800 place value. The question then became: where was the bad bit? It is not on one of the intermediate busses as these were tested.

Could it be in the tuning microcontroller? Maybe, but then I would expect other functions controlled by this chip to be faulty (like mode setting, etc.) This is not the case. Could it be in the frequency synthesizer chip? Probably as only station tuning functions are defective. Could it be elsewhere? There do not appear to be any other busses or digital control lines that could cause the set of problems that are present.

However, not confident enough of the diagnosis of the faulty LC7210 synthesizer to spend the $25 or so that Yamaha would probably charge and not finding this part in any of my normal mail order sources, I set the receiver aside for a while. I dig out my garage sale NAD for use in the meantime.

A couple of MCM catalog editions later - what's this? LC7210 - $6. I will spring for that. Next MCM order arrives, solder in a socket as I always do where possible. Replacement chip cures all problems!

With 20/20 hindsight, it is almost possible to identify the place inside the LC7210 where the 800s bit bus fault occurs based on the symptoms and the rudimentary block diagram provided in the service manual.

Comments: Although not evident from the description above, this was a frustrating experience even with the service manual because there really was not enough information present to make the logical inferences needed to come to a definitive conclusion as to the defective part. Modern consumer electronics include more and more microcontrollers where the intelligence is buried in firmware and not the hardware itself. Without firmware listings, a microprocessor is just a black box even with pins listings and internal block diagrams. It would be nice if the service manual would at least provide better indications of which functions is located where - identifying the functions of each of the components. (It would also be nice if they were written or at least edited by Americans (in the case of a manual destined for the U.S. market). Some of the translations are, well, a bit strange.

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Repair Brief #12: Sylvania TV with no Horizontal Sync

Patient: Sylvania Color Television, about 20 years old.

Symptoms: Suddenly, the picture lost *all* horizontal hold. There was no evidence of any kind of attempt at lock in. I do not know whether this happened at power-on or while in use.

Testing: With strong signal, it was determined that horizontal hold had no effect. It is as though the H sync is not making it to the lock circuitry. Adjusting horizontal hold makes picture move across screen. Angle of sides of picture changes but there is no lock - even incorrect - at any setting.

Using my isolation transformer, I prepare to scope the relevant signals. I obtain the Sam's for the set. I check for the sync signal at the input to IC400 (I think). It is there. This should be a snap - bad IC! Well, that is exactly what happens - a careless slip of the scope probe and not only a snap, but a crackle and a pop - and now I have no video, no HV, no deflection - nothing.

OK, so what started out as a simple signal problem is now a major (at least cost and pride wise) power supply problem.

Checking the first TO3 transistor I can locate - short - one dead transistor. This is the power supply series chopper.

Checking the horizontal output transistor (HOT) with an ohmmeter - short - second dead transistor.

After removing transistor, I check for rectified line voltage at the input to the chopper - nothing. Tracing this back I soon locate an open fusable resistor.

So, whatever I touched probably caused the HOT to fail (forced on for too great a time can blow the HOT as a single shot event). The shorted HOT probably then took out the chopper transistor.

This is not fun. It is not likely to be inexpensive either. It does seem that no other parts have been sacrificed. Fusable resistors and driver transistors seem ok in so far as my meter is concerned. I still assume that the original problem was caused by a faulty IC400 but this point it is impossible to confirm this since the set id dead-dead.

Damage:

Chopper transistor - $10, horizontal output transistor - $6. IC400 - $15, fusable resistor - $1.

After replacing the components, making sure to use mica insulators and silicone heat sink compound for the transistors, the set comes back alive. Sync is fine. A little touchup of the video background and gain controls (unrelated to the sync problem) and we are done. Ouch.

Comments: The lessons learned here came at a cost - but mostly to my pride. Cascade failures are all too easy to induce through carelessness. Power supply circuits are not forgiving. One would think that probing the sync signal would not be able to kill anything. However, the design of power supply and deflection systems share some common characteristics. One of these is that a single instance of an improper drive waveform can blow the switching transistor as a single shot event - excessive current or excessive flyback voltage. This is a matter of exceeding the safe operating area of the transistor.

What you learn: if possible, make all connections to your test equipment with power off. Insulate all but the last mm of your probe so that any slip cannot cause a short. Work methodically, think things through, don't be over-eager, don't take shortcuts.

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Repair Brief #13: Dead Microwave Oven

Patient: Microwave oven (don't recall the brand).

Symptoms: Totally dead - no front panel display or anything else.

Testing: Plugged unit into live outlet confirms description of problem.

First step: remove cover.

Second step: confirm that HV capacitor is discharged. Although the unit has been unplugged for several days, it never hurts to be careful. Discharge with high value high wattage resistor (well insulated) and confirm with HV voltmeter.

WARNING WARNING WARNING etc. Microwave ovens are probably the most dangerous piece of consumer electronic equipment in terms of potential for electrocution while being repaired. Much more so than TVs, for example.

- There is up to 5,000 V negative with respect to the chassis while powered and stored in the capacitor when shut down. The energy stored in this capacitor is roughly ten times that stored in the CRT second anode of a TV or monitor. A malfunctioning oven that does not blow a fuse is potentially even more of a hazard since the capacitor cannot discharge into the magnetron load after shutdown.

- The available current exceeds 1 A. Depending on the transformer, this may flow until the fuse blows or circuit breaker trips.

- An isolation transformer (assuming you had one large enough) or GFCI will not protect against HV shock since the HV is already on the secondary side of the HV transformer and, as noted, the HV return is the chassis.

- A circuit breaker or fuse is not sensitive enough and too slow to provide any protection for you.

You might think at first that the possibility of microwave exposure is the principal danger. However, unless the door seal, oven chamber, or waveguide or its seals are damaged, there is no way for microwave radiation to escape. This still means that proper precautions should be taken - don't operate the oven for longer than needed with the cover off and don't stand too close.

Third step: test fuse. Open. Since these have ceramic bodies, it is not easy to determine if the fuse died due to an overload or a short by visual examination.

A microwave oven can blow a fuse for several possible reasons. Some of these are:

1. Shorted Magnetron.

2. Shorted capacitor.

3. Shorted rectifier.

4. Defective door interlock switches.

5. Bad Triac (possibly causes transformer core saturation due to operating as half wave rectifier or SCR).

6. Bad transformer (shorted turns cause overload). Fortunately, all but the last two are generally easy to identify using just an ohmmeter. Sometimes, an intermittent or short that occurs only at full voltage will prove elusive, however.

   Some quick checks reveal that the capacitor is a dead short.

   When replacing a microwave oven capacitor, it is important to get a fairly close match for the capacitance. The uF rating of the capacitor affects the microwave power output. Note that the 'working volts' rating on a microwave oven capacitor is not the same as on common capacitors found in other electronic equipment. It is not the maximum voltage permitted across the capacitor but closer to the VRMS rating of the HV transformer. And of course, before you start pulling wires off (1) mark down where they go and (2) discharge/check for voltage on the cap one more time.

   Replacing the capacitor with one from MCM Electronics brings the oven back to life.

   Comments: It is highly likely that the capacitor failed due to a defect in manufacture rather than some other underlying problem in the circuitry. When one thinks about how a capacitor is constructed - rolled up layers of foil and dielectric - it is amazing that capacitors do not fail that often. Any nick, thin spot, etc. represents a point of excess stress and can fail as in this case after considerable use - resulting in a short circuit, dead oven, and unhappy chef.

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Repair Brief #14: Tandy Color TV/Monitor with Hum Bars

Patient: Tandy color TV/monitor found curbside. Unit appears to be in good physical condition. Remote is missing. Well, you cannot have everything.

Symptoms: When first turned on, TV appears to function normally. Why was it tossed? Well, after 30 seconds or so, a pair of hum bars begins to appear in the picture gradually getting worse until horizontal width and sync are affected.

Testing: Using a Variac, there is a point below normal line voltage where set operates perfectly. OK, so I will keep a Variac attached to the unit!

After removing the cover, the first thing to suspect is the main filter capacitor. If this should dry up and lose some of its value, these would be the exact symptoms. Jumpering (with power off) of a known good capacitor I keep for this purpose doesn't change anything. But what is this? A discolored resistor catches my eye. Maybe it is changing value as it heats and causing these symptoms. I wait a reasonable time for the set to cool and measure the resistor - 360 ohms. OK, replace with new one. Expecting this to cure the problem I am disappointed when there is absolutely no change.

Off to the library for the Sams' Photofact. Darn - Sams' does not have a service folder for this model. Nor for any similar models that I can determine (the librarian was very cooperative).

Well, the problem seems to be heat related. I get out my trusty can of cold spray. After going through nearly the entier can, it would seem that there is only one part that has an effect on the hum bars when it is chilled. It is the SCR that is part of the power supply regulator. Rather than simply obtaining a replacement, I decide to trace the circuit to determine, if possible, the possible cause of the problem figuring at this point that the SCR is simply sensitive to heat.

During normal operation, an IC drives the gate of the SCR but what is this?? Until the secondary supplies kick in and provide power to the IC, the SCR is driven by - you guessed it - the mysterious resistor. The other end of the resistor goes to the raw DC on the main filter capacitor. Now that is odd....Since I do not believe much in coincidences, I now start rethinking the significance of this. Maybe that resistor is not quite what it appears to be.

First, I remove it and see what happens: nothing. Power on, power off, nothing.

Next, I momentarily touch the resistor to the circuit pad - the set comes alive. Then I remove it. The set remains alive. And, after several minutes, no hum bars. Hum....

I then try increasingly larger values of resistance until turn on is not reliable - 15 K seems marginal, so I will go with 8.2 K ohms = that is over 25 times what I measured! No wonder there were hum bars indicating regulation problems - that low value resistor was totally overwhelming the poor IC in driving the SCR.

The set is used daily and has been operating without further problems for over 5 years since reviving it. It works great with a $10 universal remote control.

How did the resistor get damaged in the first place? I have no idea - maybe its wattage was slightly underrated and it just finally decided to poop out. I have no way of knowing what the original value was supposed to be or even, for that matter, the wattage.

Comments: resistors can and do change value, sometimes, as in this case, quite dramatically. Without a schematic, there is no easy way to determine when and if this has happened - and what the original value should have been. However, any discoloration, burn, or scorch marks should arouse suspicion. With 20/20 hindsight, these signs may indicate the presence of carbon - a fairly low resistance substance and thus reduced resistance is likely.

And yet again, a $.02 part brings a complex renders a complex piece of equipment inoperative.

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Repair Brief #15: Realistic Portable CD Player Randomly Shuts Off

Patient: Realistic portable CD player, about 4 years old.

Symptoms: Player will shut off at totally random times or sometimes will not recognize the disc. There is a clicking associated with the problem - probably focus search failing.

Testing: Attempting to play various CDs to completion provided no indication that the particular CD or power adapter made the slightest difference. There were some false leads with respect to the latter but these turned out to be strictly coincidence. The lens was inspected and cleaned anyhow with no change.

The first hint of the source of the fault came as a result of an observation that pressing on the cover would sometimes either cause the player to stop in the middle of a disc or allow it to recognize and begin playing a disc when it would not otherwise cooperate.

Perhaps, the interlock switch was not being pressed in far enough. So, rather than open the unit (I really don't like messing with the insides of portable CDs if I can help it - you will see why in a few moments), I glued a bit of plastic to the post that pokes the switch.

This seemed to help. For a few weeks, the problems had for the most part gone away and the owner was a happy camper. Not surprisingly, this fix was only temporary.

Since the quick fix had some effect, it is very likely that I am on the right track. I will have to open it and deal with the switch face-to-face.

This is not too bad except that it is necessary to remove the main circuit board to access the switch which is mounted on a little board of its own. Four screws (large enough to actually see without a microscope) to get the bottom off, another couple to remove the main board. One more and I can remove or at least extend the switch circuit board far enough to inspect its solder connections and get at the switch.

The solder doesn't look too bad but there might still be hairline cracks that are not readily visible. A little reflow and they should be fine. (Problems with solder joints here are not related to heat as in a TV or monitor but rather due to the mechanical stress that is applied to the switch every time the lid is closed.)

Now for the switch. It appears that the cover of the switch can be snapped off relatively easily. The contacts appear somewhat gummy so I clean these and pop the cover back on.

Tests with an ohmmeter now show the switch action to be solid. Wiggling the switch lever and/or the entire switch has no effect.

Great, put it back together and I am done.

After replacing the switch board, main board, and bottom cover - the test.

Fanfare please!

Nothing. The player is dead as a door nail. It now will not even focus and gives up almost immediately.

Off come the screws. Almost immediately, it is obvious what has happened. In replacing the main board, I accidentally squashed one of the printed cables linking the optical pickup and main board, partially severing the cable. In fact, 2 of the 4 conductors are cut. This is the focus and tracking drive cable so it is pretty important. What a pain!

Fortunately, luck is on my side with respect to the location of the break - it is at a non-flexing part of the cable. Therefore, repairing the cable should not be that difficult since once the conductors are connected electrically, they can be coated with a sealer and flexing will not be a problem.

To repair a cable of this type, I have two options: I can attempt to jumper the break with some fine strands of wire or I can go point-to-point from the circuit board to the destination on the optical pickup. However, the latter connections are nearly hidden and would be difficult to solder.

I opt for the first. Using an Xacto knife, I carefully scrape the orange mylar coating from both sides of the break. Then with #30 wire, I carefully solder across the break for each of the conductors. A spring clothespin holds the wire in place during the soldering. The entire affair is then coated with some clear sealer to reinforce it mechanically and provide insulation. It isn't pretty, but it will work fine. For added protection, I add a layer of plastic electrical tape.

Now, finally, reassembling the unit keeping cable routing firmly in mind, there should be no problem.

And, as expected, the player comes back to life and is rock solid with respect to playing and recognizing discs. The oops should have no effect on the expected longevity of the player.

Comments: we all can point to those minor disasters where we have overlooked something where we should have been more careful. Whenever reassembling anything, it is imperative that lead dress (ok, fancy term for how the cables are routed) is kept firmly in the forefront of your mind. It seems that with more and more miniaturization, this is an increasingly important and at times, frustrating consideration. First of all, it is very tempting to say when disassembling the unit 'this is obvious, no need to write it down'. Bad move. Often, it appears much less obvious when putting everything back in its place. I have never quite figured out how they do it during manufacturing - correctly most of the time.

Ignoring cable routing can lead, as in this case, to severed wires. It can also result in shorting between wires or between wires and sharp metal brackets or shields. Broken wires can usually be repaired if they can be located. Shorted signals can result in additional hard-to-locate collateral damage which can really turn your hair gray.

What is even scarier is that with line connected electronics or appliances like vacuum cleaners and even toasters - this can lead to electrically live parts accessible to the user. Sometimes, the plastic insulation on typical internal wiring will not fail immediately but will cold flow and cause problems later. So, one should always make every effort to assure that no wiring is being pinched and for metal cased appliances, check that the case is not electrically live - has a high resistance (usually infinite, but at least a few M ohms to both wires of the AC line with any on/off switches in both positions) after the repair is completed. For non-heating appliances or electronics, a little electrical tape goes a long way. For heating appliances you really need to make sure that bare wires are routed far from any exposed metal of the case taking into account as well any motion that may occur during normal operation or due to being knocked about or dropped.

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Repair Brief #16: Sony CDU33A 2X CD ROM Drive Failure

Patient: Sony CDU33A CDROM Drive given to me supposedly brand new but broken.

Symptoms: Drive behaves the same as a similar working drive until it is accessed. Then, there is no response by any DOS or Windows software. No CDs are recognized, always get the message: Abort, Fail, Retry?

Testing: I keep an old (well, what other type are there?) 286 PC clone system around for the primary purpose of testing peripherals. Installing the drive and software confirms the reported behavior. I was given two similar drives. The other one was reported as being intermittent but seems to work fine in my test system. This one was indeed dead.

Since it is impossible to observe the behavior of the pickup and, in particular, the lens with the cover on, the first step is to get at the guts.

Fortunately, the CDU33A is quite simple to disassemble.

There are only two major components: the Printed Wiring Board (PWB) where all the active electronics are located and the Optical Deck including laser, optics, and pickup worm drive mechanism.

The other parts include the upper plastic casting and metal shroud, solenoid latch assembly, right and left guide rails, drawer assembly, and front bezel, two springs, bottom plate, 6 screws.

There are only two electrical connectors inside: one flat printed cable linking the PWB and optical deck and a two pin connector supplying power to the eject solenoid. This is in pleasant contrast to some other CDROM drives I have seen with a half dozen or more small connectors spread all over the PWB making removal and testing very difficult and risky.

After about 10 minutes, I have the drive apart and can now reassemble the major components on the bench outside the case to observe behavior.

I prop up the circuit board and reconnect the flexible cable - noting the orientation marks. I can now run the drive with full visibility of the mechanism and optics. With a CD in place, there is no danger from the laser beam. I make sure the PWB cannot short to anything and that the whole affair cannot tip over.

Having set up this contraption (you would have to see it to appreciate appreciate this terminology), I am ready to continue testing.

Naturally, it now works perfectly.

No amount of abuse seems to phase it - wiggling cables, flexing the circuit board, trying multiple CDs, all fail to reproduce the original problems. Could it be the case? I can think of no reason why it should make a difference? Is there anything else different? I don't think so. Perhaps the sled was jammed somehow and disassembling the drive fixed it. Who knows.

After reassembly, the drive continues to function perfectly.

Comments: How many times has someone brought you a 'broken' device which has magically started working again on your bench. It certainly cannot hurt your reputation. Admittedly, here, I had to actually do an exploratory before rejuvenation to convince it that I meant business.

It has now been almost a year and the drive continues to function. I can only guess that the cable may have been poorly seated or had some dirt stuck in the contacts. Until it fails again, there isn't much more to try. Unfortunately, the saying: "if it ain't broke, don't fix it" now applies. I have no idea if the drive will ever again fail within its normal life expectancy, but in the meantime, where did I put my Win95 CD? (No comments, please, about choice of OS).

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Repair Brief #17: Panasonic Color TV Shakes and Pulsates

Patient: Late model Panasonic 17" color TV

Symptoms: Width slightly reduced. Slight evidence of 60 Hz hum bar, brightness pulsating, raster shaking, somewhat channel dependent.

Testing: All of these symptoms were easily reproduced on the bench. The 60 Hz hum bar is the giveaway indicating a low voltage power supply problem.

Rather than operating the TV off a Variac to confirm lack of regulation, I decide to just try the most likely solution - a replacement main filter capacitor. With power off and making sure the main filter capacitor is discharged, I use a pair of clip leads to jumper my test cap across its terminals.

The set now works perfectly.

Removing the old capacitor (not easy as the rivlets really do make nice heat sinks), testing with my trusty Radio Shack DMM on its capacitance scale reveals that the value has dropped by over 85% - pretty amazing that the set worked at all!

One highly overpriced replacement filter capacitor (I used a local distributor instead of my favorite mail order sources) and the deed is done.

No disasters on this one!

Comments: This capacitor was mounted next to a large heat sink - possibly the power regulator. When replacing electrolytics, we often ignore one very important specification - the temperature rating. Either the original capacitor was defective or it was not rated for the thermal conditions inside a compact TV. The TV was not that old - maybe 3 or 4 years at most. We all can point to equipment we own that is still working after 20 or 30 years going strong on the original filter capacitors.

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Repair Brief #18: Dead Zenith Color TV

Patient: Zenith 19" color TV, about 5 years old. This TV is owned by a neighbor of mine who has small kids - more on this later.

Symptoms: Dead as a door nail. Only evidence that it is connected to the line is a momentary flicker of lights when TV is turned on indicating that the main filter capacitor is being charged.

Testing: This set has a pull-type on-off switch. There were no blown fuses. Checking with a voltmeter shows 150 V on the main filter capacitor with the switch in the on position. Ditto for the collector of the HOT.

This would seem to indicate that there is a problem with the startup drive to the Horizontal Output Transistor (HOT).

Off to the library for the SAMs....

Many Zenith TVs use a simple multivibrator to generate a startup signal to the horizontal driver transistor until the flyback can generate the secondary voltages needed to operate the deflection ICs. Once these voltages are present, the startup circuit is disabled. Indeed, such a design is used for this TV.

Checking with a scope (powering the TV through my isolation transformer) at the base of the HOT shows no drive signal.

Tracing back, there is no signal at the driver transistor or from the output of the startup circuit. One of the two transistors in the startup multivibrator is bad.

I do not have a suitable replacement - it is a high voltage low current Zenith part similar to an MPSA43 - 200V. I will need to obtain one, or better yet, two to replace both transistors in the multivibrator.

To confirm that the rest of the TV is operational, I use a common technique to 'jump start' a TV where the startup circuit is defective. This is to inject a signal of around 15-16 kHz directly into the base of the HOT to substitute for the startup circuit.

With the TV turned on, momentarily touching the output of a pulse generator set for 15 kHz and a couple of volts amplitude to the HOT base brings the TV to life. Everything appears normal except that the TV does not start on its own. Somehow, I don't think my neighbor would approve of this solution. (Also, I am not giving up my pulse generator!).

Caution: jump starting a TV like this is risky. In addition to the dangers of mucking with a live TV, injecting a signal with improper characteristics into the HOT can destroy it and possible a lot of other circuitry - instantly. For example, a single cycle with too long an ON time can blow the HOT from overcurrent while driven on or overvoltage during flyback. Use this approach with care.

Replacement of the multivibrator transistors with the exact Zenith parts completes the repair successfully.

Comments: Examining the schematic of the startup circuit reveals that it appears to be designed to fail - especially with kids about. While the transistors are rated at 200 V (they are running on the 150 B+ from the line power supply), the transistor power rating is only .6 W. Even though they are running in a switching mode, I believe that repeated on/off cycles can stress these to the breaking point. Something was mentioned about my neighbor's kids turning the TV on and off repeatedly. I have not duplicated this experiment but suspect that such treatment at least may contribute to premature failure. Fortunately, in this case, it was only in the startup circuit.

Power-on is a stressful time for many types of equipment due to inrush current, transient voltage, so many things changing quickly, etc. In addition, designers may not study and characterize the behavior during startup with the same amount of care that they presumably (we hope) do for steady-state operation.

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Repair Brief #19: Samsung VCR Caught in Infinite EJECT Loop

Patient: Samsung VCR, Model VR 2610.

Symptoms: Inserting a tape works fine - it plays, it records, it FFs, it REWs. However, attempting to eject a cassette results in an infinite loop - the VCR grabs the tape back just before it pokes out of the slot. Sometimes, the tape can be grabbed in time but usually the cassette does not exit far enough.

Testing: Symptoms confirmed. With the top off, it is easy to catch the tape but I don't suppose this would be an acceptable solution. In addition, the cassette carriages seems king of sloppy - loose for want of a better term. This would indicate a mechanical problem with the cassette basket - the mechanism which moves the cassette into position inside the VCR.

First step: a close examination of the basket mechanism. Nothing obvious - no broken parts visible.

Next step: attempt to remove the basket. With most VCRs, this is a simple matter of 4 screws and perhaps a connector. Not here. There are 4 screws, but once the screws are removed, only one side wants to come loose. The left side, with most of the gears and whatsits, is firmly fixed to the base of the tape deck. No doubt, there are critical timing relationships that might be disturbed once removed. It stays for now.

Perhaps, removing the bottom cover will reveal something. 8 screws later, bottom cover off. What's this? A spring!! So now, we know that something is indeed broken and most likely in the basket somewhere. This sort of spring is not the type to have just popped off - it is a close wound coil spring with hooks at each end. And, guess what, there is also a tiny bit of white nylon which was probably the tab onto which the spring was hooked at one end.

A close examination of the visible portions of the basket above and below deck finally turns up something now that I know generally what I am looking for. Thankfully, it is accessible and I hopefully don't need to pursue removing the basket which almost certainly would not be a fun thing to do.

The spring is supposed to be connecting two gear-type wheels in the EJECT mechanism. With the spring sprung, these were free to rotate when they should not have and their free play was sufficient to cause the EJECT operation to screw up.

So, how to repair? There is no good way to glue nylon and even if there was, the tab is so small that it would be impossible to provide a strong enough bond to withstand the spring force. Replacement of the part with the broken tab is a possibility though again not a pleasent one - it would require removing the basket. Of course, replacing the entire basket is another unpleasent and expensive options. Installing a metal post in place of the tab is also a possibility - one that I do not really want to contemplate.

Well, it appears as though there is nothing particularly critical about the spring placement. Is there an alternative location to connect the end with the broken tab? Yes, it would appear that it will be sufficient to hook it around another large wire spring. However, then it is probably stretched too long, so I make a link out of a piece of a paper clip and this seems to be about right. (Paper clips, bailing wire, scotch tape and chewing gum (well maybe not chewing gum) are among my favorite things). Getting all this in place under spring tension between the edge of the case and the basket plastic frame proves a bit of challenge - requring a dental picks, needlenose pliers, patience, and few carefully chosen four letter words - but I prevail. The EJECT operation now works perfectly.

While not pretty, I believe the newly designed spring attachment will be much more robust than the original. I should write to Samsung!

Comments: This is a another case of poor design - there can be no other way of describing it. The spring is rather large (you can visualize it, can't you?) and the tab much too small. Another .0001 cent of plastic and it would outlast the rest of the VCR. There was absolutely no excuse as there is plenty of space to enlarge and reinforce the tab.

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Repair Brief #20: Nintendo Game Console Won't Reset

Patient: Nintendo original game system.

Symptoms: Power light blinks indicating that it is not able to run the program contained in the game cartridge.

Testing: Tried multiple cartridges without success.

The most common problem with these units is a worn or dirty system unit game cartridge connector. In this case, the red power/status light will continue to flash even after the RESET button is pressed with a game cartridge in place. Replacements are available for about $9 from the usual sources (MCM Electronics, etc.)

First, I try another game cartridge - the one that is not working may just have dirty contacts or may be defective. This does not work.

So I need to get inside. Fortunately, unlike some other consumer stuff, this is quite easy. Six screws underneath followed by about a dozen to remove the metal shield and circuit board so the connector can be removed and inspected.

Before removing the connector from the circuit board edge, I give the system another chance to redeem itself. With the latching mechanism removed, it is possible to press the cartridge down somewhat lower than normal increasing the chances for good contact. Indeed when this is done, it is possible to occasionally get a good reset and game startup on the TV. This certainly confirms the original suspicion.

Now, can I revive the original connector or must it be replaced? There are three kinds of problems that generally occur with these connectors:

1. Wear of the contacts to the game cartridge. Although full pressure is not applied until the cartridge is latched, there is still wear every time a game is inserted or removed. This take its toll. It is often possible to use a dental pick or a bent paper clip (one of my favorite tools!) to slightly spread the spring contacts so that they grip the edge contacts of the game cartridge more tightly. On a high mileage unit, however, they may be worn through to the point of actually breaking in half resulting in replacement as the only option.

2. Corrosion at the connector to the circuit board. Cleaning with a pencil eraser or at most some very fine sandpaper (600-1000 grit) will usually restore to as-new condition unless some really corrosive agent was at involved.

3. Kid grime on game cartridge edge connector transferred to Nintendo cartridge connector. Favorites: Coke, sugar candy, and ice cream.

So, the first step is cleaning of both sets of connector contacts and the main circuit board edge finger. You may need to use a variety of solvents to completely remove all crud. Water may work better on sugar syrup than normal contact cleaner or alcohol. For the edge finger, a pencil eraser very useful.

Don't neglect the game cartridge connectors. These generally do not wear but may collect all kinds of strange stuff. Rather than fight with the security screws that you may find holding the case together, I usually simply use a Qtip with water, contact cleaner, or alcohol - or one after the other - to clean these contacts. Again, very fine sandpaper may be needed in extreme cases.

Even if these procedures only make a slight improvement - you can press down on the cartridge and the machine will respond to the RESET button - you have confirmed that the connector is indeed the problem. In many cases, just cleaning will result in reliable operation for a long time to come.

In the case of this particular system, all three problems were present. However, for the time being at least, the system has responded well to treatment.

Comments: While the original Nintendo game machine is a couple of generations out of date, many are still in use. And, hey, young kids usually don't care. OK, you don't have to admit to being the one who cannot resist just a couple rounds of 'Super Mario III'!

Old Nintendos can usually be picked up for $5-20 at garage sales sometimes complete with a selection of games, sometimes bare. The games go for $1-$5 depending on the barganing skills of the kid selling the stuff.

However, a bad connector is almost a sure bet with a secondhand system. Consider that most electronic connectors are typically rated in terms of hundreds of insertion/removal cycles. A Nintendo machine must endure thousands of not necessarily gentle cycles over its lifetime. The connector was not designed for that. Furthermore, you are likely to find all kinds of muck inside, mostly unidentified, and often difficult to remove. Nonetheless, these things are remarkably robust, electronic failures are infrequent, and they can usually be revived without much difficulty.

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Repair Brief #21: Sharp VC7864U VCR Erratic

Patient: Sharp Model VC7864U VCR in generally good condition, garage sale acquisition, $1.

Symptoms: Former owner complained about difficulty in ejecting.

Testing: Tried playing multiple cassettes (not all at once!). For the most part, the VCR behaved normally. Maybe just a bit sluggish loading but no other obvious problems. Why did he dump it?

I did my usual cleaning - rubber parts did not look to bad, leave them for now. Even the idler tire appears to be in decent condition. I will use the VCR and see if any problems appear.

The first sign of trouble appears once when attempting to use REVIEW mode - the VCR abruptly stopped and attempted to unload the tape. The loading motor was spinning but nothing was happening (I think it was turning in the wrong direction and the belt was slipping - I am not sure). Oh boy, time to leave the cover off. Manually giving the motor shaft (fortunately it is accessible from above the deck) a couple of turns convinces the VCR to complete a correct unload cycle.

Well, this sounds like the classic 'if it is an erratic Sharp VCR, the mode switch must be dirty or bad' problem.

(2 years pass as I am in no mood to bother with this repair at the moment.)

OK, now I have a need for a reasonably decent VCR to replace my cousin's Mitsubishi HS328U which is finally dying. So, I dig the Sharp out of the closet and see about its condition. Now, it doesn't even want to play a tape at all. Well, I know I have to deal with the mode switch, so first things first.

The mode switch on this model is sandwiched between the loading gears and a mounting plate - all parts of what I will call the 'loading gear assembly'. To access the mode switch, this entire unit needs to be removed and partially disassembled. The gears operate the roller guide loading mechanism, and a couple of cam operated levers which are conveniently hidden when it is removed or reinstalled. It is driven by the loading motor via a couple of idler gears.

Timing marks: In the unloaded position, there is a hole in one gear that appears to line up with a slot. So, with the roller guides retracted (and the gears which operate this linkage have timing marks which also line up), this hole should be centered in the slot. Fine. This appears to be the only critical relationship with respect to removing the loading gear assembly.

I unsolder the 4 connections to the mode switch, remove 3 screws, and - sproing! What was that? OK, one or both cams still had a lever with spring pressure applied. Hopefully, it will be possible to extend these these when replacement time comes along.

With the loading gear assembly removed, it is still not possible to access the mode switch. Now to disassemble it. There are two fancy cam gears which obviously must be timed correctly - in one position there appear to be an arrow and triangular hole which line up. I add a couple of marks of my own for good measure with a felt tip pen. A simple split washer holds the gear I need to remove onto its shaft. (Note: these split washers are not designed to be reused but with care in removal, they can usually be replaced without any long term problems. Of course, a professional would have an assortment of replacement sizes handy.) Removing the gear carefully, there don't appear to be any flat washers or spacers to worry about.

Once the gear is removed - making a note as to which side is up though this is pretty obvious - the mode switch is exposed. Squeezing the center of the split shaft enables the cover to be popped off and the interior appears. I almost lost the springy wiper as it is not fixed to the plastic cover but popped free when first removed. A frantic search was needed to locate it on the floor. The wiper fingers and encoder contact traces seem to be in good condition but whatever was used as a lubricant is a little gummy and might be the problem. A simple cleaning seems to take care of that. I also bend the wiper fingers a bit to increase the contact force very slightly.

Now, to get everything back together. First, the wiper is replaced and the mode switch cover is snapped back in place. Free rotation is confirmed. Then, the gear that was removed is returned to its shaft along with a cam follower lever that was under it. The split washer is replaced.

To install the entire loading gear assembly means that the original gear timing relationships must be re-established. In addition, care must be taken to make sure those two cam follower levers I mentioned previously are properly positioned. This takes a bit of work but eventually, I am convinced that everything works as it should. The screws are tightened and then free movement of all the parts is confirmed by manually cycling the loading mechanism. The 4 mode switch connections are then resoldered.

Now for the test. Since this was not a hard failure to begin with, there is no guarantee that any problems will be detected.

The tape seems to load correctly but then the VCR unloads and shuts down. What is wrong? It would appear that the takeup reel is not turning. Hum, probably that rubber wasn't as great as I had assumed a couple of years back. I now do a more complete cleaning and, in particular, remove the idler tire and inspect it. It appears to be ok but as a test, I turn it inside-out.

Now, everything works as expected. Testing with a cassette cheater (shell), there appears to be adequate takeup torque. I clean the idler tire again and reinstall it in the normal configuration. All modes appear functional even when testing with a full takeup reel - requiring the most takeup torque. I will order new rubber anyhow and replace it at a convenient time or if problems reappear.

This VCR now appears to operate reliably and consistently. I have seen no evidence of the original erratic behavior. Only time will tell for sure.

Comments: I cannot overemphasize the importance of making careful notes as well as adding timing marks of your own when removing any parts of a VCR which could conceivably have critical timing relationships. Not doing this can really mess up your day. Err on the side of excess - it won't cost you anything.

Sharp VCRs seem to be particularly prone to mode switch problems: Of the 3 Sharp VCRs under my control, 3 of them have developed dirty mode switches resulting in a variety of erratic symptoms including, as noted, going into the wrong mode as well as aborting the tape loading operation for no good reason.

It would seem that a VCR design using an optical mode switch instead of one with sliding contacts would be much more reliable at only modest additional cost. After all, VCRs already use a number of optical sensors and cheap computer mice use optical encoders not very different in design from a mode switch. At least, it would be nice if mode switches were readily accessible. Some are visible as soon as the bottom cover is removed. Others require substantial disassembly with associated risks of incorrect reassembly resulting in mechanical timing problems or even damage when the unit is cycled.

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Repair Brief #22: Magnavox Console TV Deflection Problems

Patient: Approximately 10 year old BIG Magnavox color console (when furniture meant something).

Symptoms: Horizontal deflection jittery, possible vertical collapse, arcing flyback - all in one set! This info from Dave whose friend owns the set. Dave is a tech at work who is now doing more software than hardware (not necessarily by choice).

Testing: I did not actually see the original problems, nor did I have access to the entire set as Dave came in one morning with the guts of this set under his arm (more like both arms). We actually attempted to power it without the yoke or CRT but there was absolutely no evidence of anything. Surprise surprise.

Since the original description of the problems is somewhat incomplete, a visual inspection is made and the HOT is tested for shorts just to be sure. There were none. However, the visual inspection did confirm that the flyback had a narrow but rather long (maybe a couple of inches) crack in its housing, There was no conclusive evidence of arcing but this is one area where the original symptoms were fairly definitive as the owner stated that there was arcing around the flyback. (He probably knew just enough to be dangerous, but hopefully has not done anything we will regret.)

This would explain the jittery horizontal but what about the vertical problems? Were there really vertical problems. I never did get a good answer to this question - at least not until later.

While it is likely that the flyback could be patched up at least temporarily, it was decided to order a new one. The owner was willing to spend up to $150 to repair the set - I have no idea why. No match from places like MCM Electronics - must go directly to Magnavox (Philips, actually). $71, ouch. Admittedly, this is one of the spiffiest flybacks I have seen lately (at least since that A-line Zenith with the cool ribbed plastic coil form). It has a detachable CRT anode wire - wire and suction cup sold separately! Well, for $71, you cannot expect everything.

Although we have agreed to order the flyback, I decide to test the old one anyhow, so next day I bring in my flyback testing widget (12 V chopper, see document on flyback testing). This is the first time Dave has seen this tester and Ed (our chief digital design engineer) is also curious but stands at a safe distance, having a great deal of respect for a few puny kV. Ed always stands at a safe distance when anything higher than 5 V is involved!

First step - locate the HV return. In this case, it is obvious because (1) a separate bare wire is brought out to a pin and (2) this wire is connected to no other pins on the flyback. (With a built in HV rectifier, it is not possible to use a normal DMM to locate this wire.)

Next step - wrap a ten turn coil around the core of the flyback and connect this to the chopper.

Apply power - a nice healthy arc can be drawn from the HV lead of the flyback to the return connection, current draw on power supply is low. Flyback is quite functional. This does not test for breakdown at full voltage but does rule out hard shorted turns. (Ed can be overheard mumbling something about sticking with 5 V logic.)

Result is fine by me, owner wants new flyback and this one will make a great HV supply for a plasma globe or something - someday.

So, we pile the chassis and all its attachments onto a table in the corner of the testing lab awaiting our shiny new flyback (minus the red wire, some assembly required). It looks kind of pathetic there but no one else dares go anywhere near let alone touch it after an off-hand comment about charged capacitors!

Approximately 5 days later, our new flyback arrives and is soldered into place.

Next morning: I see Dave pulling up in his Chevy wagon. Guess what is in the back? The entire huge, heavy TV, belly down. Oops. We quickly find a place for it somewhat out of the way in a back room.

Apparently, there is no arcing and the horizontal deflection is stable. But, there is absolutely no vertical at all - flat lined. OK, so the rumors about vertical collapse were not exaggerated.

A little more visual inspection reveals a couple of interesting observations. First, all the deflection circuitry - both horizontal and vertical - is clustered in a small area near the flyback. In addition, the crack in the crack in the original flyback is adjacent to some of the *vertical* output circuitry. So, perhaps, the arcing was making its way to something in the vertical deflection. What kind of output chip is it? Ah, my favorite - a TDA3654. Fortunately, I have a bunch of them to keep one of my tough dogs fed. So, I am well prepared if need be.

A quick measurement of power to the TDA3654 reveals that there is none. Maybe this won't be so bad after all. Tracing back with an ohmmeter and what do I find? An open fusable resistor! And, in exactly the right place to be killing power to the chip. Could it be this easy? Actually - yes in this case. I install a normal 1 ohm 1/4 watt resistor (only for testing). I also use the ohmmeter to confirm that the rectifiers in the vicinity are healthy. We are set!

Power! At first there is nothing on the screen but then snow gradually appears - and it is full screen. There is no antenna. Of course, reception inside our building is nearly non-existent due to all the computer RF interference and steel beam construction. However, we quickly locate a pair of rabbit ears (or maybe it was just a couple of feet of hookup wire) and tune one of the few channels that is viewable at all - which happens to be broadcasting the morning cartoons. But that is just fine. Everything appears normal and I remind Dave to replace that resistor with a proper flameproof variety.

Dave cannot believe it.

Ed is nowhere to be found.

Everyone loves the cartoons.

Comments: The mechanism for the vertical failure still remains obscure. Apparently, the arc caused a momentary but not fatal short circuit in some part in the vertical output circuitry which blew the resistor. We always hear how sensitive ICs are to static - here we have 25 kV of raw power discharging nearby with apparently no permanent damage except to a 25 cent resistor.

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Repair Brief #23: Hewlett Packard AN/USM281A

Oscilloscope with Multiple Problems

Patient: Hewlett Packard AN/USM281A Oscilloscope. This is the militarized version of the HP180 lab scope. PL1186 dual channel 50 Mhz vertical plug-in, PL1187 delayed sweep timebase plug-in.

Symptoms: Horizontal position shifted almost off the screen; delayed sweep and B timebase inoperative. Alternate triggering erratic at low intensities(??).

Testing: How does one test a scope? Well, put it through its paces with reasonable input signals - a 10 MHz clock oscillator provides a nice test signal. Maybe another scope would be handy?

Prologue: (You can tell right off that this will be a feature length saga.) I bought this scope at a garage sale. Now, understand, garage and tag sales around the Philadelphia area where I live are usually of the "Aunt Minnie's old silver plate" variety. Electronic equipment is usually limited to comatose VCRs and color TVs that play in B/W (not that I complain about this sort of stuff for the right price - as little as possible). However, one little ad catches my eye: one item amongst all the bric-a-brac is 'test equipment'.

BTW, I never go to flea markets with any serious intention of buying anything. It is clear where their stuff generally originates. All the junk I turn down at garage sales ends up with hugely inflated prices at flea markets!

I get to THE sale relatively early (I am not quite the garage sale addict type who gets up at 5 AM to be first in line). All that is visible are a couple of pathetic old signal generators - one audio, the other RF. Well, $10 for an RF signal generator isn't too bad. I could probably have bargained him down to $5 but first the all important question: Anything else? (Not that I expected any sort of affirmative response given the assortment of hat boxes, deflated basketballs, and old Christmas decorations.) However, surprise surprise! "There is one other item." So he crawls under a table and drags out an HP AN/USM281A - a real oscilloscope! "Well, I have this, um, oscilloscope. It is solid state, dual channel, 50 Mhz, etc." Now, I am paying really close attention (but of course, not wanting to show it). The only oscilloscopes I had seen at garage sales until this time (beside my $3 Tek 321, but that is another story) are usually the really beaten up Eico variety). He is actually doing a pretty fair sell job. So, how much are you asking? "I would like to get $100 for it." Very interesting. Can I try it? "Sure." So, he props 'my' scope on top of a rickety old bar stool (I would have been quite upset if the thing had gone crashing to the floor but still didn't want to act interested enough to suggest he find a more stable spot.) I figure that if it appears to work at all, $100 is a good price even if I have do some repair and calibration. I fiddle with the controls, also noting that it comes with two nice looking 1X/10X probes. Suddenly, the scope really cooperates - it must really want a new home being so lonely stuck in the back of that garage. The trace scoots off to the right of the screen. None of the front panel controls have enough range to bring it back. I mumble: I cannot get the trace back. He says "Oh, um, uh..." Before he can get too far, how about $50. "Sure, ok." I didn't do enough testing to find out that the delayed sweep was also dead. For that matter, even with the 10 turn delay time pot in plain view, the existence of a delayed sweep mode did not register. I only found that out later. No amount of fiddling would produce any difference between the A timebase and Mixed A+B. The B timebase was totally dead.

So, how to go about tackling this? I have no service manual, no schematics, and looking at circuit boards, the semiconductors are HP house numbers. I didn't have an ECG manual. Fortunately, the component side of the circuit boards are readily accessible. However, tracing the wiring is a real treat with HP's love affair with multicolored striped bundled wiring harnesses. I could try to buy a manual (this was somewhat before the days of sci.electronics.repair). Nah, that would be cheating (and probably expensive). I did try our local HP sales rep when we were looking into their logic analyzers but he did the usual salesperson thing and lost interest once we signed on the dotted line.

So, I had to repair it the old fashioned way - ohmmeter, circuit tracing, seat of the pants, etc.

Objective #1: find the horizontal position problem. Even if the delayed sweep remains broken, a dual trace 50 MHz scope is very useful. Fortunately, this problem appears solid now (and not intermittent as was the case previously) so ohmmeter tests of the horizontal sweep board components should be possible. Tracing back from the deflection plate connections to the CRT finally results in a difference between apparently symmetric sections of the output stage. An 11 K ohm power resistor tests open! Well, that wasn't too bad. It doesn't appear as though there is any cause other than age. Replacing the resistor restores full range control of horizontal position. About 1/2 hour to find. Not too shabby.

At this point, I considered the operation a success and put the other problems aside. Partially, this was because what I had was usable and partially because I did not expect the delayed sweep/B timebase problem to be nearly as easy to solve.

(Actual elapsed time: about 2 years. Well you know how I suggest 'sleeping on a problem' when you cannot solve it immediately!).

Objective #2: Fix the B timebase. The only help I have with this is the fact that the A and B timebase circuitry is quite similar so some comparisons of resistance measurements will be possible. However, for some reason, my first pass over the components with an ohmmeter does not turn up anything obvious.

Using another scope (a Tek 564), I poke around the B timebase circuitry a bit to see if I can locate any interesting signals. I suppose my definition of an 'interesting signal' is one that is doing anything - not flatlined.

What's this? A ramp waveform - it must be derived from the A timebase as it maintains a fixed relationship with the A timebase output but goes into the B timebase circuitry. My guess would be that this was be used to provide a gating pulse of variable width controlled by the delayed time (10 turn) pot. Maybe following this signal will lead to something. Sure enough, it goes to what must be a comparator circuit since the pot also connects nearby. And - what is that? A charred resistor! Now, why didn't I see that before? Fortunately, there is another identical circuit across the board and that resistor is readable - 100 ohms. Now we are cooking (hopefully not literally). With great expectations - switch on. Still no action from the Mixed A+B or B timebase. As far as I can tell, not a thing has changed. The B timebase is still as dead as a door nail. The good news is that the resistor is not getting hot, so that is encouraging - probably.

Next, I continue on with my search for shorted or open parts with an ohmmeter. This time, I will be more systematic hopefully not missing anything. Finally, results! Another blown part. This time, it is a transistor. From the remaining good junction I can at least tell it is supposed to be PNP. Measuring the voltages across C-E, it appears as though a 2N2907 will be of adequate ratings (at least voltage wise). Hopefully. Soldering in the new transistor from the top of the board is not fun - but more fun than attempting to remove the board entirely. Power: Darn, still no action.

Continuing with the ohmmeter finally turns up a shorted diode but what type? Again, duplication comes to the rescue. It is a 54 V zener. I use a pair of 25 V or so zeners temporarily to substitute for this unusual diode. Now, finally, the B timebase is responding to treatment! Having done what I always caution against - turning adjustments without marking them - the behavior is a bit - strange, but the two relevant controls (don't ask me at this point what they did) could be set for proper operation of the Mixed A+B as well as B timebase.

How could 3 parts in apparently not directly connected circuits be blown? I have no idea except to suspect that the previous owner may have attempted to repair the B timebase and never stumbled upon the actual cause which was most likely the bad zener but managed to blow other parts in the process.

Objective #3: Determine why turning the intensity way down causes the alternate sweep mode to get stuck on one trace. This one is a minor annoyance only and really doesn't affect the utility of the scope in any way. It is just not quite perfect. I finally locate a couple of adjustments in the vertical plug-in that seem to have an effect on the rise time of the start of the sweep or something - they seem to modify the strange behavior as well as affecting the linearity of the left 1 cm or so of the screen for high sweep speeds. I finally find a compromise position that seems to be satisfactory.

Wow, a whole bunch of simple problems but now it appears to be in pretty good condition. A couple of drops of oil for the delay time control, clean the switches and controls, and a piece of Plexiglas to protect the CRT and it is done.

Comments: What do they say? "Real engineers don't need no f***ing manuals". Or is that programmers? Well, whatever. A service manual would sure have made the task a lot easier. But where is the sport in repairing something with actual accurate documentation?!

The AN/USM281A is still a good solid easy to use oscilloscope for general design and debugging. I don't know if this one ever saw duty in the Navy but I have seen this model going for about $250-300 from test equipment outfits like Tucker. In my tests, the scope will display a viewable waveform and lock at frequencies greater than 80 MHz even though the specs are for 50 MHz vertical bandwidth. The mainframe itself, I think, is rated for 100 MHz. It takes standard HP180 series plug-ins so if I ever come across any of those at another garage sale.... (about the same time pigs learn to fly!)

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Repair Brief #24: Sony Servolock Turntable Erratic

Patient: Jeff's Sony turntable. Two speed, quartz locked, nice - if you care about such things anymore.

Symptoms: Platter turns but 'lock' light flickers and speed is slow and uneven (even to the unaided eye and without listening, it is obviously struggling).

Testing: Both speeds (33-1/3 and 45) have similar problems. The selector switches appear to be clean and solid. By gently touching the spinning platter, it is found that there is also essentially no torque - it stops very easily.

It was quite obvious that the servo system was having difficulty reliably locking - as evidenced by the flickering 'lock' indicator and lack of torque. In addition, the platter did not appear to want to start up reliably at some rotational positions.

So, what does it use as a reference? Remove the platter! This requires popping a cosmetic cover and large E-clip. Aha, what is this? A little pickup near the edge that looks sort of like a tape head. However, unlike an audio or digital tape head, it has a series of offset laminations about 1 mm in thickness. Not visible but inferred is a magnetic stripe pattern on the inner surface of the platter which is in close proximity with the pickup when the platter is installed. Better keep magnets far away. That pattern was put on with a special jig at the factory - there would be no way to reconstruct it if some, say, accident were to take place.

As a long shot, I attempt to adjust the pickup closer to the platter surface. Perhaps the magnetic pattern has weakened or something else has drifted. Ouch, now it is rubbing. A little further back. Ah, now it is clear.

Not too surprisingly, there is no change. Symptoms are identical.

Now what? Unfortunately, there is no way to get at the circuitry - under the platter - when the platter is installed. There is no way to excite the magnetic pickup with the platter removed. Not true! After storing the platter at a safe distance, a simple magnet will generate a 20 mV signal out of the pickup. This is probably greater than the normal signal level.

The circuit is pretty simple - couple of transistors and other stuff being fed from the pickup for feedback and hall effect sensors for motor control. The motor is a brushless DC 4 pole type with the commutation control external and on the same board as the servo lock PLL.

Maybe a little signal tracing is in order. Using my magnet, I can see the feedback signal making its way through to what I assume is part of the PLL - probably the phase detector.

In retrospect, even suspecting the PLL's feedback signal was probably not valid. The key is the dependence on rotational position during startup.

So, what about the motor signals? There appear to be two outputs from the motor (in addition to the coil driving signals). What do these look like? The first (from H1 - Hall sensor 1) flips between +5 V or so and ground as the motor rotor is rotated through a complete revolution (Wow, Peter Piper picked a pack of...., sorry, just practicing.) However, H2 seems to be mostly dead - stuck at an intermediate voltage and only varying by a fraction of a volt. Well, that could certainly be a problem.

(If this had not turned up anything, I would have gone on the determine if the driving signals were correct).

Unfortunately, the actual sensors appear to be under the rotor. First the rotor and then the entire motor circuit board has to be removed to access H2. There is a slight risk that removing the powerful rotor magnet from its pole pieces will cause it to lose some magnetization (this can happen when removing the rotors of high energy servo motors, for example, if a dummy rotor core is not slipped in as the rotor is removed). However, I risk it and the rotor magnet seems to be just as strong as ever when replaced. I stick it on a piece of soft steel as a keeper to be sure there no possibility of it weakening while it is off the turntable.

The tricky part is accessing the bottom of the motor circuit board without ripping up the connections to the (fixed) servo board. The actual Hall effect sensor is in a four pin package about 2 mm on a side. There is at least a red dot to indicate pin 1. I use an ohmmeter to double check that the device itself is bad by measuring directly on the package pins. Confirmed, there is are very noticeably different resistance readings across the pins of the good and suspect parts.

I sent Jeff to buy the part (my 'customers' have to do something in return for free repairs and Jeff can convince anybody of anything).

Fortunately, Sony Parts was happy to sell this $4 (wow!) part to someone who is not a licensed Sony repair center. They were very helpful in fact, looking up the part number for H2 in their parts catalog.

Reassembly is straightforward though I had no idea if the alignment of the sensor was adequate until testing.

Now, at least the waveforms from H1 and H2 are of nearly the same shape and about 90 degrees out of phase as they should be. Replacing the platter and the lock light is now solid with decent torque from the motor. The platter will start quickly and reliably from any initial position.

Next day: Jeff comes in complaining that the turntable is vibrating! Indeed, during part of the rotation, there is a distinct vibration that can be felt from the base. What could this be? Best guess is that the pickup needed to repositioned. And, that was the problem. Apparently, my initial adjustment in trying to locate the original problem had resulted in the pickup being positioned further rather than closer from the platter. Some careful incremental movement and the vibrations disappear.

Comments: The elegant simplicity of this turntable is impressive. Too bad that turntables aren't really popular anymore. Well, maybe not bad. I cannot complain about the benefits of CDs though other may disagree. Fortunately, this turned out to be a motor problem and not an actual fault in the PLL which would probably have necessitated a schematic.

I am not sure if Jeff ever used the turntable after it was repaired (about 4 years ago) as I cannot imagine him wanting to deal with vinyl. Maybe that is why there has been no return call!

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Repair Brief #25: Kenwood KX-55C Cassette Deck with Dead Transport

Patient: Tag sale Kenwood KX-55C cassette deck marked $2-, as-is, 'dead transport'. I paid a whole $1. Otherwise, it seemed in good condition. Well, at least they were honest.

Symptoms: Front panel indicators are alive and the logic seems to repond to the PLAY and STOP as there is the sound of a solenoid but neither the capstan nor takeup reel shows any indication of even attempting to move. There is no sound of a whirring motor.

Testing: With the cover off, nothing appears locked up - everything turns freely and the belts seem to be in reasonable condition. The motor connections are readily found. Voltage to the motor is about 10 V in all modes so in all likelihood, the problem lies inside the motor casing. The only connections to the motor are the two power leads. There is no external tachometer or other apparent feedback used for speed control.

So far, this seems pretty straightforward. The motor bracket is fastened to the transport with 2 screws, a bit awkward to reach but I finally prevail. The motor itself is contained in an second metal case to provide shielding. To get inside requires prying off the cover at the non-shaft end with a screwdriver. So far so good.

Various techniques are used to perform speed regulation in a cassette tape deck. However, for a totally internal regulator, there are usually only two possibilities: mechanical governor and voltage regulator.

In this case, it turned out to be the latter - a little circuit board contained several components including a power device which was shorted. I was not able to identify or cross reference this part so I decided to make my own regulator.

However, first I needed to determine (1) if there was anything else wrong with the deck and (2) the proper voltage for the motor.

The only think I know so far is that the voltage to the motor is less than 10 V.

There is no strobe disk to watch under fluorescent lighting.

Adjusting tape speed:

Make a recording of a single tone on a tape recorder you trust - one with accurate speed.

My Heathkit audio signal generator and Yamaha cassette deck will do. I use a variable DC power supply to drive the motor after soldering wires to the motor terminals and remounting the motor in the deck. Since I will not be attempting to squash my regulator inside the case, I should not need to touch the motor again. I hope.

Apply power. Adjust the voltage to the motor to about 5 V and hit PLAY: It turns! And, there is sound from my amp. Uh Oh, what happened? The transport went into stop mode. In a VCR, I would suspect an idler tire or belt. What was that? Did someone say belt? Right, the belt has popped off of the tape counter. Maybe the tape counter has a contact on it which is used to sense that the takeup reel is turning.

Now, it stays on but the pitch is way low.

Then, I adjust the speed while listening to this same source simultaneously with the tape being played back on the unit to be adjusted. As the speed is adjusted, the pitch changes. As it approaches the correct setting, the tones beat against each other. When it is set correctly, the pitches will be equal and the beat frequency will go to zero.

Even if you are tone deaf, it is easy to adjust the pitch accuracy to better than 1/10 of a semitone using this method.

However, for this initial test, accuracy is not needed as long as the approximate voltage is determined.

The result: A little over 6 V. Excellent, any vanilla flavor IC regulator will do that from a 10 V input. The is quite low.

A scrap of circuit board, an LM317 (on heatsink, though this was probably not essential at the 100 mA or so current required by the motor), a couple of caps and resistors later, and Presto! a regulator. Speed adjust is done with a 50 turn pot. (Well, it was handy.) I do not attempt to stuff this into the motor case but screw it to the power transformer with an insulating standoff.

I now repeat the speed adjustment - more carefully this time.

One thing I do note is that after a few minutes of continuous operation, the motor speed and thus pitch changes by a detectable but not unacceptable amount (still only a fraction of a semitone) and then stabilizes. This is not due to the voltage regulator as the voltage is rock solid. I assume that the windings of the motor heat slightly and increase in resistance. Well, no feedback for speed control, what can be expected?

Regulator running cool, repair completed.

(5 or so years later:)

While listening to a tape, motor grinds to a halt. So what is up now?

Take off the cover. Hard to believe I had all the screws installed!

Checking with a voltmeter, there is only a few tenths of a volt across the motor but normal 10 V at the input to the regulator circuit. With the motor disconnected, the output of the regulator is exactly correct - 6.3 volts. So the regulator is most likely fine. What about the motor. Testing with an ohmmeter reveals that the resistance varies between about .5 and 2 ohms - much less than I would expect. So, there is a problem with the motor.

It is extremely unlikely that the entire motor shorted out.

This is the classic partially shorted Mabuchi-type motor scenario. I am not going to let a little motor get the better of me! I first try spraying it out with some degreaser - no dice, no change. I will just have to take it apart.

The end-plate is held on with a couple of bent metal fingers, pry them out. However, I cannot just pull the end off as it will rip the delicate metal brushes in the process. There are two access holes - I usually call them ventilation holes but I bet their real purpose is to permit a brush spreader tool (pretty impressive name, probably deserves a trademark) to be used to allow the brushes to clear the lip on the commutator. My brush spreader tool(tm) is - as usual - a bent paper clip.

With the end removed, I can now safely pop the entire armature out of the motor case after removing the pulley (plastic, easy press fit).

(Note, this would be risky with precision servo motors using using high strength rare earth magnets as the very act of removing the armature could lead to instant partial demagnetization of the magnets. This is generally not a problem with these cheap PM motors.)

The commutator looks a bit dirty but the real problem seems to be some metal particles bridging the segments - probably dislodged by the continuous rubbing action of the brushes. This is easily cleaned and the gaps between the segments are cleared with a pointy dental pick.

Now, measuring across any pair of segments results in a 20-22 ohm reading, much more reasonable.

Reassembly is uneventful and we are operational once again.

Comments: I can never resist attempting to repair a normally non-repairable part like a motor. Sometimes, they turn out not to be repairable or I loose a critical tiny tiny part to an unexplored corner of may basement but that is the exception. In this case, it was quite easy. The motor did not actually appear worn - the commutator and brushes were relatively smooth and undamaged. Therefore, a replacement would probably not be substantially longer lived than my restored motor.

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Repair Brief #26: Kenwood CD Changer with Erratic Behavior

Patient: Kenwood carrousel 5 disc CD changer. This is an 'everything in a drawer' type design.

Symptoms: Sometimes, it will recognize the disc and start playing. Most of the time, it will give up and go on to the next slot.

Testing: Several discs were tried without any conclusive differences in behavior. If a disc is successfully recognized, it will play without problems until about the midpoint and then the player will abort and move on to the next. Attempting to manually search forward past track 6 (on one particular disc being used for tests) will result in an abort as well.

Unfortunately, once a disc is rejected, the silly thing remembers that the spot (1 of 5) is empty so without cycling power, it is not possible to even attempt to play the same disc twice in succession.

However, this is a minor irritation.

The first problem was getting the case open. While the screws appeared to be ordinary Philips head screws, it required almost sitting on the screwdriver to persuade them to break free. Hope he never expects to have any warranty work done. The heads are barely recognizable!

Once open, the disc in the play slot is clearly visible. When the player fails to recognize a disc, it doesn't spin at all. Ha! a spindle motor problem. (Rubbing my hands!)

But first, check out startup. With suitable contortions, it is just possible to make out the edge of the lens with no disc in place. Pressing play results in the expected behavior of the lens moving up and down several times before giving up (with no CD present).

There is no chance of being able to see the lens with a disc in place. Forget it.

Well, maybe it is the spindle motor. I put a disc in and press play. Disc moves into position, pause, give up and move on.

I'll show it!

Cycle power. Press play. Disc moves into position. And -- now: give the disc a little twist. Yes! now the CD picks up speed and is recognized and starts playing.

Hummmm.

Sounds more and more like a spindle motor. Perhaps a dead spot or partially shorted winding. Or maybe a weak driver. Is this consistent? For the most part, it is. Sometimes, the disc will be recognized and will play on its own but most of the time, a little help is needed. Once it starts, a dead spot would not matter and the hardest time for a driver is when the motor is starting.

However, what about the problem of not being able to play to the end of a disc once play is successful? I confirm that this is still indeed the case. Yes, it is impossible to play past track 6 on this particular disc. Trying another one, there is a also a time location beyond which play aborts.

What does this mean? It now doesn't sound like the motor as the toughest job for the spindle motor is at the start of a disc.

However, what else could it be?

So, I roll up my sleeves and prepare to do battle with the spindle motor, at least testing it. This is not going to be fun. The spindle motor is located underneath the pullout drawer and there doesn't appear ti be any easy access. Well, every long journey begins with a single step....

As I am removing the bar with the clamper above the optical deck, something catches my eye. What was that? This is the first unobstructed view of the lens. That doesn't look quite right. Normally, the lens of a CD player or other optical drive is shiny with a bluish tinge. This one is fuzzy purple. That can't be right. Well, cleaning is easy enough not believing (but hoping) that a dirty lens could be the problem all along.

One Q-tip later and, yes, all the former problems disappear. Discs are recognized reliably, play flawlessly and to the end, and search works fine for the entire disc.

How could a dirty lens prevent the spindle from starting but then play apparently normally until a certain track? Well, I never actually did confirm that focus was established in the situations where the player gave up. But to have problems with focus but then be able to play substantially free of problems. Well, no one ever said that understanding was always guaranteed.

When discussing the results with the owner, he confirmed that the house was somewhat dusty but I know that no one in his family smokes and the player was not in a kitchen.

Oh well, at least I did not have to take the whole bloody thing (the owner is an Englishman) to pieces.

Comments: Why am I reporting on a simple case of a CD player that required a lens cleaning? Well, to point out that many problems really do have simple solutions even if the initial symptoms may point elsewhere.

In a portable, cleaning the lens would have been done as a matter of course due to the easy access. Cleaning the lens in this changer meant removing the cover as well as the bar holding the clamper. And, some of the symptoms did not really point to lens cleaning.

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Repair Brief #27: Panasonic PV 4820 VCR with Multiple Problems

Patient: Panasonic PV-4820 VCR is basically comatose. Owner says her son tried to change the 'fuse' to fix the problem!!???

Symptoms: Front panel display is alive but not much else. There is no response to any buttons or the remote control.

Testing: Tried all the front panel buttons and remote control, unplugging, etc. Nothing.

The fuse in the power supply is fine. What the @#$% is she talking about?

Once the top and bottom covers are removed, a thorough visual inspection is performed. One intersting observation is that the capstan seems to be binding - the rotor of the direct drive capstan motor is rubbing against the bottom support bracket. Surely, this cannot be the cause of all the problems, could it? A little more thought and examination of how the capstan is mounted reveals the likely answer: there is a white plastic 'knob' with a cross-slot poking through the main circuit board on top of the VCR. This knob adjusts the height of the capstan bearing. No doubt the so called 'fuse' that was attempted to be replaced was this white knob which does kind of resemble a 3AG type fuse holder. OK, mumbling something about no user serviceable parts inside, I adjusted the capstan height so that it is clear of the bracket and spins freely. I make a note to check for any problems with the capstan servo after the main problem is found since as expected, there is no change in behavior with the capstan free to spin..

Now, back to the main event. Since there are multiple major system problems - no response to any buttons qualifies - a power supply problem is indicated. This VCR uses the famous (or infamous) Panasonic switching power supply (though I did not know of its fame at the time). I locate the power supply connector and start making measurements. I do not have a pinout or schematic for this particular power supply but there just happens to be a similar model Panasonic in the main conference room. How, I wonder if anyone will miss it for a little while? Any important customers today?

One thing that is fairly obvious: there is no evidence of the typical 5-6 volts that most VCRs use for their logic. The closest voltage is 3.5 V - on a couple of pins. Checking on the power supply connector of the other VCR, these pins correspond to the 5.1 V outputs. The other voltages are a bit high but this is not surprising since there is little load with nothing else working and the regulation is probably faulty.

Rather than working on the power supply in-place I decide to remove it to the comfort of my workbench. This is for three reasons. First, if for some reason, the outputs should skyrocket, I will not have the rest of the VCR to fry. Next, moving the power supply around will probably break the connections due to fatigue anyhow (it is soldered). Finally, it is simply more convenient. Only 9 or so wires are involved, so no big deal.

Five minutes later....

Now, for a switching supply, I probably need a load at least on the regulated output. I locate a 15 ohm power resistor, that should be about right for a +5 V low current (probably under 1 amp) logic supply.

Powering up using a Variac feeding my isolation transformer, the power supply is still outputting +3.5 V on the +5.1 V output. Good, at least it is not an excessive load problem on the +5.1 V outputs (which would indicate a problem elsewhere in the VCR. What about the other outputs? Well, they all test somewhat high (based on the measurements from the other VCR). Thus, an overload on any of those outputs is unlikely as well.

So, what could be wrong? Next step: draw out the circuit. This isn't a complicated power supply, no controller chip, just several transistors, resistors, diodes, an optoisolator, etc.

A half hour or so later, I have a not quite complete schematic. There could still be errors, but it is mostly there and sufficiently detailed to identify potentially bad parts.

Since this power supply is basically working - nothing smoked or blew up - this limits the possible problems considerably.

Testing components in the regulator feedback circuits does not reveal anything.

What about the optocoupler? With power off, I tack a wire across the input terminals (low voltage side). Now, if the optocoupler were leaky, this should make no difference. Bringing up the AC on my Variac, the +5.1 V output quickly reaches +5 - probably at an input of around 50 VAC - and shows no sign of stopping there. This is the expected behavior if the optoisolator were good. Cross that off the list. This also confirms that there is no excess load on the +5.1 V supply holding it down.

What about the filter components for the +5.1 V? Jumping a good electrolytic across the input capacitor (C16) of the Pi filter has no effect. So both the capacitors are likely good as the first should be sufficient to hold regulation. What else is there? What about the zener, D11? No dice, it and its buddy, the only other zener, D15, test good.

What else is there? Hey, what is this capacitor, C21? It seems to be in series between the +5.1 V output and the feedback circuitry? Since it is in series, leakage is important. I need to swap it or test for leakage out-of-circuit. I always opt to swap given a choice.

Ah ha! Success. Replacing with a good 1 uF 50 V capacitor results in precisely 5.1 V. The capacitor, C21, seems to bypass the zener when the output is changing - it in effect limits the rise of the +5.1 V output. Thus, if it turns leaky and passes current, not only will the +5.1 V output rise slower, it will be prevented from reaching its full specified value. The poor regulator does not know the difference between a rising output and a leaky capacitor.

Next day, replacing the power supply in the VCR restores full operation. There appear to be no problems with the capstan. All modes are fully functional. No other none user serviceable parts appear to have been touched.

I write a little note explaining what 'No User Serviceable Parts' really means.

Comments: Knowing what I do now, checking C21 followed by C16 and C17, and then the AC line filter capacitor, C4, would be the first thing to do whenever one of these or similar Panasonic power supplies shows up with incorrect output voltages. What this type of failure indicates is that components like capacitors really are like peas in a pod. When from the same manufacturer and lot number they are all very similar with respect to failure modes like drying up and losing capacitance or turning leaky when used in similar environments.

Most troubleshooting on the professional level is a matter of keeping good notes and/or having a database of previous repair tech tips. While on the subject, how about those solder connections in RCA/GE chassis CTC175/76/77 and all the others for that matter?...

As far as that 'fuse'. I must admit, had I known nothing about VCRs, the white knob does look an awful lot like a fuse holder. To a homeowner, it represents an irresistible temptation. Fortunately, he stopped short of attempting to remove the 'fuse' entirely which would have no doubt resulted in serious damage. And, no adjustment screws had been tightened! Thank you for small miracles.

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Repair Brief #28: JVC HR-D860U VCR Mangled Tape

Patient: JVC HR-D860U HiFi VCR, about 2-3 years old.

Symptoms: According to the owner, the VCR gobbled up a tape and her husband 'removed' the cassette but admitted he really wasn't sure of what he was doing(!!).

Testing: In situations like this, a careful inspection of the mechanism should be the first step. For JVCs of this era, parts tend to fall off of the roller guide assemblies. In some cases, attempting to play a tape can cause expensive damage - a loose roller guide can swing up and smash the video heads.

Sure enough, the supply side roller guide assembly was loose on its track and upon removing the bottom cover, the infamous brass pin fell onto the workbench. One drop of Epoxy takes care of the roller guide repair.

So what else is wrong? Was any damage caused by removing the tape or playing a tape with the faulty roller guide assembly?

The VCR appears to be behaving just fine, thank you. At least it played the one test tape fine that I tried.

Return to owner. Try it.

Next day: It's back: Doesn't work on SLP or pause modes. Uh Oh, that sounds like a smashed video head. Sure enough, a close visual inspection reveals that one of the video head chips is broken. Most likely, this resulted from the roller guide flopping around and/or during 'removal' of the stuck cassette. Unfortunately, repair price wise, this is a 6 head VCR. Lowest head price from my source: $71. Ouch. I tell the owner. "That isn't too bad, go ahead". OK, I guess she remembers what it cost new.

One week later: installation is straightforward as the connections are all to a circuit board with no flying leads. Pop the new head on and everything seems to be fine but - what's this - flag waving? Was that there before? I sort of remembered some on my cheapo monitor with the old head (the part that was still good, didn't think much about it at the time).

So, I go and try the VCR on the Panasonic TV in the main conference room. A little better, still some flag waving. However, everything else seems normal - back tension in particular. It could just be my tapes. If recorded on a VCR with significantly different back tension and/or video heads that are not perfectly aligned on the drum (not a user or tech adjustment), flag waving is possible and does not indicate anything is wrong - just different. Many TVs will have a suitable fast vertical sync response or a special channel with this characteristic so not generally a problem.

I returned the VCR, concerned that it would still not be quite right. But, next day, everyone was happy and even with my description, had no idea what I was talking about. Plays just like new. Flag waving, what's that?

Comments: this is one of those situations where the recommendation: "always confirm what does and does not work before touching a piece of equipment" applies fully. Unfortunately, with the broken roller guide, this was not quite possible at the outset. However, I should have paid more attention to the behavior once the roller guide was repaired and before replacing the video head drum.

Interestingly, this was one of my first contacts with the JVC parts shedding VCRs but in the next couple months, came across two more JVCs - one with a dropped brass pin and the other with a loose plastic hinge pin in the roller guide positioning linkage. Then, I 'fixed' a coworker's JVC over the phone (425 miles away) by his description of the **Symptoms**: "Sure, you lost a brass pin. Pull the bottom off....".

VCRs really are like peas in a pod.

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Repair Brief #29: Panasonic VCR with Video Noise, Audio Hum, and Erratic Operation

Patient: Panasonic VCR with several problems. Owner's complaint is video noise - sometimes the video disappears to be replaced by noise.

Symptoms: Indeed, video playback is poor. Tracking does not help. At times, the video totally disappears as though the heads are clogged. I also note that there seems to be a hum in the audio at times and there is some erratic operation when switching modes.

Testing: I tested with multiple tapes. Thoroughly cleaned the video heads using a cleaning tape, then cleaning sticks, then my thumb. In no case was clear video totally restored and the heads seemed to get clogged quite quickly. There is definitely hum in the audio. Occasionally, when entering play, the VCR will abort and unload.

This may be a case of multiple independent problems.

The hum leads me to suspect the power supply. This VCR uses a power transformer, rectifier, filter capacitor prior to linear regulators. Fortunately, unlike some Panasonic VCRs, the power supply in this one is easily removed and may be tested easily. Putting a scope on the main filter capacitor reveals that there is quite a lot of ripple - and that it is also somewhat erratic in amplitude. This could indeed account for the hum and erratic behavior. Some simple calculation show that the capacitance must be reduced by 75%. I locate a capacitor that is still perhaps only 2/3 of the labeled value and jerryrig it in place. The ripple is now much much reduced and the hum is gone. Time will tell whether the erratic operations is cured.

The owner was probably not even aware of these problems!

Now for the video problems - which are unchanged.

All symptoms point to a bad head. It is quite likely this machine has seen significant use. The owner is apartment bound and spends a lot of time in front of TV.

Indications of a bad video head include:

- Any visible damage to the ferrite chips.

  No visible damage in this case.

- Excessive video snow which cannot be eliminated by the tracking controls. An image where more or less good video alternates with snow at a 30 Hz rate means that one of the 2 heads in a pair is either dirty or bad.

Definitely present at times.

- Excessive video snow or no picture on some playback speeds (SP, LP, EP, still) since different sets of heads (in 4 head or more) machines are often used for different speeds. If this is due to wear, then it would probably gradually deteriorate and not happen suddenly.

  Yes as described above. This is a two head machine so all speeds are affected.

- Inability of certain internal adjustments such as backtension to eliminate erratic tracking problems may indicate a worn video head. Horizontal bands of video noise may come and go at various places in the picture depending on what speed is being used or the playback location on the tape (beginning, middle, end). These may come and go in a periodic cycle.

  No significant response to backtension. All guideposts seems to be locked solidly in correct position.

- Need to frequently clean the video heads even if you are only using new good quality (name brand) tapes. Video heads are normally self cleaning but very worn heads can tend to collect tape oxide resulting in a noisy, snowy, or totally missing picture.

  Absolutely - even after a manual cleaning (or using the Mark 1 Thumb), bad video seems to return quite quickly.

- You have just been playing a rental, damaged, or spiced tape and you notice any of the above symptoms.

She mostly plays old tapes. However, as noted there is no visible damage. Nonetheless, old worn heads may be more prone to clogging.

Given that most of the qualifications for bad video heads are met, I go and order a new upper cylinder from MCM Electronics. It is about $30.

This does indeed eliminate the video snow.

There is no further evidence of the hum or erratic behavior.

Comments: This VCR gets heavy use. I had cleaned it a few months before the present episode and noted at that time that video playback was not that great. But at the time, it didn't seem poor enough to warrant the expense of head replacement. However, now it was definitely unusable. The gradual and progressive degradation is a classic symptom of worn video heads.

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Repair Brief #30: JVC 6 Disc CD Changer Gets Stuck

Patient: JVC 6 disc cartridge type CD changer used by Chinese restaurant for background music.

Symptoms: Music gets stuck on outer tracks of some discs. Sections start repeating, stuttering, etc.

Testing: All CDs exhibit the same problems at approximately the same time into the disc.

History: This is the infamous 'Chinese Restaurant' CD player. I believe the problems started when after several years, they decided to change or add a disc. Yes, believe it or not, we had been subjected to the same music for as long as we had been visiting this restaurant - at least a couple of years. We were regulars. On this occasion, we were just getting through the soup (these are the full course lunch specials) when, what was that? The music got stuck for an instant. Being into this stuff, my ears are tuned to typical CD problems. Must have been my imagination. Then, halfway through the main course (Shrimp with Lobster sauce), there it was again. This time, it really got stuck, repeating the same measure for several minutes before anyone noticed and shut it off. Never being able to refuse a challenge, when settling the check, I inquire: so music broken? "Yes, not work." OK, I fix. So we walk out of there with this CD player under my arm and something to do for the afternoon.

Problems of this sort are almost always mechanical with simple causes and easy solutions. Attempting to play a disc - now it was totally incapable of even recognizing the index - resulted in the motor that moves the optical pickup just spinning its wheels. The worm gear was not moving and the pickup remained stuck about 3/4 of the way to the outside of the disc. Giving it a little help, resulted in resetting to the inner track limit and then successfully beginning to play the disc.

The most difficult part about this affair was getting to the worm gear as the optical deck is mounted upside-down and to remove it requires partially disassembling the changer mechanism. However, once this is done, the problem is quite obvious: Chinese grease! The last 1/4 portion of the worm gear is gummed up. As noted, the same 6 discs had been playing for as long as I can remember and none of these ever got to this outer track location. In addition to cleaning and oiling the worm gear, I decide to order a new belt which couples the motor to the worm gear as the slipping has probably weakened it. However, I will return the player to them in the meantime as it should work for a few weeks at least.

Well, that was about 3 years ago. The same new set of discs is still playing and I still have that replacement belt sitting in my desk drawer. We did get a free meal for the 3 of us out of the deal.

Comments: I know that many people are very careful to pamper their equipment. However, unless the various mechanisms are fully exercised to their limits at least occasionally - be it the pickup on a CD player or the suspension on an automobile - dirt, grime, and corrosion can set in and result in expensive repairs later on. At least that is my theory.

Despite my general low opinion of many JVC products, I have to admit that this CD changer has been very reliable. It has probably been running 8-10 hours a day, 6 days a week, for over 5 years requiring only this one minor cleaning and lube job during the entire time. That is not a bad record!

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Repair Brief #31: Mitsubishi HS-318UR VCR Dropped

Patient: Mitsubishi HS-318UR VCR apparently fell off the TV where it was perched from a height of about 4 feet. Owner had taken it to a repair shop for an estimate - it was recommended he get a new VCR. So, this was basically given to me. Well, loads of thanks! He also had some broken pieces in a little plastic bag - a corner of the front panel and a bit of a circuit board.

Symptoms: Totally dead, no display, no other signs of life. (Yes, I know, you are not supposed to plug in a dropped VCR until a thorough visual inspection is made inside and out.)

Testing: Not applicable.

This is an irresistible challenge. Aside from the chipped corner of the front panel, there doesn't appear to be any exterior damage. But, the piece of circuit board is ominous as it is apparent that there are numerous traces broken - and probably more inside.

Overall, VCRs are quite tough. However, falling in just the wrong way can do substantial and possibly not immediately visible damage. I have heard of someone fighting off a would-be mugger with a VCR but this too is not recommended practice!

In this case, the shop's estimate was way beyond what the VCR was worth and the owner was perfectly happy to upgrade to a newer model. I did make sure to get the remote control from him just in case a miracle happened - or the remote was the only way left to access the major functions.

After removing the top and bottom covers and front panel, the extent of the damage became evident. The good news was that the main board appeared to be intact and the mechanism itself has no obvious damage though this will not be fully confirmed until the electronic problems are addressed. At least, there are no obviously broken or bent parts - and no loose screws or other parts fall out. Nothing has popped loose.

I cycle the cassette loading and tape loading mechanism manually by turning the appropriate motor shafts. Everything appears to be free and seems to operate properly.

Inspecting for broken electronic parts does not reveal anything. At least the display is undamaged. However, the corner of the front panel display board is broken off - this is the piece in the plastic bag - thank you for saving it! In addition, cracks have propagated in a couple of directions cutting even more traces. Yuk. And, these are really, really fine traces. Double yuk. And, this is a double sided board. Triple yuk. Why couldn't the display have cracked in two - put it out of its misery.

There is always a slight risk that the initial impact has already fried electronic parts as a result of a momentary short or from broken circuit traces and there will still be problems even after repairing the visible damage and/or replacing the broken components. Or, for that matter, that my initial power test fried something else. Well, nothing ventured, nothing gained.

Optimistically, at least 25 - possibly considerably more - 10 mil width traces are cut. Some of the breaks are only visible with a strong magnifying glass but as they say, a break is a break is a break.

First, I repair the board physically with some quick setting Epoxy. It almost looks like a circuit board again. There is one little piece that is missing - and some traces go smack through its center. Well, you cannot have everything! Since, this is going to be a feature length restoration, I decide to remove the display board from the VCR - unfortunately, it is soldered in, 40 or 50 pins worth. At least, this is straightforward, just tedious.

With the board removed, it will at least be easier to get at both sides as needed. There is no particularly good place to start - they are all equally bad. Well, every journey begins with a single first step....

Where I can locate suitable end points, I solder fine wire (insulated #30 wirewrap wire) between these terminals. However, in many cases, it is simply not possible to trace far enough to locate the ends. In these cases, I use bare #30 wire directly across the break. A few I take a short cut and just bridge with solder - this will bite me in the end.

I attempt to double check each connection after soldering for correct wiring and that there are no shorts before proceeding to the next.

Unfortunately, one small piece of circuit board is completely missing and traces pass through this piece. I guess as best as possible the routing of these traces and hope. It seems to be part of the tuner memory circuit.

After what seems to be an eternity - it is probably on the order of 5 hours - I am prepared for the smoke test. This requires reattaching the connections to the mainboard and I will thus loose the mobility of having the display board separate. Well, so be it. This isn't even fun!

I plug it in! Well, no smoke at least. The display shows blinking 12:00. Progress! Still, ready to pull the plug, I hit the power button. What do you know - that even works. And there is some sound from the transport initializing.

Now to try the various functions. Let's see, no response from clock set, channel up, tuning controls. It is obvious that there are still a bunch of problems. Other anomalies: the Quick Record indicator is stuck on. What's this? The display just went dark. Oops, there is is back again. Pressing on the board seems to have an effect. There is still an intermittent somewhere.

Well, this is a start. Back to work....

Solder, solder, solder. After finding a half dozen more broken traces that I missed on the first go around, try again. Now, the clock can actually be set (well, except for the minutes). Quick record is still stuck. There goes the display off again. So the intermittent is still intermittent. Ouch! Why is the controller chip so hot? Pull the plug. Checking over the connections, nothing seems amiss but in the rats nest that the back of the board has become, who can say?

Following some traces that run under the display, I locate and repair a couple more that I had missed before. I rewire those few traces that I had just bridged with solder. I never do figure out exactly how the traces running through that missing bit of board should be wired.

This is as good as it will ever get.

For some reason, the Quick Record light is now out, I have no idea why. The display at least seems solid. The controller chip is cool again. Also have no idea why. Now to try a tape....

Success of sorts. The tape will play but the sound is muddy. CUE, REV, FF, and REW even work. It is not possible to reset the tape counter and it is also not possible to set the channel memory. Previously set channels can be tuned so that, at least, is not really a problem. And, who needs the stink'n tape counter anyhow.

It is not possible to adjust the A/C head azimith enough to get truly good sound. Only later, do I discover that the tape I was using for testing had been recorded on a VCR with incorrectly set azimith so this was probably a non-problem.

Just when I thought success was in hand, all of a sudden, after playing for about 10 minutes, the tape suddenly speeds up to about 10X normal with mickey mouse sound and loses sync. This is not CUE mode but yet another problem. The STOP button works but EJECT overshoots the correct stopping position as the main motor is obviously operating at increased speed in all modes. Resetting requires unplugging the VCR for a few minutes and manually rotating the EJECT gear a couple of turns. This is going to be a peculiar way to watch a movie! Something is obviously heating up, possibly causing a failure of one or more of the power supply voltages.

After spending about 15 hours on this VCR, I am in no mood to (1) give up after being so close or (2) do any more serious work. Is there an alternative? Yes, let me cheat. Maybe simply providing a bit more cooling to the power supply will keep it happy. So, I dig up a little blower removed from a defunct ultrasonic humidifier and prop it behind the VCR. Can this possibly work? The answer is - yes. Apparently, the added cooling is just enough to prevent the thermal runaway problem. Now, it is actually possible to play or record a 2 hour movie (first experiment: Star Trek IV). With this setup, the VCR will play or record indefinitely without spontaneously going into warp drive mode.

Comments: If you take a piece of equipment that has been dropped into a repair shop, the estimate you get may make the national debt look like pocket change in comparison. Attempting to repair a VCR or any other complex device that has been dropped is a very uncertain challenge - and since time is money for a professional, spending an unknown amount of time on a single repair is very risky. There is no harm is getting an estimate (though many shops charge for just agreeing that what you are holding is - a VCR!)

I suspect that the final problem - the thermal runaway is not related to the repairs I made on the display board but due, perhaps, to a heatsink that was loosened that I did not notice. Since the small amount of additional cooling provided by my blower was adequate to keep the VCR happy, it could even have been a pre-existing condition that just did not show up in a cooler location.

While a lot of effort was expended on this single restoration, for me it was well worth it. This was my first VCR. Despite the less than total success, the satisfaction was considerable. While the HS-318UR has long since been retired I still hesitate to cannibalize it for parts figuring that it has some historical significance.

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Repair Brief #32: A Tale of Two Toshiba PA8706 AC Adapters

Patient: Toshiba PA8706 power adapter (Supply #1) for a colleague's T1000XE laptop. I can hear everyone saying "right, one of those really state-of-the-art computers". However, the power adapters for newer models are quite similar so any lessons learned are still valuable.

A second identical power pack will be pressed into service for the loan of some of its organs.

Symptoms: When the bad supply is connected to a laptop with a known good battery pack, the red power LED flashes continuously. No amount of reinserting the battery or plugging/unplugging the adapter's DC plug clears the fault. (These contortions are sometimes needed when starting with a totally dead battery and are sort of normal.)

Testing: A voltmeter reveals that the output, 12 VDC, is cycling at the same rate as the LED. This occurs whether connected to the laptop or not. Comparing this with a good adapter shows that even without a load, the output should be a steady 12 V. The other power pack works fine with this laptop as well. Therefore the fault is definitely in the power pack.

These power packs are actually universal (90-240 VAC or DC) input switching power supplies which makes for a much more exciting adventure than a simple transformer!

The first challenge was getting inside. There were obviously snaps around the sides but it took a bit of detective work (read: the @#$% thing would not split in two) to determine that there was a concealed Torx screw (fortunately not of the security variety) under the manufacturer's label. Once this was removed (by puncturing the decal rather than pealing it back), the case came apart easily. At least it wasn't sealed and potted in Epoxy.

So, what do we have? It looks like a fairly typical small switcher - line filter, bridge rectifier, filter capacitor (big!), switching transistor and rectifier diodes in TO220 cases mounted to a full length heatsink, C-L-C 'pi' output filter. Part types for the power semiconductors cannot be determined immediately because of silicone rubber heat sink boots that entirely conceal the devices.

Uh oh, what's this? A conformal coated hybrid controller. I better hope it isn't bad as there is **no** way of determining what is inside. Obtaining a replacement would no doubt be impossible as well. Naturally, this is the first component that I suspect - wrongly, of course.

Well, what does a cycling output mean? Usually, this is an indication of an overvoltage or overcurrent condition forcing the controller to continuously shut down the supply and restart. A common cause for an overcurrent fault are shorted components on the secondary side of the supply. Overvoltage may result from defective regulator feedback components. The controller may simply be bad and misinterpreting the overcurrent and overvoltage sense inputs.

What does the output look like? On my analog VOM which has a fairly fast response, it appears as though it is cycling between 0 and a full 12 V (not something in between that would indicate a severe overload or short. Running the supply on a Variac reveals that the frequency of the cycle decreases as the input voltage is reduced but that the voltage swing remains the same.

What is likely: the main switchmode transistor is probably good but there may be shorted devices in the secondary side of the supply resulting in overcurrent, a defective regulator resulting in overvoltage, or a faulty sense circuit incorrectly shutting the supply down.

So, as always, I test all of the semiconductors that I can identify with an ohmmeter. Of course, I cannot do this on the hybrid circuit so there is an uncertainty that I might have missed something. However, everything I can test checks out fine.

What is next? Capacitors, resistors. All of these seem fine. I substitute some small electrolytics just to be sure. No change. Removing the output filter capacitors one at a time also results in no meaningful change. (Maybe the cycling rate increased - I did not check.)

At this point, I am temporarily out of ideas and the supply gets shelved for a few months. There is a spare but no one is eager to give it up (or maybe I just don't want to ask) for parts swapping - which is what I really want to do. Guess which part I want to swap?

A garage sale comes to the rescue as I find an identical power pack marked $5 but it is late in the sale (after all, how many people collect these things!) and I get it for $2.50. Whether it works or not, this is a handy source of parts - as long as it does not have the identical problem.

Supply #2: I plug it in and measure its output - nothing. Humm. A dead power pack could mean anything but as with any AC adapter, the first thing to check is the wire. And, sure enough, a little squeezing and bending of the DC plug end results in momentary contact and 12 V out. No doubt, the original owner spent the $60 or so for a replacement - not having read the FAQ on AC adapter repair.

Now, with a little effort, I should have a working power pack - and a source of known good parts as well. It turns out not to be such a simple repair as I have to carefully slit the rubber plug cover and then fish the good wire ends through that to reattach them to the plug itself. As they say, not difficult, just tedious. I have been there before.

Back to Supply #1. Now, I start swapping like crazy. The hybrid controller is first, of course. As you guessed, no change. Next is the transformer, then the switchmode transistor (a MOSFET), capacitors. No change, no change, no change.

Finally, the one part that I should have suspected all along - even if my VOM said it was good - the 12 V rectifier. Swapping this part - a TO220 with a pair of high efficiency (or something) fast recovery diodes did the trick. I know, you are saying: bozo, even in your FAQ, you say to never fully trust an ohmmeter test. Well, it finally did bite me.

Comments: Most of the time, silicon semiconductors stay broken once they fail but not always. In this case, for whatever reason, the diodes would work like - well diodes - for long enough to provide full output voltage but then one or both of them would turn into short circuits or at least develop high leakage. Thus, reducing the input voltage would lengthen this cycle as it would take longer for full reverse voltage to develop on the diodes as a result of the filter capacitors charging.

With switching power supplies it is always tempting to blame the controller, transformer, and switchmode transistor - because they are expensive, difficult to obtain, or both. However, for a supply that shows some signs of life, these components are rarely the cause of the problem.

Swapping parts between a working and dead unit - or between channels of a stereo amplifier or dual channel oscilloscope - is always an ideal way of eliminating selected parts from suspicion. It is a definitive test. There is a slight risk (maybe not so slight with power supplies and power amplifiers) that putting a good part into a circuit with some other fault will blow the good part. But, this risk can generally be minimized by using a series light bulb along with a Variac to limit current to the critical semiconductors.

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Repair Brief #33: Mac Plus with no Video

Patient: A colleague's Apple Mac Plus computer. Another state-of-the-art piece of technology. But, hey, these things are still useful.

Symptoms: Power-on results in nothing on the screen and the familiar friendly 'bong' is missing as well. Just some unidentified electrical noise indicating that it is getting power.

Testing: Nothing with the case on. It is obviously not operating as a computer and does not go through the normal boot sequence or even get to the point of asking for a diskette.

This is the 'classic' all-in-one style Mac, physically almost identical to the original MacIntosh computer and the Mac 512K. The much newer Mac Classic is constructed along similar lines. All require the special 'extra long Mac wrench' (1 foot long Torx) to get at the two screws under the 'handle'. Not having one of these (or actually, having lost mine), I make a suitable substitute by grinding down the end of a triangular file handle. It works quite well, thank you.

There are 5 Torx screws: 2 lower rear, one inside the backup battery compartment, and 2 under the handle (they are not all quite identical depending on if they screw into plastic or metal). Once the screws are out, a case splitting tool is supposed to be used but a wide straight blade screwdriver or other metal strip can be used **carefully** to separate the two sections of the case without damage.

With the case removed, I start by examining the large Molex connectors for damage and cold solder joints - there are none apparent (at this time).

How to identify voltages? Well, the floppy is pretty standard, so at least +5 and +12 should be easily found. OK, +5 is low and +12 is very low. Something is probably shorted. How about some ohmmeter checks? Since this is probably a monitor problem, the natural place to start is the horizontal deflection circuit. The small B/W monitor used in the Mac Plus runs off of +12 on the isolated side of the main switchmode power supply so at least this will not be a shocking experience.

Hmmm, HOT (BU406) is a dead short. It also appears to have seriously overheated as the circuit board at its legs is somewhat blackened. The most likely cause of overheating followed by failure is a bad flyback.

Nothing else in the vicinity appears bad based on the ohmmeter tests.

How does one test a flyback transformer?

Three ways:

1. Compare resistance readings of windings with a known good flyback. If these match, substitute it. I really like this one and for a short test, it is low risk - the chance of ruining a good flyback on a low voltage deflection

circuit is quite small. It is also a definitive test.

2. Perform a 'ring test'. Pulse a winding in parallel with a capacitor and see how quickly the oscillations die down. A shorted turn or two will totally kill the Q of the flyback.

3. Drive it with a known good chopper - this is my fun flyback tester - and confirm that it does not load the drive circuit significantly and that it puts out some high voltage.

See the document: [Testing of Flyback (LOPT) Transformers] for further info.

Happily, (1) is an option as I have a good Mac Plus just sitting around doing nothing (you don't act surprised!). There appear to be several variations on the basic flyback model - 157-0042B/B but they appear to be interchangeable. Unfortunately, the ohmmeter comparison is inconclusive and cannot test the HV winding in any case.

So, I decide to swap the flybacks - it is only 8 or 10 solder connections, so quick and painless. I rummage around in my junk box (you probably get the idea that my junk box is as big as a rail car) and locate a BU406D. The built in damper diode should not hurt anything (there is an external one in the Mac already).

Installing the transistor on its heatsink and soldering in the flyback takes all of 5 minutes. Now for the smoke test. There is probably no need (and no easy way anyhow) to use a series light bulb or Variac to limit the current. The Mac switchmode power supply is current limited and unlikely to be able to kill the HOT in the few seconds it will take to verify that the screen comes up. I will know almost immediately if the voltages are more normal as the friendly bong should sound almost as soon as the power switch is flipped.

And, indeed it does. A few seconds later, I am greeted with the inquiring Mac Icon and inserting a boot disk results in the smiling Mac Icon and a proper boot sequence. The picture appears to be bright, well focused, and stable. A few tweaks to position and size, and it is perfect.

Now to order a flyback. $14.99 from MCM Electronics. I leave the BU406D in place permanently.

Three years later: it's back!

New set of **Symptoms**: single vertical line. This is a classic (no pun intended) problem with Mac monitors - bad connections to the deflection yoke. And, sure enough, whacking it brings back the horizontal, though it is somewhat erratic.

The cause is obvious: one pin of the Molex yoke connector has staged a Three Mile Island. It is totally melted and the normally white plastic is blackened and brittle.

Rather than replacing the connector, I elect to just do a bypass and solder a jumper from the remaining wire stump directly to its destination on the monitor circuit board. Who ever removes yoke connectors anyhow? The remaining three pins and sockets (1 horizontal and 2 vertical) appear to be in perfect condition so I leave them alone.

I like easy problems for a change of pace!

Comments: Old Macs, like JVC VCRs that lose parts and Sony TVs with bad tuner shield soldering, have a particular set of problems that are nearly universal. Run a Mac Plus long enough and you **will** see a bad Molex connector or dead flyback.

The flybacks usually fail either by shorted turns in the primary or secondary. Cracked cores or HV rectifier failures are also possible but not common). When it is a primary short, I believe there is a good chance the HOT will blow if not caught immediately. A secondary short may just increase the load enough to cause overheating but not immediate failure. Sometimes, there will still be enough high voltage generated to have some light on the screen but the picture, if any, will be highly distorted. (I have a few Mac flybacks at this point and it seems to be a toss up as to which set of windings failed.

I like it when the primary goes bad because I can then perform a flyback primary windingectomy and have a very nice core and high voltage winding for constructing neat and nifty high voltage invertors. Generating more than 12,000 VDC from 12 VDC is quite easy and reworked Mac flybacks used in this manner seem to be virtually indestructible. See the document: "Various Schematics and Diagrams" for a couple of complete designs using previously owned, low mileage flybacks.

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Repair Brief #34: RCA EFR485 (CTC111C) Color TV, Part 1 - Messed up Colors

Patient: My color television - the one I actually bought new (what a concept) at a discount store (after the yoke died on my Zenith B/W 21" tube set from the 1960s). The RCA was about 4 years old at the time of this failure.

Symptoms: At first, I just thought the camera work on the show I was watching was a little strange, maybe the lighting at dusk or something like that. But when the commercials also looked strange, it was obvious that the TV was the problem. There were no yellows or blues! All colors were in shades of red, orange, and cyan. This makes bananas look particularly icky.

Testing: I tried different channels, adjusting the user controls, etc. No change. Black and white programs were normal and turning the color control all the way down resulted in a normal B/W picture.

Therefore, the CRT and its drive are fine, no missing colors. This is a case of messed up colors - and there can be only one small area of the TV's circuitry that can be responsible - the chroma decoder. I suppose, a short between two of the primary color signals - say blue and green - could result in a somewhat similar symptom but it was clear by rotating the tint control that this simple explanation did not hold up.

For a while, I just watched my weird TV since until I could get the Sams' Photofact for it, there would not be much I could do. After a couple days, it didn't seem as strange but nonetheless, I didn't want to have to explain the situation to anyone who visited. So, off to the library. This is a good excuse to copy nearly the complete Sams' folder for the CTC111 chassis even though a relatively small area is involved (in this problem).

A single IC performs all the chroma functions including generation of the 3.58 MHz reference, gating of the color burst, I and Q decoding, and generation of the R, G, and B drive to the CRT socket board. A disconcertingly large number of discrete components surround this chip.

There are basically three signal inputs: luminance (B/W video), chrominance (color information), and a color burst gating pulse.

Since the B/W picture is normal, the luminance input must be fine. There is no likely scenario where a fault in a prior subsystem (i.e., tuner or IF) could mess up the chrominance in any way that would explain the symptoms. The gating pulse matches the Sams' waveform.

What about voltage measurements? These seem to be pretty close though at least one appears to be a misprint in the Sams' (I never do quite figure out if it is or not, it did not have anything to do with the problem but my control settings might not have been the same).

What else is there? The output R, G, and B drives we know are messed up but do they appear funny in any way? Nope, they are all unique and the amplitudes are similar - thus no apparent shorts between them or to anywhere else.

The chip could be bad. Yes, I should have known better but this was over 10 years ago and ICs in TVs were relatively new. Therefore, I obtain a replacement - $15, not too bad considering how many legs it has! I carefully unsolder the old one and install a socket (as I always do in these situations as damage to the cheaply made circuit boards is likely if it needs to be changed again or the replacement is bad).

With great expectations, the new chip is plugged in, the TV is turned on and-

That looks even worse than before! Not only are the colors more messed up but the contrast seems to be off as well. So, either the replacement is bad (yeh, right) or the chip is not the problem. While bad parts are possible, the symptoms looks suspiciously similar, if not quite identical. Therefore, I conclude that it must be something else. $15 wasted? No, I learned a lot: If the chip is good and the signals to it look good, there can only be one set of alternatives - a bad discrete component or solder connection in the vicinity of the chip.

Well, they all look like parts. No smoke has leaked out that I can see.

First, to determine which parts are likely to affect only the color. Based on the controls (color and tint) and identifying parts that would have an effect on phase or frequency response narrows it down quite a bit. There are some resistors, capacitors, and a couple of small inductors.

A methodical test of resistances between pairs of nodes finally turns up something. There is an inductor in what looks like a filter between two pins on the chip which measures open! That would do it. It is marked 6 on the schematic and that is probably the normal resistance - it certainly should not test open. On the parts list, I finally find it - a 39 uH inductor. Just as a quick test, I take a 1 M resistor and wind a very precise random number of turns of #30 magnet wire around it. The 1M is irrelevant but acts as a convenient form for the coil.

Now, finally, a change in the color. Nowhere near correct but this is the first time that anything approaching reasonable colors have appeared since the start of this affair. Still not quite right. I get a another 1M resistor body and wind a whole bunch more turns onto it. Now, that is a lot better. Actually, probably good enough but I have access to an inductance bridge at work so, resistor and #30 wire in hand, I finally manage to come up with a fair approximation to a39 uH inductor. Sure, you are saying, just go buy one. You know that is not my style!

Comments: There is no good excuse for an inductor in a low power circuit to fail. The only explanation can be that one of the connections to the outside leads was not made properly or the fine wire of the coil had been nicked and finally just broke. I attempted to repair it but unfortunately lost the wire inside the potting compound (it was something like #40 wire - very very thin). Just bad quality control, not an induced failure.

Although it cost me $15 to replace the (good) chip, in the end, this was probably well worth it as it definitively (well, almost) eliminated a large unknown from consideration. The TV worked well for the next 12 years and only recently developed the 'No Picture' problem to be dealt with in a subsequent Repair Brief.

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Repair Brief #35: Panasonic PV1414 Closed Circuit TV Camera with no Video

Patient: A friend's brother's closed circuit TV camera from a building he rented (or something similarly convoluted).

Symptoms: No video. Output will sync the small monitor that came with it but absolutely no signs of any response to light. You could set off a magnesium flare 2 inches in front of it - lens or no lens - and there would be no indication of any change to the video.

Testing: There are no user adjustments beyond focus (there isn't even an iris on the lens). The camera was connected to a working monitor. Nothing, zippo, zilch, nadda.

This is a fairly typical 1/2" vidicon NTSC B/W video camera. 16 mm, f1.6 lens with focus ring, 24 VAC power. Output is baseband (RS170) video from a BNC jack. Apparently, it had been working but then at some point just quit. No one knows if it was a sudden or gradual failure.

First, some vidicon theory:

A vidicon is one of a number of similar camera pickup tubes based on a non- storage photoconductive target. An electron gun, not to dissimilar from the one in a TV or monitor CRT generates a beam of electrons. A number of electrodes shape and accelerate this beam toward the target. A pair of magnetic deflection coils provide horizontal and vertical scanning exactly as in a TV. A focus coil is used rather than focus electrodes (as are common in modern CRTs).

The photoconductive target is high resistance when dark but low resistance when illuminated. When the image from the lens is focused onto the target coating, the light and dark areas of the image results in low and high resistance areas on the target. As the electron beam scans, the target current is a direct analog of the brightness variations of the image. A very high impedance amplifier then boosts this signal to the level required for RS170 video (roughly .7 V p-p into 75 ohms) which is combined with the composite sync from the master timing generator.

Anyway, back to the story...

My friend Bill has quite a decently equipped lab related to his business (special analog integrated circuits) but when it comes to something a bit out of the ordinary, he is less than, shall we say, well prepared. To test this camera on the bench requires a 24 VAC supply for its power. You would think that locating a suitable transformer between a basement and garage full of junk (sorry Bill, that is what a lot of it is!) would be a piece of cake. Nope. We had to jerry-rig a couple of adjustable AC supplies in series to get something approximating 24 V. Oops, phase backwards. Reverse and try again. Finally, 24 VAC, and not too much smoke (though there was some - probably a dead cockroach or something bigger). :-)

From the outset, Bill is insisting that the tube is bad. How? "Oh, the heater will be gone". OK, where is the multimeter?

We use his 25 year old Lafayette VOM with the bent probes (one of which is missing the banana plug at the multimeter end so the wire is just stuffed into the hole). It is probably pins 3 and 4 of the vidicon. Yep, seems low resistance to me. When the camera is powered, in the dark, it is indeed just possible to make out the faint orange glow of the heater inside the tube but this was not obvious at first. The voltage is probably correct, something like 5 or 6 V DC.

Being the more conservative type, I suggest trying to trace out some of the circuit to determine what's what.

Bill, on the other hand wants to start poking around with the scope. OK, fine. At least, many of the connector pins are labeled with signal names. There are even various voltage test points on the circuit boards.

Well, first, let use check the marked voltages. Using the state-of-the-art multimeter, every marked voltage seems to be dead on. (Now, don't get me wrong. I also have an identical VOM which I still use quite a bit. However, it is in somewhat less battle weary.)

Unfortunately, all the marked voltages are power supply outputs - not pins on the vidicon tube which is what is really needed (as you will see later).

OK, what next. "Let's check deflection." Sure, humor him. These are clearly marked on the yoke connector. On the scope, the vertical looks like a decent sawtooth but the horizontal is a really short pulse. I, figuring the inductance of the horizontal coil suggest that this might be normal. Bill doesn't buy into this. I also suggest that even if the horizontal deflection were dead, there would be some light sensitivity - the response is real time with respect to wherever the beam is hitting. As long as it is somewhere on the target, there should be some response to light. The horizontal deflection coils are AC coupled - capacitor is good - so the beam could not be fully off target. Bill is still fixated on a deflection problem. Oh well, humor him some more.

At this point, it is late, I want to do this in my more methodical way, so I bundle the whole thing into a bag and take it home on the back of my 10 speed.

Now, I do not have the nice working setup that Bill does, but I do have parts. You want parts, I have parts. In particular, I have no trouble locating a 24 V transformer and a line cord! So that problem, at least does not exist at my place.

Since Bill won't sleep until this deflection thing can be put to bed also, I decide to trace the circuit to see if the pulsed waveform is entirely consistent with how it would appear to operate. I still believe it is and it is irrelevant anyway.... The circuit is very conventional, not too unlike a horizontal output circuit in any TV or monitor except that there is only an inductor in place of the flyback. Checking the input signal, it is quite clear that the circuit is doing what it should.

Then I get a phone call. Hi Bill. So we are discussing this result someone mentions that it would be easy with a current probe to determine if the deflection waveforms were correct. Current probe! Hello? Did someone mention the words 'current probe' by an chance? Of course. I have a Tek high frequency clamp on current probe - cost me a whole 10 cents at a garage sale. The last time I used it, Bill and I were trying to measure the instantaneous current pulse in an electronic flash unit (about 60-100 A). Why didn't we think of this earlier (Bill has one as well but I bet he paid more for his! Then again, with Bill, you can never quite tell).

This takes all of five minutes - the wires are clearly marked. And, what do you know, a perfect current sawtooth! Hi Bill, guess what? Horizontal current is a perfect sawtooth.

Next, I decide to attempt to figure out what each of the signals connected to the vidicon do. There are 7 pins, the internal electrode arrangement is clearly visible, and the names are printed on the vidicon socket board:

29. Pin 1: G1 ; Grid 1 - sets the beam current (like brightness, 0 to -80V).
30. Pin 2: K ; Cathode - electron emitter. (0 V, 20 V for blanking)
31. Pin 3: H+ ; Filament, around 5-6 V DC.
32. Pin 4: H- ;
33. Pin 5: G2 ; Grid 2 - this is very close to the cathode. (400 V) (1)
34. Pin 6: G3 : Grid 3 - this runs most of the length of the tube. (300 V) (2)
35. Pin 7: G4 : Grid 4 - this is a short ring near the target. (400 V)
    1. This is suspicious as I would expect it to be somewhere in between G1 and G3 in value. However, based on the circuit, this probably is correct as it is fed through a resistor (not voltage divider) directly from the 400 V supply.

    2. This voltage seems to be the feedback for the power supply regulator.

```
     _____  ___________________________
   |                                   \______  _____
```

```
           |
           |                                   ___
           |                                  |  _______K
           |                                    |< H+,H-
           |                                  |_______
           |                            _____  ____      G1
           | ____ _____________________/       G2
           |  G4            G3
           |
        Target
    (Video signal out on external contact ring).  Biased at around +10 V.
```

Touching or even going near the target ring at the front of the vidicon results in a hum signal in the video output. Therefore, the video amplifier chain is almost certainly working correctly.

Taking measurements while adjusting the Beam and Target pots seems to indicate that they have the expected effect. There is just no beam current!

What else? Maybe Bill is right - the tube is shot.

I start rechecking the measurements - probe slips, zap - what was that? Did I see a picture for a second or two? What did I touch? Figuring a cold solder joint, I start prodding in the vicinity. Nothing. OK, recreate the incident. The G2 test point and another pad are very close. If I momentarily touch the two, there is a tiny spark and a faint but recognizable picture appears for a few seconds and then fades out. This is entirely repeatable. What is that other pad? It turns out to be G1 - the beam control grid. Surprise, surprise!

At first I thought that dragging down the G3 voltage or the +300 V rail was having the effect but, of course, it turned out to be pulling up on the G1 voltage - making it more positive with respect to the cathode. In fact, shorting G1 to its buddy next door on the same connector, +H, results in a very nice picture. (Recall that +H is around +5 or +6 V).

For now, I will see if I can get it working consistently and worry about the explanation later. I grab a 1 M resistor and solder it between +300 V and G1. Now, it is possible to adjust Beam (and all the other controls I messed up) to get a quite decent picture. The resistor provides enough positive current into the BEAM pot so that the G1 voltage can easily be brought up to 30 V - well beyond what is needed.

As far as I can tell, the video is fine, the settings are stable. So, we have a case of a device that works in way it should not - which usually means that the 'fix' is masking some other fault. Without schematics with voltage levels or a spec sheet for the vidicon, there is not much more I can do. Bill will no doubt want the thing back anyhow and it will be hard to refuse in the interest of further research.

Comments: There are times when total comprehension is not required. It would be a simple matter to substitute a known good vidicon - if I had one. There is only so much time worth spending on something like a B/W CCTV camera. Based on on my testing, it works reliably. I have had it on for several hours without any change in behavior.

Almost certainly, there is still a fault - perhaps Bill was correct all along and the vidicon is indeed bad in some way - not the way he thought, but bad is bad except when it works! Or, maybe one of the voltages is indeed far enough off to be killing the video. Maybe it will drift further out of spec over time and the 'fix' will now longer be enough. For now, it works, move on. This camera will never be used in any mission-critical application, probably chip inspection, so if it dies, Bill will just have to unpack the Mark-1 magnifying eyeballs from storage.

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Repair Brief #36: Heathkit IM2202 Digital Multimeter - Dead

Patient: Heathkit 3-1/2 digit bench/portable digital multimeter from garage sale junk box. Apparently, this kit was never entirely completed as the cover was still in its protective plastic wrap.

Symptoms: No display or any other signs of life. No smoke either so at least that is a positive sign.

Testing: Switching through all ranges and modes results in similar behavior as in no signs of life.

Here is a situation that is not quite typical of a repair: a device which is in a totally unknown state. Was it constructed properly? Were all the parts good? Did some prior attempt to make it work blow something out? In many ways it is much better to be working on a device that was functional and then blew its top than to be dealing with something that never worked properly and whose history is not available.

Well, with every long journey, start with a single step...

I don't intend to spend a lot of time on this. If initial tests do not produce any revelations, shelve it. However, I do have the complete instruction manual and schematics so this will not be a totally blind challenge.

Since there is no action of any kind - not even a hint of a display - either the power supply is bad or the controller - an MK6013 - is bad. Hope for the power supply.

This meter is designed to be used on the bench or as a portable. It uses 4 C-size NiCd cells trickle charged when plugged into its detachable power cord. Checking on each of these indicates that they are charging. After a few minutes, there is greater than 5 V across the battery which should be adequate for normal operation. Still nothing. Unplugging, shows that the cells (despite some crystallization around the ends) do hold a charge.

The power supply runs off of the NiCd battery and uses a DC-DC convertor to generate all the voltages required for the circuitry except the +5 which is obtained from the battery through a pass transistor. The neon 7 segment displays require +/- 170 V and the analog circuitry uses +/-12 V. Listening carefully, it is just possible to hear the whine of this DC-DC convertor so at least it is starting up. Are the voltage outputs correct?

Well, the +170 testpoint measures about +70, the -170 V testpoint and +12 are also low and -12. Humm, -12 is nearly non-existent.

Putting a scope on one of the inputs to the convertor transformer shows a highly asymmetric waveform. This is a totally symmetric power oscillator. Therefore, such a skewed waveform probably indicates excess load on one of the outputs - probably on just one diode of the rectifier for that output.

Before I start mucking around in the power supply, I unplug the MK6013 chip and set it aside in conductive foam. I don't really want to blow it out (assuming it is still good) through some power supply screwup. All other parts are common and readily available. I probably would never get around to searching for a replacement for the MK6013, however.

First step: disconnect all windings of the transformer that are not needed to run the convertor oscillator. Fortunately, this is easily accomplished without removing the transformer. Suck the solder, make sure the pins are clear of the pads. Power! OK, now the waveform is a nice squarewave (much higher frequency and no longer audible). This proves that (1) the transformer is likely fine and (2) it is an excessive secondary load problem.

Which output?

First, I reconnect the high voltage (+/-170 V) winding. Still a nice squarewave. The +/- 170 V testpoints measure about 180 V and there is just a hint of a glow from part of the display. Without logic drive, this could be correct.

So, the problem is in the low voltage portion of the power supply or somewhere else powered from the low voltage. Good news and bad news. This narrows down the problem - to most of the circuitry in the entire unit! However, the fault is likely in the power supply.

Next, reconnect the transformer winding for the +/-12. Now, the bad waveform is back. The asymmetry of the input waveform almost certainly points to a bad rectifier as this is the only component that could produce a load current depending on the polarity of the input. Once rectified, excess load should affect both polarities of the input waveform equally and thus not result in the asymmetric waveform.

First, is it the positive or negative 12 V that is the problem? Pulling one transistor easily confirms that the +12 V output is not the problem I then unsolder each of the two rectifiers for the +12 V and nothing changes.

Now for the -12. Unsoldering D212 makes no difference but removing D214 restores the symmetry of the waveform. Even without this diode in place, all output voltages are now well within expected tolerances. A 1N4007 takes the place of its dead buddy.

Now for the acid test: replace the controller chip. And - Yes! - we have a display. It even looks somewhat correct. Obviously, the meter has not been calibrated but it does produce the expected results for DC V and Ohms. The + indicator and a couple of segments are out but some quick jiggling and tapping confirms bad connections. The bad segments are due to loose socket pins and easily remedied with a pair of needlenose pliers. I never do discover the actual cause of the bad + indicator but the problem went away after cycling the AC/DC switch several times.

Some quick calibration shows that it is in pretty good condition. There may possibly still be some minor accuracy problems with a couple of the ranges but in general - the @$#% thing works!

A bad diode! A stupid, 5 cent, bad 1N4002 diode! Can you imagine the frustration of the original owner who, after meticulously constructing the kit - following every instruction to the letter, double checking and triple checking - is unable to make it work because of a simple power supply problem? Keep in mind that this is not a modern DMM where the major parts consist of: case, selector, IC, LCD. This is 1975 technology with many many discrete parts on two 4" x 6" circuit boards. The effort probably represented several dozen hours labor with a hot soldering iron and the extensive use of choice 4 letter words.

Comments: A Heathkit IM2202 Multimeter is nothing to write home about by today's standards but is still useful nontheless. The significance here, if there is any, is in the type of situation in which one is attempting to make a newly constructed unit operational. There are subtle differences in the diagnostic procedures required due to the unknowns involved. In this particular situation, there was no way of knowing how much damage might have been done through prior unsuccessful troubleshooting or whether - as it turned out - some original parts were bad as well. This was obviously not the first electronics kit constructed by this person - there were a number of successful examples at the same sale. Therefore, I did have some confidence that the basic construction was solid and accurate and there would be some minor problem involved - which as it turned out, was correct reasoning.

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Repair Brief #37: RCA EFR485 (CTC111) Color TV, Part 2 - No Picture

Patient: My color television - the one I actually bought new (what a concept) at a discount store (after the yoke died on my Zenith B/W 21" tube set of many years). This is the second of a 2 part Repair Briefs.

Symptoms: I turned it on and - sound but no picture. No light visible on the screen. That is kind of strange. Except for the color problem 10 years ago, this has been a reliable set. (No tuner shield solder problems, knock on plastic!)

Testing: No user controls have any effect. The screen remains black. There is no flash of light when powering it off either. There is static on the screen however, so I suspect that HV is fine. Nothing is shutting down on its own either.

Since there is sound and HV static, I assume the horizontal deflection is running. As a simple test, I turn up the SCREEN control. This results in a raster. Therefore the power supplies, horizontal, vertical, high voltage, tuner, and sound are all in fine shape. Just no #$%^ picture. Well, that narrows the area of search considerably.

This will require the Sams' and a scope to trace - sure, no problem. I still have the photocopied Sams' from dealing with the previous problem and my scope is just dying to chomp on something interesting.

The only difficulty is that the bottom of the main circuit board is not accessible when mounted in the cabinet. However, maybe RCA thought of this - there are two offset screw holes which (whether by design or not, I do not know) permit the circuit board to be moved about 8 inches to the rear - and the cabling is even long enough. Now, with the TV on its side, everything I need to get to is out in the open.

With my isolation transformer - always a prerequisite - I can conveniently examine various points in the video chain. However, some testpoints are concealed under a shield soldered at multiple points. A slight annoyance - the soldering on this shield is really really good.

Just when I have settled in to try to determine where the video signal is getting lost, the picture pops on. Actually, it kind of dribbles on - first a weak rainbow pattern and then a second later the good picture. Could this be a bad connection? Perhaps, but no amount of wiggling, jiggling, whacking, or cursing, has the slightest effect. Cycling power also does not induce the problem. It is now as though the TV is not broken.

Hmmm. sounds like an electrolytic cap or thermal problem. (BTW, Bill - from Repair Brief 35: "Panasonic PV1414 Closed Circuit TV Camera with no Video is sure that the problem is a bad electrolytic cap and wants to destroy the ozone layer with a can of CFC based freeze spray to locate it.)

Let it cool for an hour.....

One hour later - picture comes on instantly!

Let it cool for a day.......

One day later - picture comes on instantly!

Leave it alone for a week................

Finally - no picture - for about a minute, then rainbow, then solid picture.

So, how does one go about troubleshooting a problem of this sort? Give me a problem that takes a minute or hour to show itself any day but one that is broken for only a minute or two? Not fun.

Well, perhaps even when it is working, there will be some voltage or waveform that isn't quite right. Maybe a visual examination will turn up some potentially bad electrolytic capacitors. Maybe one has lost some of its value and a capacitance check will reveal the culprit. Right, keep dreaming.

First step: narrow down the search area. At this point, I have no idea exactly where the video signal is getting lost - not even which subsystem! I do know that sync is stable - examining the raster shows that the lines are correctly interlaced when a proper channel is tuned. So, this puts it after the sync separator. Since this is fed from the video at the output of the video IF, I know at least that it is functioning to this point. That leaves the entire luminance channel - joy - as well as the chroma/luminance IC (the one I tried replacing in Part 1 of this story, U700).

I spend some time down one blind alley - the chroma input to U700. Suspecting this signal, I confirm that it is indeed always present even when there is no picture. A simple test of shorting this signal to ground at the chip input would have revealed that the most its absence would do is result in a B/W picture. One dead end.

Here is a rough block diagram of the video chain:

```
                                 +--------------+
                         +-------| Lum Peak/Amp |-------+
                         |       +--------------+       |
                         |                            C v      U700
          TP-A  +-----------+    +------------+ B +-----------------+    RGB to
Video IF ---+---| Comb Proc |----| Chroma Buf |---| Lum/Chroma Proc |--- CRT
            |   +-----------+    +------------+   +-----------------+    Drive
       To Sync Sep.                                   D ^
                                 +------------+         |
              From Sync Sep  ----| Burst Gate |---------+
                                 +------------+         |
                                                        |
                               +----------------+       |
 From Vertical Deflection  ----| Vertical Blank |-------+
                               +----------------+
```

I know that the video signal is fine at TP-A at all times. I also know now that TP-B is fine and does not kill the video in any case should it disappear.

Next, I identify the pins on the Lum/Chroma Proc chip (U700) that can possibly kill the picture totally. It appears as though there are only five: 4 of these are controls or power supply voltages (constant DC levels) and the other one is the luminance input, TP-C.

One week, later, preparing for battle I am set to measure the 4 static voltages as soon as power is applied. The scope is hanging on TP-C as well to determine if that signal is present at all times. A signal here would eliminate all the stuff in the 'Lum Peak/Amp' box from consideration (and there is considerable stuff in this box - I have greatly simplified the block diagram).

Charge!, or, err, power!

Voltages: Measure, measure, measure, measure! These all check out within 5 percent or so.

TP-C signal: Yep, it comes up immediately and appears to be valid video and of proper amplitude.

There is no detectable change in any of these when the picture appears 30 seconds later.

That's just great. All five possibilities seem to be fine. Well, when the plausible are eliminated, check the implausible.

First, however, I breakdown and decide to swap U700 with my spare in a week when I apply power again. As expected (but hoped against), the screen remains black for the expected minute. When the picture appears, the color balance is somewhat off (recall, that in our last episode, there were more severe problems with this chip but that was when the actual fault had not been located). However, adjustment of the CRT drives fixes this. For all intents and purposes, the replacement U700 performs identically to the original.

So, there must be some other input to U700 that is messed up.

Well, there is another possible candidate. I had not paid serious attention to it before but it is all that is left - the signal derived from 'Burst Gate' and 'Vertical Blank'. I initially discounted this since there was a signal present even when the picture was blank - but was it the correct signal? Brief checks previously had shown it to healthy - but that was when there was a picture.

One way to find out: short it to ground and see what happens. And - yes - this kills the picture. What is also significant, is that when the short is removed, the picture comes back in a very similar way to when the 'problem' goes away - some initial rainbow effects before it stabilizes.

So, next power cycle (1 week) I am intent on catching this signal in the act! This signal should look like a 2 volt pedestal during horizontal blanking with a narrow 5 volt pulse riding on top. This is called the 'Sandcastle'. I am now thoroughly familiar with what the correct shape should be.

```
                                 ___
             |\                   ^
             ||                   |
          __||_                  7V
________|      |_________       _v_
```

1 Week passes......

Scope, are you ready? "At your service".

Look at that! The pedestal is there but the narrow pulse is missing. Finally a clue. Some quick voltage measurements of the 'Vertical Blank' circuitry shows that it is impossible for it to be at fault as the pedestal would not appear normal. Therefore, it must be the 'Burst Gate'.

This is a fairly simple circuit - a transistor buffer is driven into saturation by the inverse blanking signal. An RC delays its turnoff at which point the positive going pulse at the collector is coupled via a C-L-R network via a diode to U700. The following is somewhat simplified:

```
                             12V
                              |
                              /
                              \ R744
                              /
                              |  C710     CR700      R747
                              +---||---+---|>|---+---/\/\--- TP-D
_____    __       R742       |/        |         |
     |_|     ----/\/\---+---| Q701     C         /
                       _|_  |\         C L703    \ R741
                C709   ---    |        C         /
                       _|_   _|_      _|_       _|_
```

- - - -

Next step: to determine if this transistor is working correctly. This time, scope probes on input and output. The verdict: input and output are both stable instantly at power-on. Having confirmed this, I immediately kill power. Maybe these quick checks will permit whatever is being cured in a minute to remain sick. Now what?

What about the other side of C710. Nothing. How can that be?

Coupling capacitor? Quickly bridging another one doesn't result in any change. Kill power. I cannot afford the bench space, need to get this wrapped up!

On a hunch, I check the resistance across L703. 20 K ohms, Huh? No way, it is marked 21 ohms on the schematic. Not another dud inductor! (Recall that this was the problem in Part I - messed up colors).

I pull L703 - it measures open. How could an open inductor result in a flat-line output? One might think this would increase the output. Well, with the inductor removed or open, the diode charges the capacitor as it would in a power supply and results in the diode output being clamped to zero volts. It actually makes sense.

First I try winding an inductor but even with as many turns of #32 wire as I can fit on a 1/2 watt resistor body, the value must be way too low as the output is still dead.

Rummaging around in my inductor drawer, I locate one that looks kind of similar. Unmarked, but of approximately the right size and construction (I really don't have a great stock of inductors.) The original is marked 471 which I assume to be 470 uH but I didn't photocopy the page of the Sams Photofact with inductor ratings, unfortunately. The results with my unmarked replacement are mixed - the picture is there (well, that really doesn't prove anything) but it seems a little bright. This signal looks fine, maybe the bright picture is my imagination. OK, try a different larger one. This even measures the same on my ohmmeter as the original should (like that means anything). However, the picture now appears normal.

Since the poor lonely inductor sitting on my bench still measures infinity ohms, I am confident that this is indeed the problem. Exactly what mechanism results in a delayed start inductor is not quite clear. It is not heat as there is no time for any thermal effects and the power dissipation in the inductor is about as close to zero as one can imagine. Is it simply the voltage pulses appearing across some kind of marginal semiconductor-like junction formed by corrosion between the coil wire and the leads that eventually results in good contact?

Attempting to 'disassemble' the broken inductor simply results in broken inductor pieces everywhere so I will never really know for sure what happened - until another one of the half dozen or so similar inductors in the TV decides to do its open circuit thing.

Maybe someday I will actually order the correct replacements for both of the dud inductors - this new unmarked one and the homemade inductor that fixed the previous messed up color problem. For now, it seems to be fine and the TV shows won't be any better with the proper replacement parts anyhow.

Comments: No doubt next time (sure, if there is a next time) I will test all the similar inductors first! What could possibly lead to a batch of unreliable inductors is another one of those mysteries of the universe. After all, an inductor is just a coil of wire soldered to a couple of leads. There is no thermal or mechanical shock and the circuit is very low power in any case. The TV is not in a damp location or subject to any other kind of abuse that I know of though based on the appearance of the innards of the inductor, some type of deterioration may have taken place.

How should one diagnose a problem of this type? In hindsight, I guess testing components in the vicinity of the Lum/Chroma Proc after waiting a week and with power off would make sense. But, some of the elapsed time was required to localize the problem to that chip. However, once it was clear that one of the signals to U700 was messed up, the ohmmeter checks would have greatly reduced the additional required debug time. Would freeze spray have worked? Perhaps - if anyone had thought to hit the inductor. There were no electrolytic capacitors anywhere in the circuitry around U700.

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Repair Brief #38: Sylvania RXX170-WA01 Color TV Clicks - No Picture or Sound

Patient: Garage sale TV. Waited for price to be marked: $5. Paid $3. Then asked if there was remote - they wanted to charge me $30 for that! Just kidding.

Symptoms: Pressing front panel power button results in a click but no indication of deflection or anything else. By listening carefully, it is just possible to determine that the 'on' and 'off' clicks are not quite the same sound. Therefore, the system controller thinks it is cycling power - this is not a shutdown problem. There is no response of any kind to any buttons on the remote control.

Testing: With the cover off, the first check is to determine if the horizontal output transistor (HOT) is shorted - it is not. Applying power (using my isolation transformer), the main filter capacitor shows the expected +150 V from the bridge rectified 115 VAC. Shutting power off causes this voltage to decay over the course of about 10 seconds - therefore, the power relay, its control, and main filter capacitor are probably good. Checking voltage at the HOT shows that it is present (though high - I suspect this is simply due to the fact that there is no substantial load with the set not running). Thus, this is a startup problem and not a catastrophic failure of the HOT, flyback, or some other expensive part. More importantly, startup problems usually have a definite cause and are not likely to reoccur.

The next step is to obtain the Sams' Photofact for this set. A trip to the library is in order. Until then, what about the remote control? Is it bad or is there something else in the TV itself that is not responding to the remote?

A quick check with my IR Tester reveals that the remote is not putting out any IR signal for any button presses. I double-check the batteries - they are good and will operate other remote controls. Opening the remote control is not as bad as some - one screw and some snaps along the sides. Nothing looks immediately amiss - no broken parts. But this is the component side of the circuit board. Depressing some catches around the edge allows it to be removed. Hey, what is this? Along one edge, a trace has been lifted off and broken by one of the catches. Did I do that? I thought I was being careful enough. Well, it needs to be jumpered and soldered in any case. That does it! The remote now puts out a strong IR signal - and operates the TV (to the extent that this is possible - at least it clicks in exactly the same way). I still have no idea of how the trace got broken or if I did it though this would imply an impossible sequence of events as I did not open the remote until *after* it did not work. But it did definitely fix the remote problem. For good measure, I also put a dab of glue on the ceramic resonator which is flapping in the breeze.

Now, back to the main event. Checking the Sams' index is disappointing - this model is not listed in the (1995) manual. However, a model with a very similar number is. Well, asking for the folder doesn't cost anything. Examining the schematics of this folder (for a RXX168-WA01) shows that there are enough similarities to justify copying costs. In fact, it appears to be virtually identical (I cannot actually locate any differences of any consequence). Generally, on the first round, I copy the schematics and any resistance charts and chip descriptions (block diagrams). Later, if I need specific information like part numbers, I will copy the appropriate additional pages.

Since there is voltage on the HOT, there is almost certainly a problem with the startup drive. Checking the base of the HOT shows that there is no drive present when power is turned on.

Checking the base of the horizontal driver transistor shows that there is nothing there either.

How is startup drive derived?

Various models of TVs and monitors use different techniques: multivibrator, deflection chip powered from standby supply, high value resistor supplies current to horizontal driver or HOT directly, etc.

For this TV, a single chip is used for sync and deflection, a TDA8305 - TV Signal Processor. However, after examining every pin on this chip, it is apparent that there is no DC power available until after the set starts up and the flyback supply is running. The supply voltages for the chip are all 13 V - rectified, filtered, and regulated off of a winding on the flyback. This leaves only one possibility - there is a high value resistor between the 130 V B+ and the base of the horizontal driver transistor.

The collector of the horizontal driver transistor has the expected +130 V B+ so the transistor is not turning on or is open (not likely).

First, I unsolder the base of the horizontal driver transistor so I can check the junctions with an ohmmeter - it appears good. Better make sure to reconnect that before applying power or else there will be 130 V on the IC!

Next, I test across R502 - startup resistor. It injects current into the base of the horizontal driver transistor. This applies a pulse to the HOT to initiate the flyback supply. And, what do you know! The resistor tests open! At first I thought I was just using the wrong scale on my VOM. However, it is indeed open - might as well be a pair of disconnected wires. It is a 47 K ohm 1/2 W film resistor. A quick power calculation shows that 130 V across a 47 K ohm resistor is about .3 W - close enough to suspect that simple heat dissipation and thermal cycling over time resulted in an isolated failure. In fact, there is no possible mechanism that would result in a forced failure of this resistor. Even if the 130 V supply was running high, the maximum dissipation is just about 1/2 W.

A replacement - with a 1 W resistor this time - restores normal operation. Not a bad set for $3 (+$2.40 in copying costs and a resistor).

Comments: These are the types of repairs that pay the rent for repair shops. A quickly identified cause with an equally quick and definitive cure. A return problem related to this repair is extremely unlikely. Realistically, a 15 minute repair from start to finish is possible.

This Sylvania TV is also nice to work on. Everything is on one circuit board, components are clearly marked, and it is possible to access everything without disconnecting more than the degauss and speaker connections (not needed for testing in any case). Too bad that a 2 cent resistor was specified with a marginal power rating. All too frequently, startup problems in TVs, monitors, and other switchmode power supplies, are caused by open high value resistors.

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Repair Brief #39: Sony Compact Stereo Model HP-179P - FM Dead

Patient: Sony compact stereo system - AM/FM radio, turntable, cassette (at least it is not an 8-track!!!). This is one of my charity repairs. (actually not charity in this case but low income people who would otherwise not get the stuff repaired at all.)

Symptoms: AM works fine but there is only low level static from FM. General whacking and prodding produces no reaction.

Testing: Exercised all buttons and controls, no change. An antenna seems to make little difference.

Getting to the **top** of the tuner circuit board is not too bad - just remove the turntable, uh, record changer (you know what they are, right?). Four screws and disconnect the motor and audio connectors.

However, even before that, I have to vacuum the thing! Why? Apparently, in packing it up (in a pillowcase, no less), some powdered laundry detergent or something similar was spilled into the thing. Yes, the adventures I have! Even my shop vac has difficulty getting every last particle out but for now, it will have to do.

With the turntable removed and set aside, the tuner and preamp board is readily accessible.

The FM tuning capacitor and front end are easily identified. Touching various points in this circuitry results in a large change in output but no selectivity. There appears to be a strong station which peaks around 102 MHz but it is obvious there is no heterodyning action as there is absolutely no selectivity. However, the front end is sensitive to my touch and therefore it is likely that the following stages are good.

I was just about to give up and head for the library and possible Sams when I decided to poke around a little more. My some quirk, I happened to press on a coil in the front end box and instantly good reception returned - as long as I kept my finger on that coil! Another bad connection? A wooden stick worked just as well as my finger (I was sure relieved since I didn't look forward to spending the rest of my existence holding onto that coil). So, probably a bad connection. When operating, reception seems to be absolutely perfect. Most probably the local oscillator was at fault.

Now, the fun begins.

Getting to the bottom of the circuit board is a whole lot more difficult than getting to the top.

First, the back panel needs to be removed. Then several screws holding the circuit board and a ground strap that needs to be unsoldered from a shield. Now it may be moved, but is still attached to the front panel via the dial cord. And you know how much I love to restring dial cords! For a while, I thought the cord would stay put even when pivoting the circuit board up enough to inspect and resolder but no such luck. With a thoroughly disheartening 'pling' the dial cord popped off of its pulleys. Well, at least the board is totally free and the bottom can be accessed.

I resolder all the pads in the vicinity of the coil since may of the connections looked questionable (though there were really none that I could say definitively were bad).

After flipping the board back over, reception now appears to be solid. Pressing, prodding, and pounding have no effect. Will it be permanent? I surely hope so!

Replacing the dial cord turns out to be easier than I had expected (unlike that time where I melted it with my soldering iron!) The only question was how many turns on the tuning knob shaft but there is obviously only one possibility (3) based on the total length.

Checking out the rest of the unit:

The tape deck appears to be functioning, Fortunately, none of the soap powder made its way into the tape mechanism.

The turntable, however, is a sad story. Soap powder everywhere. I remove the platter to find - more soap powder everywhere. It is necessary to disassemble, clean, and regrease the main platter bearing and changer gears.

Only then do I notice that the counterbalance weight for the tone arm is missing and the stylus is bent and would need to be replaced. Checking with the owner, it turns out that she doesn't play records (I can see why) and therefore, as much as it pains me, I will not bother to restore the turntable at this time (and probably never). It would be simple - I would have to come up with a suitable substitute for the weight and order a stylus.

Finally, I check out the dial indicators. One is burned out and another is intermittent (broken filament). The stereo light is burned out as well. These will come from MCM. At first I thought that substituting light bulbs I had in my stock would suffice but the cost of the proper replacements was so low that it wouldn't be worth it and mine would not work as well.

Comments: The world it seems is full of these 25 year old compact stereo systems. While audiophiles and snobs may look down their noses at them, the majority of people are perfectly happy with their performance (or lack thereof). Repairing one of these may not have the glamor of working on a laserdisc or projection TV but this lack may be more than made up for by the flood of enthusiastic appreciation from the owner - especially if they would otherwise not have been able to afford a repair.

Problems with compact stereos are very often low tech - lubrication, dirt, bad connections, dried up capacitors, burnt out light bulbs. A schematic is rarely needed and access to the interior is usually straightforward (though perhaps not as easy as one would expect as in this case).

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Repair Brief #40: Mitsubishi HS-U53 - Bad Tracking

Patient: My Mitsubishi HS-U53 HiFi VCR purchased new in 1990 (yes, hard to believe I actually bought something new!). Pampered, used mostly to tape Startrek and NOVA episodes. Not abused at all. How can it do this to me?

Symptoms: Tape is accepted but attempting to play or even display a still results in a garbage picture - tracking is way off. In addition, play results in no tape movement and eject follows as if the VCR finds the content distasteful.

Testing: I tried several tapes but it was obvious that something was very wrong.

I enjoy the challenge of reviving a garage sale acquisition purchased for $1 but I really do not like having to fix something for which I paid real money!

Nonetheless, I have no choice. Actually, this VCR has always been a bit finicky about how a tape is inserted. If pushed into the cassette slot too slowly, it might grab the tape and spit it out. If the tape was accepted, there was a chance that it would not seat correctly and never advance. Therefore, I wasn't entirely surprised by the failure.

Despite all my advise about most problems being simple and mechanical, I was naturally thinking that **my** problem would be something esoteric!

Once the cover is off, the extent of the problem can be seen. This VCR uses a 'rapid access transport' which means that the tape is immediately wrapped around the video heads in the fully loaded position except that the pinch roller may not be fully engaged. Starting from this position is indeed quite fast - less than a second to enter play or any other mode except super fast rewind which unloads the tape back into the cassette. The tape is in very light contact with the spinning drum but with no tension applied - which winds down on its own after a few minutes to conserve motor life (wear of the video heads would be negligible in this state).

Anyhow, back to the story. Checking the tape position after loading reveals that the pinch roller is not moving properly over and down as it should. Further close examination reveals the reason: there should be two wings on a spiral plastic cam gear which guides the pinch roller movement. One of these has apparently broken off allowing it to lose contact with its mate. (I did find the broken-off piece - I really like to account for all parts so they cannot jam something at a later time.)

Fortunately, MCM Electronics has a repair kit for about $12 which includes the entire assembly with a new pinch roller as well as one belt. I guess this is a common problem. Inspecting the pinch roller reveals some fine cracks (somewhat unusual for a pinch roller of this age) so a replacement is worthwhile.

To be safe, I scribe timing marks on the 2 or 3 gears that might be disturbed during the swap. This is always a wise precaution if no service manual is available. As it turned out, this was not needed as the new pinch roller assembly dropped right in without moving anything.

Comments: Why does this sort of thing happen? Originally I thought that Mitsubishi saved 2 cents on the plastic reinforcements and thus timed it to fail after 4 years. Perhaps this is the case. However, the consensus now appears to be that the lubrication of the shaft on which the pinch roller assembly slides gums up or dries out resulting in binding and subsequent breakage.

In either case, the end result is an annoying repair.

I did make sure to liberally lubricate the sliding shaft but fully expect the problem to reoccur in a few years. Now, if I only would do the types of preventive maintenance I recommend to others perhaps this could be avoided!

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Repair Brief #41: Mitsubishi FA2100-CW FAX Machine Will Not Send

Patient: Mitsubishi FA2100-CW facsimile machine. Old but perfectly usable technology. It should send and receive faxes. What more could you want?

Symptoms: Receive seems to work properly. Attempting to send a fax results in continual redials and the destination phone is never reached.

Testing: Initially, problem was not known. So I had to set up WINFAX on my PC to provide a suitable source/sink at the other end. See below. Once I unjammed the paper roll, receive seems to be fine. Attempting to send a FAX, however, results in repeated attempts to dial without success. Local copy function works correctly.

This fax machine was apparently acquired by my 'customer' as a result of the down-sizing of a local hospital. There is a user's guide but no installation or setup info. Well, better assume all the DIP switches are set correctly. Write them down just in case I should accidentally move one without realizing it (I actually did not do this and was lucky. However, it is a good idea).

At first I thought that the fax machine was never connecting to the phone line and I tried to identify which of the 4 internal relays was supposed to do this. Using a multimeter, the one whose coil was being activated was easily determined but there was nothing measurable across its contacts. Monitoring the phone like with a DMM showed, however, that it was picking up - the 50 V on-hook voltage drops to something like 5 V when dialing.

Further testing by monitoring the phone line both with the fax machine's phone and a separate extension reveals that the dial tone never goes away and the tones seem to be somewhat weak though apparently of the correct DTMF frequencies. The fax machine's built in phone does dial correctly, however. Interesting.

Time for some inspection. Disassembly is actually fairly easy - 2 screws to remove the bottom panel, 5 screws to remove the circuit board and a heat sink. Only complication is the roughly 10 cables that need to be disconnected to free the logic board from its wiring harness.

Oops, what is this? The backup battery is hanging by one lead. Apparently, this had been replaced relatively recently (I really have no way of knowing) and whoever did it was too lazy to access the bottom of the circuit board. Therefore, they attempted to solder in the new pack by heating the leads from the top instead of the pads. It may have worked long enough to close up the unit but was certainly not a long term repair. The other lead is somewhat loose as well.

While I don't expect this to fix the main problem, it is dealt with first. Additional wires need to be solder to the flimsy tabs on the battery pack since they break off as soon as I attempt to reinstall it in the circuit board holes. Some silicone sealer is now used to secure the pack to the board.

I reinstall the board with all 10 of its cables to confirm that **the** problem still exists and that it will now hold its time and other memory settings.

Now the machine is continuously trying to eject the input copy. What is going on? After some minor panic and confirmation that all connectors are indeed installed correctly, I realize that I am trying to run it on its side and there are some interlock switches that are gravity dependent. Setting the unit upright makes it a whole lot happier.

It now appears to hold its settings but as expected, will still not dial for fax transmission.

Out comes the board again.

So, what next? Tracing the circuit might be possible - it is a double sided board - but what about my usual approach - test all the semiconductors and capacitors in the area of the phone line circuitry. This has proven successful on more than one occasion (see Repair Brief #2: USR Data Modem Won't Dial, for example).

And, guess what? I found a little black diode that tested *open*. Now, that is unusual. What type? The part number is not listed in any of my databooks and cross references. Well, if it walks and talks like a 1N400x type, that is what I will try. The symbol on the circuit board is just a diode so I assume it is not something fancy like a zener or Tranzorb surge protector. So I put in one of my lonely looking 1N4007s - I dare you to blow! Hopefully, this wasn't supposed to be some kind of high speed or high efficiency type.

All other components that I can reasonably identify test out at least in-circuit with my DMM.

Reinstalling the logic board with all 10 cables is now pretty quick. I have the technique perfected!

So, now for the test.

Mode: Manual Dial. Telephone number: My PC's modem number.

Uh oh, behavior is the same. I am just about to scream or beat something over the CRT when I pick up my extension phone and hear: "Please touch 1 for sales, touch 2 for service.....". Huh? My PC does not have a voice mail system. It dialed a wrong number!!! Actually, I told it to dial a wrong number. After all, how often would I need to dial *my* PC? I didn't even remember my own phone number correctly.

OK, this will work. After transposing a couple of digits, I get it to dial the correct number but now WINFAX is not picking up. Not surprising as I never configured it for receive.

Finally, I am able to send a fax to my PC.

The customer will need to re-enter the other stored info like rapid dial numbers, their fax number, header and footers, etc., but it would seem that the fax machine is now functional.

Now where did I put the fax number of that pizza place?

Comments: This is yet another example of a simple problem bringing down sophisticated technology. I would have had no chance of successfully troubleshooting anything in the fax logic. However, phone line circuitry problems are quite common - especially after the storms we had the previous week. (I have a VCR coming in which failed during the storm as well). Without the circuit diagram, I have no way of knowing if this was, indeed, storm related damage but the probably is quite high that it was.

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Repair Brief #42: Mitsubishi HS3381UR VCR Tracking Bands

Patient: A former colleague's Mitsubishi HS3381UR VCR. (He now works in California and we are near Philadelphia. However, he visits frequently. It worked fine before the move (except for the occasional spasms of B/W only playback but that is another story), he says.

Symptoms: Tape plays but the bottom of the picture is snow and the remainder of the picture has an appearance similar to CUE (forward search) mode - multiple tracking noise bands are visible. However, the tape is clearly playing at normal speed as the audio is is normal.

Testing: Confirmed with several tapes. Same symptoms. CUE and REV result in similarly confused pictures.

The picture is broken up. The top two thirds has the same exact appearance as it would in search mode (CUE or REV) - 3 or 4 bands of noise with good video in between. The bottom third is snow. However, the sound is normal (but no HiFi sound) so the speed is normal and this is strictly a tracking problem. Once you have seen this set of symptoms a couple of times, the diagnosis takes about 3 milliseconds.

We did try to help diagnose the problem long distance. Unfortunately, his description of the picture was not clear enough or the email connection was bad - or something. This turned out to be hopeless. His interest in repairing things usually ends with changing batteries in the remote control anyhow. I am just glad he didn't cause additional problems by using sandpaper on the video heads or attempting to straighten the tilted guideposts with a pair of pliers!

So, next time in town, the VCR is dumped in our hardware lab....

It rattles! And, this is not even a JVC!

Upon removing the cover, the problem is obvious: the right side tilted guidepost has fallen out. It was probably fine as long as the VCR was in an upright position. However, the baboons who packed up his apartment probably had it sitting upside-down for the move so the guidepost worked loose. This is a 5 minute fix using 5 minute Epoxy using just the smallest amount - a dab on either side - then pressed fully into place and rotated if possible to distribute the adhesive (you don't want a continuous coating as trapped air in the cavity may cause the post to pop out before the Epoxy cures.) Tape path alignment should not be needed.

Comments: It seems as though older Mitsubishis are virtually guaranteed to have at least one loose guidepost. I have seen 3 or 4 in rapid succession. These often don't cause problems until the VCR is moved but the symptoms are quite obvious once you have seen a couple (even if you don't shake the VCR!).

Mitsubishis, JVCs, who else?

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Repair Brief #43: Panasonic PV2812 VCR - no Play or Record

Patient: Panasonic PV2812 VCR used for a lot of time shifting. The owner is apparently quite eager - desperate would be a better term - to have it back.

Symptoms: Play results in snow and shutdown in a few seconds. Record also results in shutdown. FF and REW work normally.

Testing: Multiple tapes result in identical behavior - just snow in play and then shutdown.

This is one of those VCRs with almost no controls on the front panel. Therefore, testing almost anything beyond play, record, and channel selection requires a remote control. I didn't get the remote control so I had to use one from another older Panasonic VCR. Some of the buttons behaved a bit, well, strangely. At least the basic functions seem to be standard.

With the top off, the problem is quickly identified. This model uses a tape transport that loads the tape half-way as soon as a cassette is inserted. A plastic lever called a 'sector gear' drives a metal lever with a vertical post called a 'control arm' which is supposed to pull the tape out of the cassette. (Thanks to Frank Fendley (Studio Sound Service, frank.fendley@datacom.iglou.com) for providing the correct terminology for these parts and for identifying the specific part numbers so I could obtain the necessary replacement).

The first observation is that the tape does not move after play or record are pressed and the microcontroller is shutting down due to lack of takeup reel rotation.

However, the underlying cause is not a common idler or belt but failure of the control arm to pull the tape beyond the pinch roller. Thus, in play, the pinch roller comes down and presses against the capstan but there is no tape there! Without the rotating capstan to pull the tape through, it just sits there. Without control pulses, I guess the blue screen circuitry kicks in and there is no picture. Eventually, the lack of takeup reel rotation results in a shutdown to the stop position.

So, what can prevent the control arm from doing its thing? If this were a late model Sony, it would be dried up lubrication but in this case the arm swings quite freely.

However, it appears to get hung up just short of the pinch roller. How does this work? A spiral multifunction cam gear that looks somewhat like a miniature washing machine agitator (supposedly called a 'Pressure Roller Lift Cam' by Philips who apparently invented the technique) is used to:

1. rotate the mode switch via gear teeth around its bottom edge,

2. move the control arm back and forth using a cam follower lever called a sector gear whose end presses against a cam affair near the bottom.

3. move the pinch roller up and down and press it against the capstan using a stirrup type cam follower which starts at the top and follows the spiral.

The mode switch appears to be fine and properly timed - in the tape half loaded position, the timing marks line up precisely and in the tape-out position, its timing mark lines up with a notch on the plastic case. One can only assume that there was some intelligence at work here!

The pinch roller appears to do exactly what it should coming down and then pressing against the capstan - which does rotate properly during the time it is supposed to be playing.

Therefore, we are left with the control arm itself. This is driven by a cam on the outside of the main gear but not directly - there is another lever - the sector gear - which actually contacts the cam. This drives the control arm via a set of 6 gear teeth. As a result of the way the two levers are pinned, a slight change in cam position results in a large movement of the control arm.

Except that it is getting hung up on something.

Unfortunately, it is almost impossible to view the goings on with everything in place. However, I really don't want to take anything off that (1) might require retiming or (2) have circuit boards hanging by multiple cables (as would be required for this series of Panasonic and clone VCRs).

What appears to be happening is that the actual control arm (which is made of metal) is getting hung up. The sector gear is made of plastic and - guess what! - has a crack!!! It isn't a break and not even much of a crack but will need replacement.

However, is the crack the cause or the result of the current problems?

It is just a small crack so I assume that the overall behavior will not be as grossly affected as it seems to be. Could the crack have been caused by some other problem?

Mechanically, there really isn't much to this. The only way it could not work would be for the control arm to have changed vertical height somehow or bent, or for there to be some obstruction or gummed up lubrication preventing full movement.

It seems as though a projection on the metal control arm itself is supposed to fit into and clear the cam as it pivots. Imagine: Cam moves lever #1 (the sector gear); lever #1 meshes with the gear teeth of lever #2 (the metal one with the control arm post); and a projection on lever #2 then fits into a cavity on the same cam gear. Thus, this cannot be a timing or electronic problem as the mechanics are totally self contained and only depend on the relationships of the two levers. The gear teeth that mesh them are timed properly - the little timing marks align. But the projection just stubbornly keeps hanging against the cam.

I did remove the metal lever completely to check for cracks or bending - there was no evidence of either of these conditions. I also tried raising and lowering it a carefully recorded amount - no change except that when raised, it hit the pinch roller before getting stuck so it was obviously not too low to begin with.

Finally, I decide to remove the pinch roller assembly - this seems pretty harmless as it is fully up and everything should operate fine with my cassette cheater, pinch roller or not. This gives a clearer view of what is going on.

It appears as though there is considerable stress on the plastic lever as the crack widens significantly during part of its travel. However, upon unloading, the pinch roller does move fully as it should. Interesting. Careful observation now reveals that the projection must be entering a cavity in the cam which is not visible and the cause is now likely to be that crack in the plastic lever.

When loading, there is enough stress to deform the lever and due to the mechanical amplification of the lever system, shifts the point of entry of the projection just enough for it to miss the cavity every time.

However, during unload, there is less stress and thus it pops in place for at least part of the way.

With a little less spring torque on the control arm, operation seems to be reliable even with the bad plastic part. Thus, the crack was the cause and not the effect - which is comforting as I was not looking forward to a convoluted failure!

Once the replacement arrived and was installed, I confirmed the timing (I just avoided ruining my whole day as the agitator thing tried to jump up but I calmed it down), and then lubricated some key points as well. The VCR was then whisked back to its expectant owner.

Comments: Once again, a very simple common problem like a cracked plastic part can result in symptoms that are confusing. This would have been a lot easier if there was better access to the mechanism. Unfortunately, this series of Panasonic VCRs puts the main circuit board on top and while not actually covering the cam gear/pinch roller/loading arm certainly gets in the way. I don't like removing it because there are a bunch of cables that never seem to go back just the way they should - at least not without some persuasion.

Unlike the Mitsubishi broken cam follower problem (Repair Brief 40: Mitsubishi HS-U53 - Bad Tracking) which bears some similarity, there doesn't appear to be any real cause for this failure except just normal wear and tear and perhaps too flimsy construction of the plastic sector gear. The design with a projection that must enter a recess seems like some sort of interlock to guarantee that the tape is fully beyond the pinch roller before it comes down and would possible crunch it. In all fairness, there must have been some merit to this design. At no time was there any damage to the tape despite such a fundamental failure of the tape loading mechanism.

However, once a crack develops, it is likely to get worse as the stress is a lot greater on the part when that projection cannot enter its cavity in the cam gear.

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Repair Brief #44: JVC HRD-550U VCR - Tracking Problems

Patient: A colleague's JVC HRD-550U 2 head VCR. I was actually expecting this job about 4 months ago but being his third VCR, apparently wasn't an acute emergency case.

Symptoms: Since this is a JVC, I don't even bother to plug it in before taking off the top cover and jigging the guide posts.

Testing: Jiggling the roller guide assemblies reveals that the right hand one is loose. Removing the bottom cover produces the missing brass pin.

I cycle the mechanism half way and pull the plug to gain access to the roller guide assemblies. It is important to take care at this point to prevent the relatively unconstrained roller guide from flopping up and hitting the spinning video heads - a relatively expensive lesson.

So far so good, a drop of Epoxy and that guide post is better than new.

Pop in a tape and...No picture. This was supposed to be straightforward. :-(

Both roller guides are seating properly but - wait - guess what? A missing tilted guide post!

Two dropped parts in one JVC at the same time! Fabulous.

Sure enough, the post is sitting quietly on the workbench minding its own business not caring one wit for being absent from work.

Break out the Epoxy once again. At least this post stays put once pressed into place (unlike the Mitsubishis that have the same problem but the cavity in which the posts are inserted are so closely machined that they trap air and the posts keep wanting to pop back out.)

Try #3: Ouch! The tape is grabbed on the wrong side of the roller guide. After carefully extracting the cassette, it is obvious that the roller guides are not fully retracting into the cassette. Thus, when the cassette drops, sometimes the tape is in front of the one of the posts. How can that be? In addition, sometimes the tape would not load, whirring motors, and it would give up and shut down.

The repairs look fine - brass post snug against the shoulder and nothing to catch on anyhow. What about the other one.

Now some history of this machine. It dropped the plastic pin on the opposite side roller guide linkage a couple of years ago. I replaced this and reinforced it with a tiny screw. The screw is quite secure but it appears to be this roller guide that is getting hung up, but on what?

At first, I thought that a plastic projection on the underside was hitting a sliding widget (great name, huh?) which it seemed to not quite miss as it should. When in the fully unloaded position, the projection on this widget keeps the roller guides in the retracted position. Apparently, it is doing it job too well and preventing it from retracting in the first place!

Carefully bending the plastic which allows the roller guide to pop home results in correct loading but failed retraction the next time EJECT is pushed.

Great! I have a VCR that can be loaded at the factory with one movie and will work fine as long as the cassette is not ejected!

So, is there a timing problem - something off by one tooth - or something else? The only thing unusual about that roller guide assembly is my reinforcing screw. Remove it!

And, sure enough, now loading and unloading is flawless. Apparently, the head of the screw added just enough height above the roller guide assembly to catch on the metal of the cassette basket in the down position. Lesson: when you reinforce the roller guide hinge, use a very thin headed screw.

I have no idea why this didn't show up after the first repair or maybe it has been a problem all along and the owner never realized it. Some careful filing leaving just enough head slot for a jeweler's screwdriver blade and everything appears to be happy.

Comments: This single VCR has has now had 3 of the 6 possible common dropped parts - drop off. In a professional service situation, it would really be prudent to head off the inevitable and reinforce or glue the others. However, they seem as secure as when brand new so I leave them alone. Perhaps, I just need material for a future Repair Brief!

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Repair Brief #45: SEARS (Goldstar) VCR, Part 1 - Broken Cassette Loader

Patient: Well worn SEARS Model 580.53471750. This is a Goldstar chassis.

Symptoms: Cassette platform is loose indicating a broken part. The owner apparently had someone extract the cassette - cover screws were missing (again - this is not the first such instance).

Testing: Cassette jams as soon as it is inserted. Fortunately, no additional damage is done.

Well, removing the cover is easy at least. Now, is the broken basket assembly the cause or the effect?

To remove the cassette basket assembly requires taking off the front panel (3 screws), video head cover sheetmetal (3 screws), and then 6 screws to actually unfasten the unit itself. The complete assembly can then be unplugged and removed to the convenience of my workbench.

And, hey, what do you know? There is a transverse shaft which keeps the two sides in sync - it drives the left-hand side from a motor and gear reducer on the right-hand side. The little right-hand gear is - missing! Not just fallen off but gone. Apparently, whoever extracted the cassette did a little 'clean-up'. No, it didn't fall off, it is **gone**.

Thus, I need one gear. Better make that two gears - its left-hand mate appears to have a fine crack just waiting to spread.

Frank Fendley of Studio Sound Service identified the part numbers - at first thinking I wanted the large drive gear which has a couple of projections and a spring. This mistake, however, got me to looking at that part and noticed that a plastic post had developed a crack and *was* in the process of breaking, so add one of those to the list.

Hopefully, there is nothing else wrong with the VCR that caused the missing gear to crack in half. However, without the basket in place, it is kind of difficult to be sure. I probably could have nursed it through the cycle even with only the one gear in place but I have confidence that this is indeed the main problem.

The parts arrive 2 days later. The two small gears fit perfectly but the large gear is apparently a slightly different revision and I need to ream out a section of the hole to accommodate a shoulder on the mounting shaft.

I, of course, violate my Rule #1 - mark everything before removal and a couple of email messages back and forth are needed to get the timing adjusted properly.

After a little lubrication with plastic safe grease and reassembly, normal functions appear to be restored.

When I returned the VCR to its owner, she commented: "So, that little plastic piece was the problem?". Thanks. No user serviceable parts....

Comments: The lesson of this story (aside from not messing up the timing) is to always check related components - mechanical as well as electrical - for possible stress or pending failures. This applies equally to capacitors in a power supply and plastic gears in the cassette loader.

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Repair Brief #46: Beckman Model 310B Digital Multimeter with Random Display

Patient: Beckman portable DMM Model 310B I acquired because - you guessed it - it was broken.

Symptoms: Most ranges result in a random display alternating between large arbitrary positive and negative numbers. There do appear to be differences depending on mode - DC V vs. Ohms but not in any decipherable way.

Testing: Changing battery, applying various inputs, whacking it, using the DMM to hammer nails - no change. Though it might have been my imagination, the character of the screwups may have changed after pounding some 20 penny spikes!

I had taken a look at this multimeter to attempt to repair it a couple of years ago. At that time, I completely (so I thought) disassembled it to locate any standard chips hoping that if I could get pinouts, I could determine what was wrong. There were none except for a couple CMOS CD parts - one in the clock generator and the other in the piezo buzzer circuit.

Everything else was custom and what was worse was that I could not even locate the main A/D and display chip! It had to be there somewhere. since the 2 or 3 custom 16 pin chips I could find were not large enough and not in the proper place to perform these key functions (they turned out to be precision resistor networks - I think).

So, for two years, this thing sat on top of Jim's filing cabinet gathering dust.

Finally, with nothing better to do (right, I can hear you saying: "sure, likely story") I set out to solve the mystery.

After pulling off the LCD panel, cleaning its contacts, and reinstalling - with no change in behavior - I noticed a 'wart' on the backside of the PCB board behind the display. What's that? It has no business being there unless it were hiding something. This 'wart' was a couple of molded plastic pieces that with 20-20 hindsight was obviously clamping something in place.

Prying off the first plastic piece revealed - a second one.

Prying off the second plastic piece revealed - a little circuit card with a blob of Epoxy - chip-on-board - in the center and 40 or so gold pads on the long edges. Ah ha! The A/D and display chip at last. Of course, a lot of help this will be if I need a replacement - no markings of any kind. Connections were via those aligned rubber strips LCD watch manufacturers are so fond of - and which I always suspect for bad connections.

So, I clean the chip-board contacts and reinstall. No significant change.

OK, maybe a little deeper. Next, I remove the chip-board, its mounting, and the two rubber connector strips and clean everything with cotton swabs and alcohol.

Now, finally, a change. The display looks to be half way normal. In fact, at that point I thought it was entirely fixed. Checking with a handy .1 % resistor that just happened to fall out of the sky, the ohms scale seems to be dead-on. Hurray, but premature.

At this point, I go about cleaning up the case thinking that this was pretty easy.

Then, I tried it on a 1.5 V Alkaline battery and got - 3.43 V. Huh? Did I pick up an Lithium by accident? Nope.

My AC line measures around 250 V according to the meter. Since none of my VCRs have melted down, perhaps, there is still a problem.

Well, maybe there are still some bad connections. So I go through the entire exercise of disassembling the chip-board once again and double check all pads. Reassembling results in no change and jiggling, pressing, and other wise fondling the display/IC area doesn't alter anything.

What next? How can ohms be perfect and all other ranges (I also tested DC current and Diode check) be off by more than a factor of 2?

As noted, this thing has a chip-on-board IC - unmarked - for the A/D and display driver and custom Beckman parts for key resistor networks. Thus, it is virtually impossible to determine any circuit details (not to mention the 32 pole rotary selector which cannot be used with the unit disassembled for testing).

There is one pot - full scale adjust - which has about a 10 % range end-to-end and affects everything but resistance. Perhaps, resistance is calculated by performing a comparison with a known resistance. Then, they would both be off by the same amount. Maybe I could bugger this pot to drop it down but I would really like to determine the root cause.

Modifying the adjustment pot circuit turns out to be impossible since it is connected to the above mentioned unidentified resistor networks and any attempt would be a shot in the dark.

So, now it works fine as long as I multiply all my (non-resistance) readings by about .4. I thought I was able to 'fix' DC volts by installing a 1.3 M ohm resistor across a point found by trial and error. However, this did not help AC volts or any of the current scales. And, apparently it messed up the offset as + and - readings seem to differ by an unacceptable amount.

For awhile (like a overnight), I just let the problem bounce around.

Suspecting that the reference voltage was incorrect - low resulting in the higher than correct readings, I searched for anything that might be a voltage reference. There were a bunch of transistor-like things but one stood out since while it had three legs, two of these were shorted together. Jumpering across the unconnected pins with a high value resistor resulted in the readings increasing. Measuring across it with a working multimeter read .54 V. Disconnecting the part entirely resulted in readings that were now **low** by a factor of about 2.5. Since the present part at .54 V makes it read too high by a factor of just over 2, a reference of 1.2 V should be about right. I knew I had saved that bag of 1.2 V zeners for a reason! Sure enough, putting a 1.2 V zener in place of the unidentified part results in nearly perfect accuracy on all ranges I tested - DCV, ACV, DC mA and Diode Check. No doubt it could be tweaked now if I had some voltage reference that I trusted. And, Ohms is still fine (actually probably better since the higher reference will increase resolution).

So, I still need to identify the reference part: HCC 8069 J010? It is a TO-92 but doesn't show up in my ECG or SK databooks.

After posting symptoms to sci.electronics.repair, I did get some useful comments:

(From: Kevin Carney (carneyke@watson.ibm.com).)

> "I've repaired many of the 300 series over the past ten years or so. The problem described sound like one of the finger contacts driven by the cam wheel is staying closed or not making contact. If this meter has these type of contacts it may be your problem. Solving it requires patience taking apart bending contacts putting together and testing. Good luck, Kevin."

As noted, it does not appear to have been bad contacts in this case though this info is certainly worthwhile to keep in mind for the future. The unit had very little use and except for the one contact I bent putting it back together :-((and subsequently had to unbend) the selector switches (all 32 sets of contacts) appear to be in pretty good condition.

Then, one Netter who prefers to remain anonymous replied:

> "I have the part in stock. I will snail mail it to you if you send me your address. The Beckman part number listed in the manual is FG3000-231-102. It is a 1.2 Volt Zener in a TO-92 package. The markings on the part are LT1004 CZ-1.2."

So I guessed correctly. My 1.2 V zener is marked LM305, BZ1-2, K002. I do not know if it is equivalent to the specified part so I accept this generous offer.

Comments: Test equipment is the stuff one depends on to troubleshoot other broken equipment. Therefore, it is disheartening in some ways to have to repair a DMM. To find multiple problems on a lightly used instrument is also disappointing. I suppose it is possible that my prior poking around searching for the random display problem caused the zener to fail but what an unlikely part to damage! I am not entirely sure the bad connections explanation is entirely correct or at least that it is a permanent repair but I will keep my eye on that.

Now all I need is a voltage standard to set its calibration.

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Repair Brief #47: Quasar TT4259WW Color TV - Dead

Patient: Bill's brother-in-law's 17 inch color TV.

Symptoms: Only the channel numbers work. In all other respects, it is a paper weight - and a big one at that.

Testing: No change when run up on a Variac. It remains dead.

So, Bill gives me a call at 7:30 in the evening: "I have this TV, about 13 inches. Only the channel numbers work, nothing else. Can I drop it off?" No, Bill, if you want to come and help to troubleshoot it, that is fine, pick a time. Otherwise, hold on to it. You can clutter up your basement. "OK, I will see if I can get dad to watch Bobby". Any excuse to get away from the kid. Five minutes later: "How about a half hour?" Sure, fine.

About 45 minutes later (30 minutes of Bill time), he comes lugging this huge TV down the basement stairs. At first, I thought it was at least 19 inches but measuring the CRT, 17 is about right. Well, at least it *should* be easy to work on - lots of empty space.

Plug it in and just as expected, only the channel numbers work. No picture, no sound, no static, no deflection whine. The thing has push button controls so I guess the standby power is ok. Time to check the power supply and HOT.

Eight screws later, the back comes off cleanly. There is a nice 3" x 4" parts layout diagram, still legible, so that is a help.

Check the fuses. One is black. Bill, which is the fuse closest to the back?

"Uh, looks like the B+".

Check the horizontal output transistor (HOT) with my trusty 25 year old Lafayette VOM. Case (collector) to other pins: 0 ohms. OK, bad HOT. What else?

Unfortunately, they saved a couple cents and soldered the transistor rather than using a socket. Bill, write this down: The yellow wire is on the right. "Done."

Removing the bad transistor is easy though we manage to lose one of the lockwashers. Well, as long as it is not on the circuit board somewhere.

I go into my HOT drawer and pull out a 2SD871. Nah, that is too good a part for testing *this* set, how about a BU208A? I won't be too unhappy if one of these blows. (Note: I have no intention of leaving either in place once the set works. I will order the proper replacement, a 2SD950.)

Installation is equally smooth with the yellow wire on the right. These is also a little insulating sleeve which I swear went on the yellow wire pin but Bill thinks went on the other. Oh well, I will put an insulator on both later on. Replace the fuse.

I go get the Variac and series light bulb widget and plug these in to my isolation transformer rig.

Starting with a 100 W light bulb.

Bring up the voltage until about 100 V - channel indicator lit - push ON button. Light bulb flashes brightly and set shuts off.

OK, Bill, unplug the degauss coil from the mainboard.

"What? Huh? Where is it?"

Locate the coil and work backwards. Here, this connector....

Try again. Similar result. Up voltage to 120. Now, it stays on, not to full brightness but more than I would expect if the set were working properly.

There is still no picture, no sound, no static on the screen. I think I can hear the deflection whine, however. The HOT is holding.

Try a larger light bulb!

I put in a 150 W outdoor flood. Try again. Turn Variac to 130 V (or whatever its maximum is).

There is still no picture, no sound, no static on the screen. I definitely can hear the deflection whine. The HOT is still holding.

Then, Bill says: "Shut it off. Shut if off. I see smoke...."

Sure enough, there is a wisp of smoke coming from the vicinity of the flyback. It stops too quickly to determine the source. There is a small electrolytic there as well and the smoke could be originating elsewhere. The odor could be burning plastic or burning electrolytic.

Now for the real smoke test! I go get a foot square piece of Plexiglas that was once part of a homemade HV capacitor to use as a shield if something should decide to blow up.

Power it up again. After about 20 seconds, the smoke appears but it is still not possible to determine if it is the cap, flyback, or something else.

Well, change the cap. It is a 1 uF, 160 V electrolytic. I will show it! I put in a .8 uF, 200 V polyester type. No change - still smokes. This eliminates the capacitor. Bill is sure it is coming from the flyback at this point anyhow.

Bill is getting ichy as he knows his dad won't be able to take much more of Bobby. So I suggest that we pull the flyback and I will test it later. The big pins are a pain but attempting to discharge the CRT HV under the suction cup thing yields nothing as expected.

Bill is about to leave. Hey, how about buttoning this baby up so it is not cluttering up my workbench. "OK," Just a couple of screws, put the other stuff in a plastic bag. "I think the flyback is bad."

Next day:

I get out my flyback tester widget - the 12 V chopper - and hook it up. Ten turns of wire around the core connected to its output. If the flyback is good, this should excite it to produce 8 or 10 kV with only a small load on the power supply.

I locate the HV return on the flyback by turning up the juice just enough so it is oscillating - barely. Measuring on the 5000 V scale of my Simpson 260 shows a couple kV between the CRT HV connector and only one pin on the base of the flyback. That must be it. The others show zero volts.

Now, turning up the input power to my normal 'full' results in a nice 1/4 inch arc between the HV output and the return. Is the flyback good? Just then, an arc develops between the return pin and its neighbor. What is this? Kill power. Did I pick the wrong return pin?

I drag out the TV chassis to confirm that the pin I selected was indeed the HV return. It was. The other pin is a winding for one of the auxiliary outputs of the flyback.

So, what is going on? A quick check with the multimeter solves the mystery: All resistance measurements are reasonable except one - and a fundamental one at that. I measure 1.76 K ohms between the CRT HV connector and three pins on the base of the flyback - and one of those is the pin that arced.

Therefore, this flyback is history. Apparently, internal breakdown between the output of the HV rectifier or multiplier and the low voltage windings resulted in destruction of the original HOT and blown fuse. This is a pretty spectacular failure mode!

I call Bill on the phone: flyback is bad as expected. Short, CRT HV to pins on base. "I already told him it probably wasn't worth fixing".

The flyback is definitely bad but could it have damaged other circuitry in the TV? After all, until the HOT popped, that HV was arcing internally to the low voltage windings. I suspect that it did not cause any damage, however. Despite the fact that the HV output is on the CRT capacitance and could really zap something, it is likely that the short didn't develop suddenly but over at least enough time for the capacitor to discharge harmlessly. The actually current available from the flyback HV output is quite small and the low voltage flyback windings have almost no resistance to ground.

We will probably never know since Bill talked the 'customer' out of spending the money for the expected repair parts. The HOT would probably be around $5 and the flyback is $26 from Dalbani. Add shipping and this will likely come to over $35 for a 13 year old TV. And, there would still be a chance that it would not work at all without additional parts or have long term reliability problems.

So, if anyone has a good TLF14617F flyback they want to sell cheap....

Otherwise, the set goes to the great TV spare parts graveyard in the sky (or actually in the attic of my garage).

Comments: I promised that not all these stories would have entirely happy endings. This is a case where determining the extent of the damage and cutting losses made the most sense. If I come across a replacement flyback (sure, like they are all standardized!) then it will be worth the effort to see if that is all that is needed.

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Repair Brief #48: SEARS (Goldstar) VCR, Part 2 - Shutdown in Play and Record

Patient: Well worn SEARS Model 580.53471750. This is the continuing saga of the VCR described in Repair Brief #45: "SEARS (Goldstar) VCR, Part 1 - Broken Cassette Loader.

Symptoms: VCR will enter Play and Record successfully but then shut down in anywhere from 10 seconds to 10 minutes.

Testing: I was able to confirm these symptoms and it didn't take long, about 2 minutes the first time, 10 seconds the next. I tried several tapes without any apparent change.

It was only two weeks since returning this unit to the 'customer' after repairing the cassette loader. These are classic symptoms of dead rubber but I knew the rubber parts were fine having replaced them not so long ago. And, observing the behavior as it shut down, there was never a problem with spilled tape or a weak takeup reel. This is confirmed by testing the takeup reel torque using a cassette cheater (shell).

The reel rotation sensors would be the next natural suspects. What about them? Well, there is only one, for the takeup reel. The tape counter does increment but on closer examination, there does appear to be some weirdness. Instead of counting 0000, 0001, 0002, 0003, etc. It occasionally skips counts. So the sequence might be: 0000, 0001, 0003, 0005, 0006.... I don't know how the microcontroller determines that the tape is moving but it might just test the least significant bit periodically. If the counter is skipping counts - say only doing odd numbers for a while - this could end up not changing for too long.

So, now I start playing with the takeup reel with the VCR in STOP mode. Fortunately, the counter is active and I can simply twirl the takeup spindle to my heart's content. It doesn't take long to realize that IT is behaving strangely. If I go very slowly, there will be times when the counter display will free-run, counting rapidly and continuously. This is, in fact, most likely what is happening - the reel is turning slowly enough that as it passes through these 'bad' areas, the counter skips a count or two. Why?

Putting a scope on the sensor signal doesn't reveal anything amiss - it changes smoothly from low to high and back again. However, when it is approximately in the middle of its range, the counter does its free-run thing.

I trace the circuit to a buffer on a little circuit board tucked in a very inconvenient spot needing to extricate it from several connectors. Examining this circuit shows that it is, well, just a buffer. No hysteresis or debounce. Its output is changing as expected. Tracing the output reveals that it is going to a large multilegged creature - the main system controller chip. So, if that does the debounce, I am kind of out of luck as I am not going to invest in a new microcontroller.

Well, I will show it! I build a little widget board with a single transistor (2N3904) and a couple resistors as an additional buffer and put this in series with the original signal. I then add a feedback resistor from the output of both buffers to the input of the first one. This adds just enough hysteresis to prevent the circuit from even likely lingering in the bad area.

At first, this works like a champ but then the sensor seemed to be losing sensitivity and its output refused to go low! Could a dying sensor be the entire problem? No, I don't think so. That free-running count problem would still exist even if the transitions were sharper - it might be unlikely during normal tape movement but could still happen if the tape stopped at a just the wrong spot.

Removing the sensor under the takeup reel requires popping the split washer and pulling the spindle - taking care not to lose the washers under the spindle. It could be worse.

The sensor is a roughly 3/16 inch diameter affair with an LED and photodiode pointing at a four quadrant aluminum reflecting pattern on the bottom of the spindle. Everything is clean and undamaged so perhaps the LED or photodiode is in the process of failing. It doesn't really matter which is bad as failure of either would render the device useless.

What to do? My usual places like MCM Electronics do not list a replacement and I really wouldn't have a minimum order anyhow. I check with Frank Fendley - he has it - but I cannot justify the $5 S&H for a $2 part.

I will make one from the guts of an optoisolator! I at least want to do this to further test my theory (though at this point I am nearly certain that the sensor is the **final** problem).

I totally destroy 2 optoisolators in the process but finally extract both an LED and photodiode intact. Fortunately, my friend Bill has bags of these left over from his switchmode power supply design days.

The circuit board is marked so it is easy determine which leads are the LED and which are the photodiode. It isn't pretty but with a bit of filing and other manipulation, using the correct chants, etc., it finally is positioned to have enough sensitivity to activate the counter. Unfortunately, the top of the LED rubs on the bottom of the spindle during rewind slightly scraping the reflecting pattern but not enough to affect anything. A bit more filing and a key incantation and it seems to be solid. The response does not quite seem to be as sensitive as I would like but operation appears to be consistent, reliable, and repeatable from one end of a T120 tape to the other.

In fact, I ran the VCR for about 20 hours in Play and Rec, end-to-end of tape, and at SP and EP speeds without any apparent problems. I know I can obtain the replacement part but for now my kludge is just fine, thank you. The @#$% VCR will probably now die in a couple months in some other interesting and creative manner.

Comments: This is my VCR from hell. It seems to have problems with multiple unrelated failures at nearly the same time. I have already had to replace the video heads (due probably to just plain wear and tear) and also suspect a bad connection in the video circuitry as well. Sometimes, I have simply needed to clean the video heads. In addition, the 'customer' insists on using old, worn, and damaged tapes.

Assuming that the cause of the aborted Play and Record was a weakening sensor and/or bad debounce circuit inside the microcontroller, there is no way of tying these in with the prior failure of the gear on the tape loader mechanism. If it were just out of warranty I would credit Goldstar with timing multiple parts to fail simultaneously but it is at least 8 years old at this point.

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Repair Brief #49: HP DeskJet Professional Printer, Part 1 -

Dead

Patient: Garage sale HP DeskJet Professional ink jet printer in pretty good physical condition except see below. $5*.

Symptoms: Switching power on results in absolutely no indication of life either from the front panel LEDs or motor movement.

Testing: The output of the power brick is marked and I was able to verify that it was approximately correct - 20 VAC. Since it is a simple transformer, it is probably good. Attempts to evoke a response from the printer without opening the case were all dismal failures.

You probably know me better than to believe I paid a whole $5 for a broken printer. Well, I did get a PC power supply and a bunch of old hard drives and controllers as well. As of this writing, the power supply and at least one of the hard drives are known good.

Unfortunately, I neglected to ask what the original problem was. But from his attitude, the printer must have died totally. Otherwise, he would have likely mentioned that it was probably a minor problem (and attempted to charge more than $5).

Anyhow, the printer is in a box sitting on the ground and somewhat waterlogged. I don't know if the stuff was out all night and it rained or what.

First test, as noted, was of the AC adapter which is apparently just a transformer. Its output read a bit higher than the listed value that is typical of an unloaded wall transformer.

After drying the case off, I plugged the printer in and turned it on.

Nothing. No sign of movement from any of the motors, no lights on the display, and no response to any buttons.

OK, time to get inside. Some HP engineer probably won an award for the mechanical design of this thing. (I seem to recall reading about this product line in a past HP report.) Indeed, it is easy to get apart and the subsystems are readily accessible. The top of the case is held in place with 4 snaps. There are only 5 modules inside: power supply, logic board, print head driver board, printer mechanism, button and display panel. Except for the fact that HP seems to used weird size philips head screws, the entire thing can be disassembled to the module level in about 10 minutes. However, I would have preferred screws to hold the top of the case in place rather than snaps as it is necessary to deal with the snaps every time the top is removed - which during troubleshooting is quite frequently as the paper tray is part of the top cover.

Back to the story. All I have done to this point is remove the top of the case. However, the next time I switch it on, the print head whomps to the left end of its travel and seems to be trying to fling itself off into space.

Power off. Let's try that once again. Power on: Whomp-whir! Power off.

Then, I notice the puddle of water on the logic board!

First, I try to deal with in-place by mopping up what I can get to. Then, I start up the old air compressor and use that to blow and dry the water. Well, it isn't really up to the job so I start up the 3 horse shop vac on blow. However, I cannot get under the print mechanism where the bulk of the logic board is located.

Removing the print mechanism requires only disconnecting of 3 connectors and a ground strap (one of those darn HP philips head screws!).

Now, it is easy to get to all parts of the logic board. I also remove the EPROM and dry out under it to be sure.

I replace the print mechanism.

Ready? Power on: Nothing. OK, we try that once again. I said power on: some lights on the display. There is no response from the buttons and no motor movement. Several more power cycles results in somewhat random lights but no other action.

OK, I will take out the logic board so I can inspect the underside for water. This requires removing 7 or 8 screws and the power connector. The board is fine. I also reseat the power connectors.

Reassembling - ready? Power on: Now, I get lights AND the print head seems to be doing something reasonable, like the reset sequence. Back and forth, prime, and then the On-Line light comes on. Its pitiful brain thinks that everything is fine and ready to print. Is it?

Along with the printer came about 15 sheets of somewhat water damaged (but now dry) paper. This should be good enough to test it even if every third sheet jams and tears.

Now, how to do a self test? Fortunately, the complete HP users' manual was part of the deal. "Hold the FONT button while turning on power". OK, no problem.

Now, the printer goes through all the expected motions of initialization and then proceeds to load a sheet of paper and....

Nothing. Actually, as far as it is concerned, the self test worked fine. But, there is no ink on the paper! Well, the cartridge could be empty but it doesn't feel that way. Based on my past experience, it is nearly full. The nozzles could be clogged but sucking on the business end of the print head (yuck) results in some ink drops appearing.

At this point since I do not have another cartridge to try, I decide to strip it down completely once again and do a thorough inspection. Somehow, I don't think the water was the cause of the original problem. All connectors are reseated (including those to the print head which are the flexible printed variety).

Everything looks fine except for the solder around the DC power connector output pins of the power supply. There may be a hint of cracks around several of them. Well, my soldering iron makes short work of those!

Put it all back together once again. No change. There is always a chance that operating the printer with the waterlogged logic board may have damaged something - always fear the worst, right? Therefore, I decide to do a little exploratory probing of the print head driver board since everything seems to be fine except there is no action from the ink jet nozzles.

A bit of ink jet theory: There are something like 50 thin film heating elements inside the micromachined chamber at the business end of the print head. These heaters are pulsed at precisely the right time by the logic to vaporize the ink in direct contact with them and expel a drop of ink toward the paper. If a heater is bad or a nozzle is clogged, there will be a missing line (out of the 50 possible lines) on the paper. Priming is supposed to assure that the nozzles are clear, loaded, and ready to go.

First I test for power - there is both +5 V and +20 V. I assume the +5 is for the logic and +20 for the print head nozzle heater elements. There are something like 50 nozzles and I have no intention of testing them all but it is fairly easy to determine that the print head receives +20 for power and the nozzle driver pull low to turn them on. Probing with a scope while the printer is supposed to be doing the self test confirms that there are pulses at a representative sample of the nozzle wires.

The only thing left to do is try a new cartridge. But, that has to wait until I can 'borrow' one from the office.

Two days later.

None of the cartridges we use at the office are exactly the same part number but they do have the same array of gold pads and the same size print head itself. I take one of each of the two types we have (one is the super-high capacity type - all right!.

I first try the cartridge that looks exactly the same as the one that came with the printer (though the part number is different).

And, what do you know! The self test is nearly perfect. There is one missing line. This could be a bad driver (hope not) or defective cartridge (yeh, right!).

Next, I try the PaintJet 'high capacity' cartridge and this also works but now there are 2 missing lines. :-(

Going back and forth, they are consistent. I am not sure if one of the two missing lines are the same on both cartridges. Could something be marginal or is the priming not working? However, all other nozzles seem to be rock solid. Reseating the connectors to the print head makes no difference. If I knew which drivers were involved I could look at the signals but it will be difficult to trace the circuitry from the driver board to the actual nozzle.

Comments: I suspect the original problem resulting in the dead printer to have been a cold solder joint on the DC power connector which I repaired. I don't really think that the nozzle problem was caused by the water since the print head driver board was never wet. Since the data connection to the print head driver board is a 20 pin cable, this must be a common bus and thus it is unlikely that any failure on the main logic board could manifest itself as a single or pair of bad nozzles. Stay tuned.

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Repair Brief #50: Panasonic PV1545 HiFi VCR - Eats Tapes

Patient: Garage sale oldie but goodie. Asked $10, paid $5 ("Sure, I just want it out of here"). I did suggest to the owner that he could probably fix it himself for under $3 but I guess he hadn't read the FAQ, or it didn't match his decor, or something. I did ask about the remote but that had long since walked.

Symptoms: I was told by the owner that he had to open the VCR to extract the tape. I asked: "You didn't do anything that I will be cursing you out for, did you?". The answer was 'no' but he did not sound all that convincing....

Testing: No take-up reel movement in FF, CUE, or Play modes even with a cassette cheater and no load on the take-up reel. Not that I am terribly surprised.

If this had not been a HiFi VCR, I would probably have passed as I have enough Panasonics of that era. However, I also know that those machines can be kept going with minimal effort and investment almost indefinitely.

The first step is virtually automatic: replace the idler tire.

Removing the idler on this VCR can be accomplished without any disassembly beyond taking off the top cover - but this was easily done as the owner never replaced the @#$% screws. Grrrr.

Pop off the split washer (careful - don't loose it. Yes, I know, you are not supposed to reuse these....).

Since I don't happen to have the proper size tire in my inventory, I first try to turn the old one inside-out but this little bugger refuses to cooperate. I finally find one that can be stretched to fit until I obtain a replacement (actually get one from my secondary inventory at work).

FF and REW now work fine. Play, however, results in a picture which is nearly total snow with a distorted picture showing through and no HiFi sound. I use my Mark 1 thumb on the heads - no change. I then clean the video heads using cleaning sticks and alcohol - no change. Then, I realize that I have not tried to adjust the tracking control and on some machines, if tracking is way off, the picture will not just have noise but will be totally unwatchable. Sure enough, the picture and HiFi sound now come in clearly.

CUE (forward search) works fine. REV (reverse search) results in snow and then shutdown. Then, I realize that I have not replaced the split washer on the idler. I don't know if this was the cause, but replacing that washer results in REV working fine after this. Maybe, the idler assembly was creeping up on its shaft.

For good measure, I also check the two belts under the deck. They are in good condition. Therefore, I just clean the belts and pulleys. I also give the top side a general cleaning - capstan, pinch roller, roller guides, fixed guide posts, full erase head, and A/C head stack. The only detectable oxide/dirt buildup was on the capstan and pinch roller and even this wasn't that significant.

Recording seems to work as well. I leave it recording for several hours to be sure that there are no thermal problems.

Comments: This VCR is about 11 years old but in excellent condition. Older Panasonic VCRs were built very solidly with a lot of metal in the transport and reliable electronics. As noted, little tends to go wrong - rubber parts, power supply capacitors. Thus, keeping them going requires minimal effort. While these machines don't have spectacular features by today's standards, they will outlast a bucket load of the cheaply constructed junk that passes for many modern VCRs.

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Repair Brief #51: HP DeskJet Professional Printer, Part 2 - Missing Lines

Patient: Garage sale HP DeskJet Professional ink-jet printer in pretty good physical condition. Original problem was described in Repair Brief #49: HP DeskJet Professional Printer, Part 1 - Dead.

Symptoms: Ink-jet nozzles #45 and #47 do not work resulting in a pair of white lines every 1/8" or so on the printout.

Testing: A variety of new and used print cartridges produce similar results except that in some cases, only 1 line is missing (??).

As you will recall, this printer was dead (and somewhat waterlogged) when I picked it up for $5 at a garage sale. Drying it out and soldering a few suspicious connections resulted in everything working except for 2 nozzles on the print head - #45 and #47. Well, 24/25ths of it works, what do you want for $5?? :-)

Interestingly, when using a new PaintJet cartridge, only 1 nozzle appeared to be bad...

The electronics for the DeskJet is divided between two circuit boards - the main logic board and a smaller print head driver board. Due to this way of partitioning I did not think that the water I found on the logic board could result in damage in such a way that only 1 or 2 nozzles were affected.

(From: Paul Grohe (grohe@galaxy.nsc.com) in reply to Repair Brief #49: HP DeskJet Professional Printer, Part 1 - Dead.

> "I concur. If just *one* jet is not firing, then it is on the driver/flex-cable/connector/cartridge side. All the nozzle decoding is done on the driver board, so the 20 pin interconnect cable is okay. The DC (well..really 20VAC) power connector does take some abuse in normal service, this could have aggravated the cold joint."

Given this behavior, there are several possibilities:

1. Bad driver(s) - stuck off resulting in no heating and no ink.
2. Bad driver(s) - stuck on burning out print head heater(s).
3. Bad connections to print head - flex cable, connector, or contacts.

(From: Paul Grohe (grohe@galaxy.nsc.com).)

> "I assume you have cleaned the contacts (with a Q-tip, on both cartridge and socket). Use a magnifying glass and check *each* of the gold 'bump' contacts. Repeated cartridge swapping, or improper insertion, can cause a crack to form around the base of the 'bump' and the pad (or the pad and the trace). The 'bumps' can also be 'flattened' by cartridges that were forced in at too much of an angle. There should also be some 'give' or 'sponginess' to the contact area to assure even contact with the cartridge."

I have done this inspection - everything looked ok (at least as best I can without removing the flex cable).

I removed the driver board and gave it a thorough visual inspection. As expected, the soldering was perfect. Leave it to HP.

(1) would be difficult to find until I had a complete wiring diagram of the driver board, flex cable, and print head. Therefore, I defer on this until I have exhausted other possibilities.

(2) would be rather disappointing as this would mean that I have already blown two new print cartridges ($20+ each) in testing (and that the problem was probably in one of the 40 pin HP ASICs). At first I was *sure* this was the case (of course, always fear the worst!) as testing between certain contacts on the print cartridges resulted in unexpected readings. Most of the resistances were around 32 ohms except for 1 which was open (blah) and another which was high (51 ohms).

Then I examined the pads under a magnifying lens and found that the open contact was indeed - open and not even connected to anything by design. The 51 ohm reading was too consistent - all 3 of my cartridges (including the original that came with the printer) measured nearly the same value. If this were due to a partial burnout, it would be an amazing coincidence.

The shorted driver theory was finally put to rest when I took one of the cartridges into the office and confirmed that it functioned properly in a working printer.

(From: Paul Grohe (grohe@galaxy.nsc.com).)

> "Check for broken/bad traces in the flex-cable that goes from the driver board to the cartridge. Ohm out the cable between the supply commons and the individual driver lines (at the PCB) with the cartridge in place. I think the jet resistance was about 50 ohms (It's been a while). There were four separate jet sections (commons). All four commons were tied to the +20V supply through four separate (12 ohm?)

series current limiting resistors. The driver outputs seemed to be grounded emitter, open collector (w/clamp diode?). The jets themselves are driven individually and are not multiplexed."

This (3) seemed like the next step. I drew a diagram of the two 28 pin connectors on the driver board. Then I identified the 4 common lines (1 for each 12 or 13 nozzle heaters). These went to some common 10 ohm resistors to the +20 V power supply. I then measured between the nearest common and each pin to the print head. When I was on a heater fed by that common, the resistance would be about 32 ohms. When to one fed from a different common, it would be around 52 ohms (32 + 2 * 10). In every case but 3, these made sense:

- One of these measured high even though it seemed to be no different than the others. I finally concluded (or rationalized) that this was the funny high resistance element in the cartridge.

- The other two tested open on the cartridge that had 2 defective nozzles but one of these was the proper 32 ohms on the PaintJet cartridge that had only one bad nozzle. Interesting.

Time to disassemble the flex cable connecting the driver board to the print head.

The retainers on the flex cable at the connector-end just snap into the open position and the cable comes free. Four screws release the print head cover and the cable then pops free of its indexing posts.

Under the contact area is a rubber pad with a little bump for each contact. All the bumps seem to be in good condition and minding their own business.

A careful inspection of the flex cable shows that it is in virtually perfect condition as well with no cracks or wear at any locations including the 56 contact points.

However, the indexing holes seem to be a bit deformed. Could the cable have worked out of position slightly resulting in poor contact to a couple of pads? Wishful thinking, maybe....

While it is it out, I confirm connections between the two open pins and the corresponding contact pads - finally correctly locating them. Following the many fine traces is a bit tricky to say the least.

Reassembly is equally straightforward. I take care to center the flex cable on its indexing posts. Is it my imagination or are the contact pads now sitting flatter and more uniformly than before?

On a hunch - I really did not expect anything to change - I check the two open pins. And, what do you know? They now measure 32 ohms. At this point, I am now, of course, absolutely confident that the printer will work!

The first few lines out of the self test are disappointing as it appears as though there are now many marginal nozzles. However, guess what? The top line of text which previously listed the numbers of the bad nozzles is the normal printout - ID E. Before it was: 45 47 ID E. The printer's pathetic brain thinks all the nozzles are working fine. Then, half way into the second page, the print died out totally. OK, maybe that cartridge needs to be cleaned and primed. It has been bounced around, turned upside-down, and otherwise abused. A little blowing into the vent hole (drip, drip - love that dreaded black finger disease) and a wipe - and we try again. Now it is perfect - no missing lines, no smudges, run, drips, or errors. I have a working printer!

Comments: Once again, that actual problems turn out to be exceedingly simple: bad connections in both cases. As noted previously, the HP DeskJet series in general is a well engineered design with only a half dozen basic components. While my printer is one of the oldest, the fundamental design has not really changed dramatically in the last several years as evidenced by the fact that print cartridges for some much more modern printers work just fine in this old machine. The print quality with a new cartridge is nearly laser-quality. Yes, HP seems to come out with a new, faster, cheaper, color, etc., printer every few weeks. But, looking inside newer printers shows that their basic design and construction is quite similar.

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Repair Brief #52: Aztech CDA-268-01A CDROM Drive - Drawer Continuously Closing

Patient: Aztech CDA-268-01A double speed CDROM drive in excellent physical condition.

Symptoms: Drawer is constantly trying to close. Shutting off power and pulling the drawer out half-way results in drawer closing and motor spinning its wheels.

Testing: A universal CDROM interface card (Panasonic, Sony, Mitsumi) was used to confirm that this was not a case of there just not being an interface card present. See the text below.

This drive was sent to me as non-working having been removed from a PC after it failed with the symptoms described above. An IDE CDROM was purchased to replace it so it was not known whether the interface (probably a sound card) was at fault.

I first began testing drive simply connected to a spare PC power supply (with an auto headlight to provide the required minimum load for the supply).

It's behavior was consistent - the poor little drawer motor just continuously tried to close the drawer regardless of pushing the any buttons. The Busy light remained solidly on. The motor was getting quite toasty in the process.

Note: this drive has two front panel buttons that serve multiple functions. to open and close the drawer and start and advance tracks for audio play without software. While I was not sure of their exact function at this time, neither button evoked a response of any kind.

So, I wonder if my magic spit will have any effect? Some careful trials on the interface connector revealed a pair of pins where pressing with exactly the *correct* concentration of magic spit(tm) would cause the motor to quit and the Busy light to go out momentarily.

Hmmm. Maybe the interface card is required after all. There might be nothing wrong with the drive. The original interface may have been bad. Since the replacement used IDE, this would have gone undetermined.

What type of interface is it? Originally, I thought I was actually told IDE but a close examination of the pin configuration showed this to be impossible as the grounds were in the wrong place. It is a 40 pin connector, so SCSI is ruled out. Therefore, it must be one of the proprietary interfaces: Panasonic, Sony, or Mitsumi.

Since I am not willing to cannibalize one of my working PCs to obtain an interface, this waits until the next time I am in the office. A co-worker (OK, actually, the boss management weeny) who insisted on having a PC built for him but rarely uses it and never has to the best of my knowledge used the CDROM won't notice if the card disappears for a few days: "What, your CDROM drive doesn't respond anymore? it must have gone bad from too much loneliness.... I will get to it as soon as possible." HeHeHe. :-)

The interface card is a universal type - a jumper will select between the three types. It is obvious from the pin configuration that the Mitsumi interface is the only one that makes any sense with one complete row of ground pins.

With the interface installed on my state-of-the-art DTK 286 mainboard, the behavior is unchanged. The drawer still insists on attempting to close forever.... With the cable installed, the magic spit no longer has any effect so the pins involved are probably being driven from the interface.

Thus, the drive is really and truly bad. I assume that what was happening was that my magic spit(tm) was triggering a master reset and thus disabling all operations. This is encouraging in some ways - the drive is not completely hosed.

What next? Checking the drawer switch is fairly easy and it is definitely good - zero resistance at either end of its travel.

To get at most of the circuitry on the board requires removing a sheet metal shield - 3 solder connections, no big deal.

I expect that if the drawer switch signal goes directly to an LSI chip or ASIC, this drive becomes spare parts as such a multilegged creature is not likely to be easily obtained, inexpensive, or replaced without a great deal of cursing even with proper soldering equipment.

However, on this drive, the drawer switch signal goes to a 74LS244 octal buffer in a surface mount package (joy!) and a pullup resistor. Checking at the buffer input, the signal swings very nicely between 0 and 5 V.

Checking at the output we have - stuck around 2 V. Is the buffer bad? That is what I thought at first but then I realized that:

- The enable to the buffer is not simply tied to ground (on) but is driven from another chip.
- The output is connected to a data bus and not a dedicated chip input. Therefore, I am seeing the average bus activity of that bit and not a solid level.

Using a fine soldering iron and dental pick to lift the leg, I disconnect the output pin of the 'LS244. Now, this output tests low regardless of the drawer switch signal level - either it is bad and open or it is tri-stated. However, momentarily grounding the enable pin to the 'LS244 allows the output to swing the full 5 V following the drawer switch signal and this confirms that the the chip is actually good.

The enable signal looks sick - it is floating at around 1.5 V. How is it generated? Would you believe, a surface mount 74LS00??? Most of the circuitry on this board is in a few large custom chips and yet there are still a few jelly beans as well! Grumpf, there is no accounting for designers' tastes. Better for my chances of repair. Interestingly, there are absolutely no adjustments of any kind on the mainboard - probably a digital servo system.

Checking the LS00 shows that the gate in question has its inputs on pins 13 and 12 and its output on pin 11. Pin 13 has a nice periodic pulse on it but pin 12 looks as dead as pin 11 - not a solid logic low but close enough to ground that the output (it is a NAND after all) should be high and it is not. Lifting the output pin makes no difference so it is not being loaded down. Power and ground connections to the chip seem solid. Checking the other 3 gates of the chip show that they are equally screwed up with outputs that are in never-never land and do not change significantly (though there is some slight response) when the inputs switch. My suspicion is an internal power problem with the chip, not that this helps us.

```
                                             _  1/8 74LS244
                                            | \
                Door Switch o----------------|   >o----X-------o Data bus
                                            |_/         (Break at X and
                              13 _____       o Enable    pulse data bus)
         ___|___|___|__ o---------|     \ 11  |
                              12| NAND |o---+ Dead - about 1.5 V
                1 _____        +---|_____/
            +---|     \ 3     |                NANDs are sections of
            |  2| NAND |o----+                 74LS00 in SMT package
   Ground o--+---|_____/  Dead - about 1 V
```

To see if the relevant output of the 'LS244 (the bus line) actually has an effect, I connect a fine insulated wire to it while it is still disconnected from the 'LS244 and power the drive. Now, momentarily touching this to ground will sometimes get the drawer to stop and even sometimes the CD will try to spin up (accelerating past Warp 10 and never actually succeeding in reading the directory (I presume since it never stabilized). I expect this is due to the fact that I am overriding whatever else is supposed to be on that bus line and it is getting really confused. Poor thing. :-(

At first I thought a neighboring 74LS04 (hard to believe, huh?) was also bad but the designer morons at Aztech or Mitsumi or whoever actually did this board did not tie many of the unused inputs to valid levels so they were just floating. (With LS TTL, unused gates should be forced to a constant output by tying their inputs to ground or through a pullup to Vcc, whichever is appropriate for the logic.) So that was a false alarm.

In fact, only 2 of the gates on the LS00 are used (1 of these as an inverter, see the diagram!). Only *1* inverter on the LS04 even connected to anything. What a waste!

My initial thought was to wire up the unused LS00 gates to substitute for the bad ones but these, too, were deader than the proverbial dodo. I thought about wiring some unused sections of other jellybean chips (there was a mostly unused 74LS08 across country) to create the needed logic. But sanity prevailed and I decided to try to locate a replacement. I finally found an old PC I/O card (that might even have been bad) with a 74LS00 in the same SMT package.

Fortunately, at the office, we have a PACE rework station so removing the old LS00 and its replacement goes smoothly using a tip that heats all of the pins simultaneously. After cleaning up the pads, I use a super-fine tip soldering iron to tack pins 11 and 4 and then solder the rest of them without too much difficulty.

Now for the test: Although I did not take the rest of the drive, I should be able to cause the Busy light to go out if I can convince the drive that the drawer is actually opened. And, sure enough, momentarily grounding the drawer switch signal results in the Busy light going out. Furthermore, the behavior is slightly different on every other push of the Open/Close button indicating that it is actually trying to read the disc when it thinks the drawer is closed. Of course, with no optical pickup attached, this might be rather difficult!

The initial functional test will be made with an audio CD since that should be good enough to confirm basic operation. Apply power: drawer closes and stops, Busy light goes out. OK, we are cooking (no smoke!). Insert disc, press the button. Drawer closes, discs starts spinning, sort of. Well, actually it starts spinning in the wrong direction (counterclockwise). Then, apparently it thinks better of it and accelerates clockwise. While it does not go ballistic, it is certainly spinning faster than the 1X speed. Of course, I really don't know what it should be doing not having an instruction manual! A little experimentation with the buttons and then it seems to be spinning more slowly. Maybe I hit the combination to play the audio CD. Time for the headphones.

And, sure enough, track 1 is playing, a bit scratchy, but nonetheless, there is music! A little more experimentation with the buttons reveals that the left hand button advances the tracks and will cycle back to the beginning once the last track is played. The right button pauses the play with one push and ejects with a second push. Of course, if I could interpret the icons on on the bezel, I might have been able to figure this out without trial and error!

The scratchy sound is a little disconcerting knowing that data readout is more critical. Furthermore, it seems to have problems accessing the outer tracks. Stopping the CD results in similar strange rotation before it finally decides to open the drawer.

Well, the CD I am using has seen better days, being a casualty of a couple other Repair Brief CD experiences. So, I get a good CD. Unfortunately, now my Vivaldi is not even recognized! Grrrrr.

I clean the lens.... No change.

There is one other possibility that doesn't involve thousands of lives and millions of dollars - I have not yet replaced that sheet metal shield. Perhaps there is some interference between the electronics and the pickup.

Sure enough, after soldering the shield into place, *all** detectable problems vanish - even the peculiar wrong-way rotation.

Now for the computer. Rather than putting together my state-of-art DTK 286 system again, I will install the CDROM in a real PC (OK, well a real PC from about 5 years ago).

Hardware installation is a snap. What about a driver? Since it has a Mitsumi interface, I assumed it would work with a Mitsumi driver. Wrong. After finally finding the correct I/O address (as my interface card is not marked well - just jumpers for Bits 1-4 but what position is Bit 1 and is a jumper a 1 or a 0?), it will still not initialize properly though it does find the card - the light on the drive flashes. No combination of IRQ or DMA makes any difference.

Internet to the rescue! A Lycos search turns out to be totally worthless not even being able to quickly locate the Aztech homepage. Did you know that there are 4 or 5 companies with Aztech in their name?

However, using Yahoo, an entry of "Aztech CDROM" results in the third or forth entry being a link to the Aztech Utility/Driver FTP Directory. Sure enough, there is an entry for my CDA268-01A, ATCD268.ZIP, Install Disk V1.35, 53,561 KB.

Download, unzip, pop into the PC's A drive and 5 minutes later I have a working CDROM. No runs, no drips, and no errors. I was tempted to install Win95 but I figured that wouldn't work really well on a 4 MB 386!

Comments: Despite what I had to say about the Aztech engineers, this drive seems to be a very clean design. There are virtually no discrete parts and no adjustments of any kind on the mainboard. The layout is fairly wide open on a double sided printed circuit board. There is also an LSI chip on the optical pickup itself - perhaps the focus/tracking servos and front-end decoding.

I expected this CDROM to either have a trivial problem like a bad connection or bad drawer switch or a fried custom irreplaceable chip. I would never have anticipated that a jelly bean 74LS00 would up and die. But that it is what it did as there is no evidence of any kind of trauma, spike, or spill. One assumes that 20 year old technology will be reliable. This is yet another example where the initial expectations and fears can be totally unfounded.

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Repair Brief #53: Craftsman Electric Drill - Worn Motor Bearing

Patient: Garage sale electric drills. I picked up two of these (similar models) at different times).

Symptoms: Running the drill at anything near full speed results in a spine tingling squeal.

Testing: Putting a drop of oil in the rear bearing will quiet it down for a few minutes but this is not a long term cure.

This is a classic case of cost cutting (or how much the Marketing department controls the Company) resulting in early failure. Simple bronze bushings are used at both ends of the motor shaft. At the gear-box end, this is acceptable as this is enclosed and shielded against contaminants. However, at the handle end, all kinds of stuff can find its way into the motor and bearing. In particular, when using the drill with a sanding disk, fine powder easily infiltrates the motor absorbing lubrication. (Please, no comments about using the proper tool for the job. The fact of the matter is that electric drills do get used in this type of service.) The result is a dry bearing which rapidly wears if not attended to. It is hard to ignore as the result is a spine tingling squeal whenever the drill is running.

How to deal with it? I could probably have purchased a replacement bronze bushing from Sears Parts or used the good one from the other end of one of the drills to fix the other. However, what is really needed is a double sealed ball bearing instead. The seal is the important part though at the speed at which the motor runs, a ball bearing isn't a bad idea in any case.

I have upgraded a couple of these drills to ball bearings. The substitution is straightforward requiring disassembly of the drill - removing of the front gear reducer and then one side of the case. At this point, the old sleeve bearing is easily freed from its mounting (just the plastic of the case) and pulled from the shaft. The shaft is likely undamaged unless you attempted to continue running the drill even after going deaf.

The drills I upgraded had bearings that were 7/8" OD, 5/16" thick, and with a 5/16" ID center hole. The old ones were worn by almost 1/32" oversize for the center hole but the motor shaft was undamaged. I found suitable replacement double sealed ball bearings in my junk box but I would assume that they are fairly standard - possibly even available from Sears Parts as I bet they are used in the next model up.

If the gear reducer needs to come apart to access the motor, take note of any spacer washers or other small parts so you can get them back in exactly the correct locations. Work in a clean area to avoid contaminating the grease packing.

The bearing should be a press fit onto the shaft. Very light sanding of the shaft with 600 grit sandpaper may be needed - just enough so that the new bearing can be pressed on. Or, gently tap the center race with hammer (protected with a block of wood). Make sure that the bearing is snug when mounted so that the outer race cannot rotate - use layers of thin heat resistant plastic if needed to assure a tight fit (the old sleeve bearing was keyed but your new ball bearing probably won't have this feature).

These drills now run as smoothly as Sears much more expensive models. Of course, the chuck will probably fall off at any moment...

Comments: I had to do a similar upgrade to a cheap shop vac which had basically the same problem - the top bronze bushing had lost its lubrication resulting in accelerated wear and failure. Unfortunately, access to this was quite a bit more difficult requiring almost total disassembly of the motor/blower unit. These sorts of failures are common with inexpensive hand-vacs as well.

This isn't rocket science but a simple modification like this can significantly extend the life of a tool that would otherwise be discarded. Of course, if it were designed properly in the first place, such upgrades would not be needed.

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Repair Brief #54: NEC CDR-260 Double Speed CDROM Drive - Intermittent

Patient: A friend of a coworker's CDROM Drive inherited from his company when it broke (of course). Got that?

Symptoms: The thing was sitting on the edge of Dave's desk when I showed up in the morning. All the pieces were there, some assembly required. I could not really get a coherent description of the problem - I thought it had something to do with the drawer opening... Sound familiar? (Recall Repair Brief #52: Aztech CDA-268-01A CDROM Drive - Drawer Continuously Closing).

Testing: I had to reassemble it first! Then I suggested I take it home since I really didn't have time to deal with it at work.

First, I give it a careful examination but find nothing. I then reassembled it to the point where power can be safely applied. I did not bother with the interface, just the power. For these occasions, I have an old switching supply conveniently mounted under my PC desk - and one that doesn't even require one of those quaint headlamp minimum loads! At first the drive appeared hesitant to spin the CD but then after a couple of minutes, seems to be fine - the 2X and Busy lights flash on momentarily as the disc spins at what I assume to be 2X speed. It seemed to behave all night as I would every so often push the Eject button to open and close the drawer.

At this point, I figured the problem had gone away or was solved or something. Suspecting bad connections at the flex cable connector, I disassembled the unit once again and cleaned and reseated these. I cleaned the lens as well while it was accessible Testing showed it to still be fine at least in so far as the basic reading of the disc identification was concerned.

Email to Dave: The CDROM seems to work, I will try it when I come in next.

Next time at the office, I installed the drive in a PC that we had been using for various CDROM and CDR projects which was conveniently in pieces.... It was running Win95, so I assumed that the CD would be found automatically. You know, Plug 'n Pray!

The drive has what I assumed to be an IDE interface - the missing pin was in the correct location. I finally found the info on jumper setting where one might actually expect to find it - on the label!

However, trying all reasonable combinations of jumpers (Slave, 8/16 bit) with the harddisk set for Master on a single IDE controller did not result in any recognition by the New Hardware Wizard. The first time I tried it - with no jumpers resulting in the CDROM being set for Master - I did see harddisk errors and the Busy light on the CDROM drive flashed as the harddisk was being accessed.

Then, I noticed that it did not seem to be initializing properly, again - the red and orange LEDs did not flash on when I inserted a disc. Hurrrumph.

"Hey Dave, well I thought it was fixed but now it is dead again."

Back home and with the top cover off, I watch as it is supposed to be spinning up. Now the disc will not turn at all! However, if I give the spindle help, it will seem to try for a little while but never get to the proper speed. Ah ha! Can we spell - are you ready: Spindle Motor?

Disassembling the drive further to access the bottom of the optical deck reveals a cheap brush type permanent magnet motor - essentially the same as those used on our favorite Pioneer CD players and changers. We know what a joy they are!

Testing with an ohmmeter results in readings between 12 ohms and 0 as the motor shaft is slowly rotated. This is one sick motor.

First, I tried spraying it with tuner and control cleaner through the ventilation/brush access holes in the rear. This did not seem to make any noticeable change.

I can use a power supply to attempt to clear the short. First, I unsoldered the red wire so that there is no chance of blowing any of the circuitry when external power is applied.

First, I got my genuine Heath variable power supply but this proved incapable of spinning it as the current limit kicked in at 700 mA. Into a dead short, this was not enough and the voltage stubbornly remained near zero.

So, I got my trusty "destructo-proof give it all you can take" variable power supply. Now we are in business!

Turning it up to about 10 V allows the motor to spin at high speed hopefully flinging the metal whiskers or other crud off of the commutator.

That did it! Now, the reading varies between about 15 and 20 ohms which seems much more reasonable. I resolder the red wire.

This will work now!

Sure enough, spinup is once again consistent. At least now, I am sure it will remain that way for a little while at least.

So what about trying it on a PC at home. Now, which PC to use.... Paul Grohe suggested the 'blue one' when I asked him if he knew of a proper software driver for the NEC. OK, where is the blue paint? :-)

After giving up on my version of Netscape trying to download a .EXE file, I finally used ftp to get NEC-IDE.EXE, a self extracting .ZIP file containing README.TXT and NEC_IDE.SYS which is a universal driver for NEC IDE CDROM drives under DOS/WIN31. (Win95 has these drivers built in but my newly painted 'blue' PC is only a 4 MB 33 MHz 386.)

After following the instructions on modifications to the CONFIG.SYS and AUTOEXEC.BAT files, I am ready. The jumpers are set for Slave and 8 bit.

Long pause.... "No drives found - initialization aborted". Boot completes

Grrrr, maybe it is 16 bit...

Long pause.... "No drives found - initialization aborted". Boot completes.

Double Grrrr, let me remove the Slave jumper, at least that will confirm if the drive is recognizing IDE commands as it should conflict with the harddisk and cause harddisk errors or cause the boot to hang with "HDD Controller Failure".

Long pause.... "No drives found - initialization aborted". Boot completes.

Wait, that messed things up when I tried it at work (before I figured out that the Slave jumper was needed at all). What else could be wrong....??

Maybe, power needs to be cycled to reset the drive.

Slave, 8 bit:

Long pause.... "No drives found - initialization aborted".

One more time - Slave, 16 bit:

Short pause, Busy light flashes, "One drive found....." Success! The drive is now accessible under DOS and Windows.

Semi-documented software is soooo much fun! :-)

Email to Dave: The drive works, same spindle motor problem as Pioneer changer. I cleared it for now but changing motor will be a slight pain....

I never did notice any problem with the drawer.

Comments: It somewhat amazes me that many CDROM drives still use the same cheap brush type permanent magnet motors as Pioneer and many other CD players. When driven at more than 1X speeds especially, these are prone to metal particle migration or metal whisker formation or whatever - more commonly known as crud buildup. Thus, the same problems that are so common with many brands of CD players are destined to appear on CDROM drives - and the same, at least temporary - cures are effective. The use of a brushless spindle motor - even common in some basic CD players - would totally eliminate the possibility of this failure mode. Even some cheap Walkmen tape players use brushless drive motors. Perhaps, these drives are *not supposed* to last that long by design, good excuse to upgrade.

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Repair Brief #55: RCA FPR560ER Color TV - Erratic Behavior

Patient: RCA FPR560ER (CTC130C chassis) 19 inch color television. This is a nice TV but it has been driving Bill up a wall.... (You will recall my friend Bill from Repair Briefs #35 and #47.)

Symptoms: The TV will power itself on/off and/or lose channel lock for random amounts of times at random times.

Testing: Whacking did not seem to have any definitive effect - but this TV is quite solidly constructed so it is not clear that the whacking reached the relevant components.

I got involved with this after Bill had initially attempted to repair the TV for what he thought was a simple case of a blown horizontal output transistor (HOT). He had replaced it with something from Radio Shack that they called an HOT. :-) The transistor ran extremely hot and lasted about an hour. Now we know why Radio Shack called it a HOT! (I don't even think Radio Shack lists higher power transistors in its current catalog - I wonder why!). Next, he replaced it with a TIP552 which has decent specs. An additional heat sink was added as well (although we know this should not be needed with a properly functioning deflection circuit). Nonetheless, this seems to be holding up.

However, Bill then noticed the onset of the erratic behavior and believed that the blown HOT somehow caused the set to start acting weird.

I suspected that the erratic power cycling caused the original HOT to fail. Thus, this was a symptom of another problem, not the cause.

The behavior took on a variety of forms. Among them were the following:

- Sometimes the screen would go black for a few seconds with or without the channel numbers incrementing at random and then come back as though nothing happened.
- Sometimes the TV would actually appear to click off for a few seconds or longer.

- Sometimes in the middle of the night the TV would just decide to turn itself on at full volume.

Needless to say, this is no way for a self respecting TV to act!

Bill and I decide to spend a little time on it. Bill drags out a rickety typewriter (you remember them, right?) table to put it on. Will this hold, I ask? "Sure. If it collapses, we won't need to repair it." OK, keeping my distance. It holds. However, the TV operates fine for the few minutes we have allocated.

Bill (who used to design switching power supplies) is attempting to come up with some explanation involving a problem with the power supply or control logic.

We, of course, know better. From early on, I was working on the hypothesis that bad connections were involved but where were they? No amount of wacking seemed to evoke a response. And, the TV never would perform on demand. We even dragged it over to my place and I would run it whenever I was around but it never screwed up - until s couple of weeks after it was lugged back to Bill's house. I kept telling him that it wasn't fixed. But, Bill is the kind of guy who figures if it doesn't screw up immediately, the problem probably went away. Yeh, right.

For about a year, he was using the TV on a switched outlet. He would shut it off totally when not in use and live with the erratic behavior when it was on. During the course of an evening, it probably would only misbehave once or twice.

At least the HOT seems to be surviving.....

Finally, it became too much and it was relegated a corner of the basement where it sat for another 6 months or so. Every so often he would mention the TV but I wasn't really that eager to deal with it.

Then, while on a cleanup crusade, "Sam, take this thing. If you cannot fix it, trash it. I will go get a 27 inch set on sale."

So, we lug it back to my work bench. Even though it is only a 19 inch set, it is quite heavy and somewhat bulky. Since the only way I can get it off my bench will be to fix it, I start the search....

Unlike some more modern sets that can best be described as a CRT with a wart (the main board), this has one circuit board for deflection and video, one for the tuner, another for the A/V inputs, power supply, etc.

Checking each in turn (I didn't start with the tuner hoping - more like wishful thinking - that the problem would be elsewhere since the tuner required more disassembly):

- Power supply - all soldering looks good.

- Deflection and video - removing this requires disconnecting some cables but once this is done, it comes out enough to examine in detail. Everything looks fine.

- A/V - this is unlikely to be the cause so I do not attempt to get to the underside which would be a pain.

- Tuner - to get at the bottom of the board requires unsoldering a metal cover at several points. My Weller soldering iron is not up to this but a 140 W soldering gun comes to the rescue.

  Almost immediately, some suspect pins come into view. However, they are not obviously bad. First, I try to measure for resistance changes as I flex the board and/or press on each pin. This turns out to be impossible as there is no convenient place to hang clip leads and my DMM's response is too slow anyhow. The only way to find out is to now prod each one with power on.

There are three main blocks of large pins. Viewed in the normal orientation, these are at the upper left, middle top, and upper right. Starting at the upper left results in immediate gratification: tapping lightly with my solder sucker causes the set to power on and off in a manner very similar to the original symptoms. There is definitely a hairline crack around at least one of these pins. Well, there is only one way of knowing for sure. I resolder all five of the pins on this connector. Now, it is rock solid. Hitting it with a (insulated) hammer has no effect.

I also solder all the other similar size connector pins on the board.
Now, to come up with suitable substitutes for half the cabinet screws which Bill lost....

Comments: While this is not the infamous CTC175/176/177 tuner solder problem, these older RCAs seem to have a less severe case of the same disease. I have seen others with cracked solder connections often in similar locations. Unfortunately, the only way to be sure of the repair is to let Bill start using it again. One can never be quite sure of a repair to an intermittent problem that happens so infrequently.

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Repair Brief #56: Toshiba M4200 VCR - Weak Intermittent Audio

Patient: Garage sale Toshiba M4200, $13. Owner mentioned audio problems suggesting that it needed a new audio head. I love it when the owner offers a diagnosis - they are almost invariably wrong.

Symptoms: Indeed, audio is somewhat weak but not as bad as I was led to believe. I expected nothing. When pressing START, the audio seems to fade in rather than coming on at correct volume every time.

Testing: Playing various tapes at multiple speeds exhibit similar symptoms to a greater or lesser extent.

First, I tried cleaning the tape path. This seemed to make a slight improvement but not much. Adjusting the azimuth setting on the A/C helped a bit more (but I found out later that it was the VCR on which the recordings were made that was misaligned.)

As a more extensive test, I let it record for a couple of hours. The beginning of this tape played back somewhat weak but was otherwise quite listenable. However, about halfway through, the audio dropped out totally over a span of a few seconds. After this, only silence.

As another test, I play a tape (Battle of the Bulge, if you care) and after about an hour and a half, the audio starts fading out to be replaced first by silence and then a sort of whine/buzz.

Interestingly, the video is rock solid and perfect under all conditions.

Could this be an electronic problem? Perhaps, the audio driver/preamp chip or its power supply is failing due to heat? We always tend to suspect the hard-to-locate or expensive problems first.

A careful examination of the tape path reveals the problem but at first not the cause: the tape is moving up on the A/C head so that the audio track is no longer aligned with the record/play head. The control track is wide enough that enough overlap is still present and there are no servo problems. I can only surmise that alignment is such that a combination of the audio and its guard band are in contact with the audio head. Very gently pressing on the edge of the tape restores full audio volume but eventually it wanders off again.

The tape movement is also not mirror smooth - it is rippling between the A/C head and right roller guide. However, no tape edge damage seems to result.

So, what is the cause?

At first, I thought that there was some actual mechanical alignment problem. It could not be with the roller guides as the video is perfect (this is a non-HiFi VCR so there is no issue of HiFi head alignment). Roller guide tilt, fixed guide post vertical height or alignment, even A/C head tilt, can affect this.

Careful experimentation with the adjustment of the A/C head doesn't result in any noticeable improvement.

Could one of the fixed guide posts have shifted? Not likely, they are screwed down tight and locked.

What about the capstan and pinch roller? I had cleaned them but could the capstan have shifted position changing it angle or something like that? Again, not likely - the 3 screws are secure and this VCR did not fall off of a 10 story building as far as I know.

This leaves the pinch roller.

The pinch roller seems to be in reasonable condition but not perfect. So, as a test, I will grind off the outer deteriorated (oxidized) layer which is hard and shiny instead of resilient, dull, and rubbery. Removing the pinch roller is very easy - just pull up on the plastic cap and the pinch roller is freed.

I used a #8, 2 inch machine screw and nut to mount it in my drill press. Then, a file and fine sandpaper were used to remove the outer somewhat hardened (oxidized) rubber layer. Care must be taken not to upset the perfectly flat cylindrical shape of the rubber surface.

This appears to result in a substantial improvement. The audio is still a little weak but much more consistent. It is now possible to play a long tape to completion without audio problems.

Although resurfacing the pinch roller is generally considered a temporary fix I have used the VCR this way (though only occasionally) for several years.

I recently obtained the correct replacement from Frank Fendley since he was able to identify the exact part number.

In addition to replacing the pinch roller, I had to construct a battery compartment cover for the remote control since this was missing. Can you believe it? I really expected more for $13! :-)

Comments: When I got this VCR, I wasn't as aware as I am now that old rubber parts - even if they look good - can result in these sorts of symptoms. Of course, we all know that erratic audio, random speed changes, and crinkled tapes edges can result from a hard worn pinch roller. Therefore, the usual cleaning, inspection, and replacement of dead rubber parts should be performed first before contemplating exotic mechanical or electronic problems.

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Repair Brief #57: HP DeskJet Professional Printer, Part 3 - Print Fades Out

Patient: Garage sale HP DeskJet Professional ink-jet printer in pretty good physical condition. Original problem was described in [Repair Brief #49: HP DeskJet Professional Printer, Part 1 - Dead] and [Repair Brief #51: HP DeskJet Professional Printer, Part 2 - Missing Lines].

Symptoms: The printer will be happily going its merry way when within the space of one line of text, the ink will fade out across the page. After this, only blowing into the vent hole (with resultant possible mess) will result in any ink on the paper. This may occur after only a few lines or several pages.

Testing: A number of cartridges and text files were tried with similar results.

As you will recall, this printer was dead (and somewhat waterlogged) when I picked it up for $5 at a garage sale. Drying it out and soldering a few suspicious connections resulted in everything working except for 2 nozzles on the print head - #45 and #47. Well, 24/25ths of it works, what do you want for $5?? :-) This problem turned out to be bad connections to the cartridge due to the flex cable with the 56 contact points shifting position.

Just when I thought the printer was fully functional, what do you know? Halfway down a page of text, the type dies out over the course of a couple of lines. Now, keep in mind that I had been using the printer without incident since finding the bad connections in the print head.

My first thought was that something electronic was changing - perhaps a power supply or pulse width - resulting in too much to too little juice to the nozzle heaters. This would be a @#$% to find unless it were one of the power supply rails. Even then, a few seconds shift in level would be all that was needed to mess up the carefully orchestrated operation of the nozzles.

I went to far as to monitor the +20 V while printing without seeing anything out of the ordinary - just a few mV change in value depending on the load (number of firing nozzles/amount of black ink on the line). I removed the print head driver board and examined it for cold solder joint. There were of course none as is typical of HP's quality manufacturing. I wiggled anything I could think of but nothing correlated with the drop-outs.

(BTW, never stick anything into the vent hole. I found out the hard way that this may result in failure of the vent valve and ink all over the place since it depends on the cartridge being sealed above at normal operating pressure to keep the ink in place. I salvaged the cartridge (maybe) with a blob of silicone sealer over the vent hole. I do not really know what the long term implications of this might be.)

At this point, I even sent an email message to Paul Grohe asking if he had seen the symptoms described above since from his postings and email it is obvious that he is knowledgeable on the subject of DeskJet printer repair.

The problem in detecting this was that as noted, whatever was happening would only need to occur for a second or two to then require manual (by blowing into the vent hole) priming.

Come to think of it 1, why didn't normal priming work?

Come to think of it 2, did normal priming ever work?

Although it never quite registered until now, normal priming cycles never seemed to accomplish much of anything. I always had to blow to get anything to print if a cartridge had lost it 'charge'.

OK, so how does priming work? Very cleverly actually.

There is a kind of 'service station' where the print head is positioned for priming. When in position, a rubber cup seals against the face of the print head and connects with a drain tube below. In the base of the printer is a positive displacement roller and tube pump - a set of rollers (I assume they are rollers as I did not entirely disassemble the unit) rotates against a compliant plastic tube (like the blood pump in a heart-lung or dialysis machine if you have ever seen one of those). The direction of flow is determined by the direction of rotation of the rollers. This is controlled by the position of a spring loaded 'feeler' which enables one of three 'shift levers' to be lifted to engage the sucking pump (Maybe, one of them blows - I didn't entirely figure out what they all did). The position of the 'feeler' is determined by print head location which is under control of the print head servo system. Thus no additional electronics is needed. Slick.

The priming action, which operates off of the paper advance motor takes place between pages - when there is no paper being fed. With my printer and the drivers being used, it appeared as though it should prime between every page.

Was it working?

I removed the print mechanism and found a drive gear I could rotate by hand. With the number one shifter lifted, the pump should have been sucking. Was it? Using some of my Magic Spit(tm) in the drain tube, I could see it being pushed out of the tube - away from the print head. Darn, it is working. But then, when I let up, it appeared to get sucked back in. Huh? Maybe something was blocked.....

After removing the cartridge, I got a syringe with some water and loaded up the little cup so the water was even with the top.

Shift, rotate, rotate, rotate. Nothing! It should have sucked that water away in the first pass.

I got a toothpick and attempted to insert it into the bottom of the cup and locate the hole for the tube. At first, it would not go anywhere but eventually, I found the hole. Still nothing. I then rounded off the end of a resistor lead to use as a probe. With this, I was able to push it (gently!) down and into the semi-transparent tube so that I could see it. A little manipulation (sort of like root canal if you have been unfortunate enough to be familiar with that) cleared out the channel. Well, at least, any dentists reading this will know what I am talking about.

Finally, rotating the pump by hand resulted in obvious movement of the water (now mixed with ink). Enough rotation and I was able to clear the cup of liquid and dispose of it via the drain. Obviously, dried up caked on ink was blocking the hole and tube connected to the cup. Priming could not possibly have worked.

Now for the test.

I installed my original old cartridge which had never worked properly under any circumstances. And, what do you know?! I get quite a nice printout on the first try without doing any of the manual blow priming I had needed previously.

I sent another email to Paul Grohe starting something like:

"By now you are probably saying "what a moron". I cleaned out the priming tube which was totally blocked with dried ink. So far so good."

The next day I received a lengthy reply outlining some other problems of a similar nature that are common with DeskJets. These will be added to the FAQ.

So, the priming had not worked for as long as I have been mucking with this printer!

Now, hopefully, this is the last Repair Brief on this printer!

Comments: This is probably monotonous by now but once again, this was a simple mechanical problem. Not an expensive chip. Not a power supply. Not even a bad connection. Just dried up caked on ink. What is amazing is that it worked at all. Perhaps, the filled cartridge had enough pressure from the weight of the ink to not be as finicky but when it got used up somewhat began to cause problems.

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Repair Brief #58: Magnavox FD2000-SL01 CD Player - Dead

Patient: Garage sale Magnavox FD2000-SL01 CD player. This is a classic top loader. It is as big and heavy as a typical full size VCR. I paid $2 but also got the service manual as part of the deal - slightly waterlogged but quite legible.

Symptoms: Power is alive - the front panel LEDs come on but discs are not recognized though they do spin.

Testing: Tried various CDs, whacking, cursing. Nothing changed.

First, a description of the FD2000-SL01:

While we have become used to CD players of all shapes and sizes with various levels of feature-mania, let us not forget their roots. The Magnavox Model FD2000-SL01 is probably one of the earliest consumer CD players. It is a design more reminiscent of a linear tracking servo locked turntable - which is probably one of its close ancestors. The engineer was probably told: "We need a consumer CD player - yesterday. You have designed linear tracking turntables. Make it operate like one of those."

The service manual (included in the $2 price) has a date of 1983. The manual was ordered in 1988 (I have the invoice for that as well).

The front panel buttons include the usual PLAY, STOP, PAUSE, >>, <<, and REPEAT. There are even STORE and CANCEL buttons. However, there is no time display, only two rows of 15 LEDs.

The top row LEDs are illuminated to show the complement of tracks on the disc while the bottom row LEDs indicate the current track that is playing and/or the next track to which it is seeking. The top row LEDs go dark to show which tracks have been played so this is similar to the traditional calander or linear displays of modern CD players - but in LEDs instead.

Pressing PLAY while playing serves as a track forward (>>|) button. There is no track reverse (|<<) seek.

As noted, it is a top loader, about as large and heavy as a full size VCR. The see-through double action lid permits one to watch the CD spinning - what a concept! The interior is pretty much packed with electronics - as opposed to any modern CD player or compact stereo you might encounter!

Internally, the FD2000-SL01 consists of the following modules:

- Optical deck with its own front-end circuit board. It uses a radial voice coil type actuator.
- Servo board (about 8 x 8 inches).
- Demodulator/audio board (about 8 x 8 inches) with the actual EFM decoder on a separate mezzanine card. These two boards are enclosed by perforated metal shields.

- Display/button board mounted behind front panel.

- Power supply board (about 4 x 6 inches) and power transformer.

The pickup uses the Philips rotary actuator technology - little different from modern Philips CD players or CD ROM drives except that it is much more solidly constructed with individual parts - the laser and photodiode array - designed to be field replaceable assemblies. However, while you would think this design results in rapid access, think again. As you will see below, this player has by far the slowest seek time I have ever encountered.

We now return you to the present:

With the bottom cover removed, the optical deck comes into view. Pressing PLAY does result in some action - the pickup bounces to the far end, then back to the home position - perhaps a couple of times - before giving up. During this time, one can hear some high pitched whining as the servos attempt to locate the disc directory.

After a few minutes of wiggling and prodding, I am successful at getting the disc directory to apparently be read - the number of LEDs corresponding to the number of tracks on the disc are illuminated. Expectantly, I connect the audio outputs of the player to my handy-dandy Heathkit compact stereo. However, the speakers remain disappointingly silent. :-(

At this point, the servo systems appear to be working - if a bit erratically. I assume there were/are some bad/dirty connections in the cabling or socketed chips. In fact, in the end, there is still at least one bad connection I have yet to locate.

Seeking to the next track reminds me of an inch-worm moving along: zeek, zeek, zeek, zeek, zeek,....., zeek (though inch-worms don't, I suppose, make these sorts of sounds). I assume what I am actually hearing (the 'zeeks') are the sounds of track ('track' here referring to the spiral groove or line of pits on the CD) crossings. If the positioner is moved by hand, you can hear the same track crossing sound - almost like dragging the stylus across an old LP - but much more closely spaced of course. With a practiced ear, it is even possible to count the tracks. Let's see... This CD has exactly 17,243, or was that 17,244? :-)

It takes about 20 seconds (and 40 to 50 zeeks) to seek from track 1 to the last track on a typical CD using a coarse-fine search strategy. So while the rotary actuator should result in a very short seek time, the designers had not taken advantage of their superior technology. Audible search (>>, <<, at least I think it should be audible), makes a more conventional dit, dit, dit, dit... sound.

Some careful tweaking of the focus and tracking adjustments shows that these are probably optimally set already. Since seeks work and the disc directory can apparently be read, it is likely that the optical components including the laserdiode and photodiode array are fine. As a double-check, I put my scope on the RF test point. The 'eye' pattern is stable and free of noise.

All power supply voltages check out.

To go further, I need to get to the top of the circuit boards. The cover comes off easily enough - the owner had been in there already and lost most of the screws. Grrrr. The only connection to the cover is the interlock switch which is easily bypassed. In order to get the CD to spin properly, I remove the clamper magnet from the lid and set it on top of the CD. The laser beam is safely blocked by the CD so there is no danger.

Getting to the demodulator/audio board requires removing the metal shield by prying it out with a screwdriver. The servo board is underneath this (the foil side is accessible from the bottom after its shield is removed but since the servo systems seem to be working for the moment, I should not need to get to it).

Since I have the schematics, I first go for the audio signals out of the left and right channel (separate) D/A converters - nothing.

Working backwards from the D/As indicates that there is no activity on the digital lines into the D/As. This confirms a digital problem in the readout or decoding logic. The audio circuitry is likely in good condition. Woopie!

There is a mezzanine card mounted in the lower right corner of the servo/logic board which does the EFM decoding. It includes some sort of controller, static memory, and some logic and I/O buffers. There is no activity on the outputs of this board - or on its local bus. In fact, although the clock is running, nothing else seems to show any signs of activity. The main chip is a CX7934. I have been unable to identify its internal functional block diagram or even a pin description. So, while all power and as best I can determine, all inputs are correct including the EFM input (buffered squared up eye pattern), audio muting, clocks, and power. I do not know for sure if this chip is dead but it sure appears that way. I believe it is also is running somewhat hot...

Thus, for now, I am shelving the unit. I may return to it in the future. In the meantime, the only sound produced by *this* CD player is the zeek, zeek, zeek of the rotary actuator.

Comments: This was an entertaining experience since many interesting signals are actually accessible with the level of integration used in this design. Modern CD players use 2 or 3 chips to do all of the processing with serial data running between them. Here, there are actual bits you can hold in your hand!

I would still like to get this machine operational. It is a wonderful example of early CD player design. I would be interested if anyone has one of these complete CD players or individual components that are likely to be functional sitting in an attic, basement, or junk pile. I am pretty sure I need the mezzanine card (possibly designated 30-892-C16) at the very least.

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Repair Brief #59: GE 13AC1504W Color TV - Dead (With Other Problems)

Patient: Garage sale 13" GE color TV. Sitting by itself on the lawn near end of sale. I think I paid about $5 for it - which was probably about $10 too much!

Symptoms: Initially, the TV appeared totally lifeless.

Testing: External whacking had no effect. However, some prodding of the mainboard would occasionally get it going. Once running, it might continue to work but with erratic messed up color and occasional vertical jitter.

This is one of those GE chassis affectionately described as 'bad solder connections held together by copper traces'. I, however, wasn't familiar with these at the time, so the troubleshooting took some time - make that lots of time!

Among the problems were:

- Erratic startup.
- Incorrect and washed out color.
- Jittery vertical deflection.
- Dirty tuner and controls (trivial in comparison with the others).

Since prodding had an effect, bad connections were indicated. But where? Careful examination of the soldering didn't reveal anything. Suspect joints that were touched up made no difference.

Most connectors seemed to be firmly seated and without detectable problems.

A couple of power transistors in the vertical deflection hanging out in midair (by design) were connected via 3 pin plugs. These seemed to have some weak contacts so I extracted each pin and bent the contact to increase the spring force. This helped some with the vertical jitter but the erratic startup and color problems remained.

Prodding also had an effect on the color problem but it was not possible to localize it.

Off to the library to copy the Sams' Photofact for the set. Silly me. I thought that would actually help!

It took me more time than I care to admit before realizing that this was a double sided circuit board and those stupid rivet things where not just test points or wire connections. I had not checked the top side wiring!

Now more about this disaster called a TV:

The wiring on the circuit board uses what are called 'rivlets' - poor man's through-holes or vias. For each connection through the circuit board or to a wire, a metal rivet is first set in the board and clinched. Then, the wave soldering machine is supposed to complete the electrical connection by soldering the rivlet to the circuit board traces. This has to be done on the top as well as the bottom but with solder from the bottom. The only problem is that the temperature probably wasn't high enough or not enough or improper flux was used. Initially, the connections were fine and the TV worked reliably for anywhere from a few milliseconds to several years.

However, repeated thermal cycles finally resulted in numerous intermittent connections.

Removing the mainboard requires unplugged 8 or 10 connectors. Fortunately, most were keyed and labeled so I got away (by accident) with not drawing a picture of how they were arranged. I had copied the Sams' Photofact schematic for the set but not the entire folder with the parts and connector placement. The mainboard may be removed without disconnecting the CRT anode as the flyback is mounted to the frame.

What I finally did to more-or-less fix the set was to use a soldering gun with fresh solder and flux to rework every rivlet I could find on both the top and bottom (basically going over it twice) of the board. In some cases, components had to be temporarily removed as some rivlets lurked underneath.

This did cure all three of the major problems.....

Until I buttoned it up. A couple days later, the picture faded to black over a period of 15 seconds - and then came back over the same amount of time. Oops, forgot to rework the CRT driver board. Sure enough, I found an obvious bad connection to the CRT filament - this one I could actually touch.

A couple of years later, the convergence deteriorated suddenly. You guessed it. I hadn't reworked the little convergence board.

A while later, the poor color problem returned intermittently. On initial power-on, the color would be fine but would then drop out and shift toward blue/green. It was sometimes possible to obtain correct color by turning the COLOR control all the way up and the TINT control to one end.

I finally bit the bullet and resoldered the entire mainboard yet again.

Now it is working again (crossed fingers). Anyone need a great TV?

Comments: The 'proper' way to reliably repair this chassis would probably be to remove all the solder from each rivlet, scrape the solder mask from the traces in the vicinity, and add bare wires through the rivet hole and to the traces to complete the through-hole connection. Then, fresh solder and flux with a hot iron. One could spend their waking life on one such set! There are probably only a half dozen actual rivlets that are the problem children. However, there is often no visible evidence of the bad connections. Even with the schematic, locating them based on would be difficult and there would be no way of knowing where the next one would crop up.

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Repair Brief #60: Canon FaxPhone 80 - More or Less Dead

Patient: Garage sale Canon FaxPhone 80 really big and old fax machine. Hey, it was only $2. (They gave away the supposedly dead microwave oven free - I still am not quite sure if there is anything wrong with it other than the missing temperature probe. Maybe the Fax was dead and they should have charged $2 for the Microwave!)

Symptoms: Buttons and LCD display do seem to work but there is no paper movement, it keeps insisting on paper problems 'Check Paper' when attempting to copy. It was also flashing 'Load Ink Sheet'.

Testing: I only have about 2 feet of the semi-special paper this machine uses. It is a thermal wax transfer type print mechanism with a full width ribbon. I try copy mode but there is no action. Even paper advance complains (once I located the correct button with no manual and those 'universal' icons).

You might call this a plain paper fax - but one using a special ribbon, a wax transfer type. The ribbon seems to be mostly used. The 'Load Ink Sheet' message was caused by the marking on the last few feet sensed by an LED/photodiode sensor. Hopefully, there is enough left to at least test the machine while troubleshooting. Better yet, I just rewind it a few feet. So what If I get the previous owner's faxes in negative (like a used carbon ribbon from a typewriter or impact printer) superimposed on my test! Actually this could be interesting. :-) I don't even know if one can buy this type of ribbon anymore.

The paper seems ordinary - perhaps a roll of shelf paper would work just as well as the kind Canon no doubt sold for this unit.

In all fairness, it does seem to want to cooperate - just that the paper is not moving. So, what operates the paper advance (and the cutter, for that matter - it makes a horrible grinding noise and seems sick as well - there is likely a common problem).

In order to access the electronics, I need to remove the cover. This turns out to be relatively straightforward - 2 screws in the front and 2 on top. The phone itself unplugs but is not needed anyhow as the keypad remains with the main chassis.

Now, I can see the gears. My first observation is that one gear is just twitching when the paper should presumably be doing something. Sound familiar? Try Repair Brief #1: Daisy Wheel Printer - Carriage Gets Stuck.

It seems that getting to the electronics takes a little more work - two more screws in front and removing the rear panel. Then, the entire mechanical assembly swings up enough to get at... the driver board for the paper advance motor. It is a small separate board, easily detached from the frame. Very convenient.

Of course, pressing paper advance with the machine in this state results in the paper actually advancing - what a concept!

Prod, prod, flex, flex. Oops, there it goes into spaz mode again. So, how about those bad connections? I reseat the connectors - no change. A visual inspection of the back of the board shows a number of solder pads that may be suspect but no smoking gun. Running my finger over individual pins has no effect other than to draw blood. However, flexing the heatsink/board combination does seem to make the problem come and go. Well, there is only one way to find out.

About 10 minutes and a hundred or so solder connections later (just to be sure, did nearly every one), the paper advance function is now stable. Flexing and prodding the board has no effect. Hurrah!

OK, so do I have a working fax? With my precious 2 feet of paper, I set out to copy a page - seems like some old assembly language program. Well, as they say, a page is a page is a page.

Sure enough, copy mode seems to work and the quality isn't half bad.

Will it work with a phone line. Simplest is to transmit a fax to my PC but that would involve disconnecting from the Net! No way.

I send a one page fax to work - "To sam - Fax Test #1". I am in no hurry.

Next time at the office, sure enough, the fax was sitting in my (physical) mailbox.

This fax will prove convenient for sending though I will have to find a not exorbitantly priced source for the roll paper. For now, I rewound the ribbon about halfway to provide more than enough for any of my needs. Let's, wasn't that a wedding invitation that just went by? :-)

Comments: The motor driver circuit board does not appear to plated vias (I cannot even recall now if it is double sided). In any case, there was clearly inadequate support for the leads of the larger component - just a thin film of solder. The holes were grossly oversized and with no plating, did not provide adequate mechanical support for even slight thermal expansion and contraction cycles. As soon as touched with a hot iron, the solder pulled away from most of the pin - I had to add a fair amount of fresh solder to produce a decent bond.

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Repair Brief #61: Sony D14 Portable Compact Disc Player - Smoked

Patient: Player given to me to look at. I was told that it didn't work and smelled really bad...

Symptoms: Even unpowered, it did smell really bad. :-) I had to borrow a Sony AC adapter to test it. The unit was totally dead. Applying power didn't help the aroma either.

Testing: Using the proper Sony 9V adapter results in no action, not even the display does anything other than all segments being black.

So Sharon (not her real name), our purchasing person (before being laid off), hands me this Sony portable CD player. "A friend of mine, Larry, would like to know if there is any hope". Sharon appeared kind of embarrassed to ask me to deal with this dead fish. :-)

Even with the cover closed, it is obvious that something unfortunate happened. I don't believe I was actually told that an improper power adapter was used but this would become obvious pretty quickly. The sorts of catastrophic failures I found do not generally occur spontaneously.

This is one of the early Sony portables - solid metal construction. The bottom comes off easily revealing a scorched surface mount part. Hmmm, maybe this won't be so bad after all. Wishful thinking. A little tracing reveals that the crater where the part used to live is basically across the 9 V DC input. Protection diode. I scrape its remains off of the board clean with alcohol, and replace with a 1N4007.

No change - surprise, surprise.

Furthermore, it still smells really bad.... It might even be a little worse.

So, how do manufacturers of portable devices protect against accidents or stupidity?

There is often some kind of protection in the form of one or more of the following:

1. Diode across the power input with reverse polarity so that it normally does not conduct. It will short circuit a reverse polarity supply and hopefully fail shorted with excess reverse current.

2. Diode in series with power, again for reverse polarity protection. It will simply not conduct if the polarity is wrong.

3. Maybe a fuse or two in disguise. There are things called "IC protectors" which look like little black transistors but with only two legs. Hard to identify on surface mount, though.

4. Overvoltage crowbar - zener triggering an SCR at substantially higher than normal input voltage. This shorts across the supply and (hopefully) blows an internal fuse if the resulting current is excessive before the SCR and circuit traces vaporize.

In this case, only (1) was present - at least I could not locate any fuses, fusable resistors, or IC protectors.

What next? I still need to locate the source of that really bad smell.

Nothing else on the readily accessible solder side of the mainboard seems to be in distress. Unfortunately, getting to the top side components requires unsoldering a bunch of skinny wires (labeling them) and a flat printed cable (the focus and tracking drive, which I managed to eventually rip from repeated assembly and disassembly).

This done, I still don't see anything smelly on the top of the board. Then, I notice *the box*. It is a sealed metal enclosure about 1" x 1/2" by 2" housing the DC-DC converter which powers most of the player's circuitry. Although, there is no visible charring (how can metal char?), this is the only possibility. Fortunately, only 4 or 5 pins anchor this module to the circuit board. Once removed, it is obviously the source of the aroma. Yum!

I use an Xacto knife and soldering iron to remove the cover - soldered along the edge. Then the damage becomes clear: the largest transistor is totally melted, split in two, and unidentifiable. Traces on the little circuit board are also destroyed. The insulating cardboard *is* nearly charred. However, other small transistors and discrete components appear to test fine using my multimeter.

I try a generic NPN power transistor - no output from the DC-DC converter. It appears not to be enabled as the on-off switch is a logic level going to the main microcontroller which appeared to be dead. I even tried to substitute external power supplies for the voltages provided by the DC-DC converter. Again, no change.

Tracing the input power connections show that they go directly to a large multilegged chip. Generally, reversing power on integrated circuits is not a good thing to do as they rarely survive.

Obviously, something more powerful than a typical AC adapter had been used Usually, such damage is the result of something like attempting to use an auto cigarette lighter adapter to power the device.

Nothing I have received so far in my quest for dead optical pickups, portable CD players, CDROM or optical drives, has been in anywhere near the sad state of this poor Sony. :-(

I sent Sharon email:

> "Larry probably tried to power this thing from his cigarette lighter, huh?
>
> It would probably have survived for a while on the 12 to 15 V of the auto battery instead of 9 V from the adapter. But, he probably got the polarity reversed. With the virtually unlimited current capacity of an auto battery, the microcontroller was toast before it knew what hit it. Any fuse would have been too slow to prevent terminal damage even if the circuit traces didn't vaporize first.
>
> If Larry wants it back, no problem. It still looks like a CD player. If he takes it in for repair, the technician (while holding their nose) will even probably agree that it was a CD player at one time."

Actually, with the blown up parts removed and the circuit boards cleaned with alcohol, the odor has mostly disappeared. I still have it as a reminder that AC adapter connections and ratings are not the same as data cables which can often be reversed without damage. But not always - like those 44 pin min-IDE connectors used on laptop harddrives - they smoke really expensive parts if plugged in backwards because power is also on the connector at one end. :-(

Sharon forwarded my email to Larry who confirmed my suspicion. He was attempting to use the player in his car.

I did remove the optical pickup and tested it. The laserdiode, focus and tracking coils, and motors were fine (I have not tested the photodiode array but expect it to be undamaged as well).

The DC-DC converter isolated most of the circuitry from damage. Unfortunately, at least that one large IC, presumably the main system controller, ran on the wall adapter DC voltage directly and appeared to be toast.

I also have a bag of smoked digital clocks, a smoked clock radio, and a smoked cordless phone (which I have since repaired) from Larry (now Sharon's former friend)..... I will discuss those in a future Repair Brief. Stay tuned for: "Clocks, Clock Radio, and Cordless Phone - Smoked." Till then, you can attempt to guess what happened. :-)

Comments: those voltage, current, and polarity ratings marked on portable equipment are there for a reason. The voltage rating should not be exceeded. Using a slightly lower voltage adapter will probably cause no harm though performance may suffer. The current rating of the adapter should be at least equal to the printed rating. The polarity, of course, must be correct. If connected backwards with a current limited adapter, there may be no immediate damage depending on the design of the protective circuits. But don't take chances - double check that the polarities match - with a voltmeter if necessary - before you plug it in! Note that even some identically marked adapters put out widely different open circuit voltages. If the unloaded voltage reading is more than 25-30% higher than the marked value, I would be cautious about using the adapter without confirmation that it is acceptable for your equipment. Needless to say, if you experience any strange or unexpected behavior with a new adapter, if any part gets unusually warm, or if there is any unusual odor, unplug it immediately and attempt to identify the cause of the problem.

Some devices are designed in such a way that they will survive almost anything. A series diode would protect against reverse polarity. Alternatively, a large parallel diode with upstream current limiting resistor or PTC thermistor, and fuses, fusable resistors, or IC protectors would cut off current before the parallel diode or circuit board traces have time to vaporize. A crowbar circuit (zener to trigger an SCR) could be used to protect against reasonable overvoltage.

Not this one, unfortunately. All the smoke has been released....

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Repair Brief #62: Zenith System 3 Color TV - Intermittent Blue Fog

Patient: Trash-picked 25" Zenith System 3 Model SC2569W in pretty good physical condition.

Symptoms: Occasionally, mostly during the first few minutes but possible other times as well, picture is replaced will solid blue screen with retrace lines.

Testing: Running the set resulted in occasional blue flashes. Tapping the cabinet did not have any effect.

My cousin (the one with the 3 kids, 2 dogs, and 13 goldfish), was walking the LARGE poodle when she came across this TV sitting on the curb. The owner was about (or perhaps she knocked - that wouldn't be out of character - so the symptoms were available. "Screen occasionally turns all blue".

Upon my return from garage sale-ing, I get this call. "Are you interested in a Zenith TV"? How big? "Big". OK, I will check it out. My usual rules are that (1) I don't tend to bother with consoles, (2) TVs with knob tuners unless they fall into my lap, (3) those that are excessively abused, or (4) those that are really old but not old enough for antique status.

This one turned out to fit the requirements - a table model only slightly larger than the CRT. No remote - darn. Have to send her back for that! Fortunately, I have a half broken remote from one of Bill's dead TVs (you know, the one that had a totally white picture that I may talk about in a future Repair Brief, then again, maybe not, it isn't pretty) It is (was) a Zenith A-line chassis TV but fortunately the remote seems to work. Of course, Bill lost the battery compartment cover - typical. :-(

Getting it home wasn't too bad - only half a block away, fit the back seat of my car.

At first, the supposed symptoms didn't show up. Great! Maybe the ride home has cured it!

Then, after screwing around with a broken CD player for a while, came back and turned it on - and - what do you know? Picture came up all blue and flashed to normal.

Removing the cover is easier than some - 8 screws, back slides off and set is fairly stable though I wouldn't want to sit on it.

Now, of course, no amount of tapping or prodding can make the picture turn blue. Turn it off and wait.

A few minutes later, powering on results in a few flashes of blue - and - more importantly, tapping on the CRT neck seems to affect it. Prodding the CRT driver (neck) board or anywhere else has no effect.

The detailed symptoms appear to be:

1. Blue gun turns full on but with Red and Green still visible under the fog.
2. A second or so later, red and green disappear and only blue remains.
3. Tapping or waiting results in screen flashing to black (presumably as some capacitors charge or something)

and then normal picture appears.

This is almost certainly a heater-cathode (H-K) short in the picture tube. Since it is intermittent, I cannot simply measure the resistance but must check it while running.

I fabricate a temporary isolated filament (heater) winding by wrapping 3 turns of insulated bell wire around the flyback core. Carefully, I unsolder the picture tube filament connections to the CRT driver board and jumper the temporary winding to this. My multimeter is connected between the filament and signal ground.

Now, applying power should result in the blue gun video drive voltage appearing on the filament when the short occurs.

Sure enough, after a few on-off cycles with no problems, the meter jumps to a reading greater than 100 V. With the heater isolated, no apparent change takes place to the picture.

To do a permanent repair, I first determine that 3 turns is satisfactory: Reducing it to 2 turns results in a dull orange glow from the filaments and slightly fuzzy slightly dim picture. 3 turns was correct - the glow is bright orange. (I could also have compared it with the original.)

I locate a couple of feet of well insulated wire and make a more permanent winding, routing the wires well away from the high voltage connector and any hot components. I carefully cut the traces on the CRT driver board right at the filament socket - maintaining the spark gaps to a couple of other socket pins. Then, the new winding is soldered directly to the filament pins.

I could also have probably reused the winding on the flyback and just isolated it from the ground on the CRT driver board but this would result in more stress on the flyback - probably irrelevant but the homemade winding was easy enough.

While the set is open, I adjust the position of the CRT as well - for whatever reason, perhaps since new, it is tilted and off center on the bezel. If I hadn't removed so much dust, I would have suspected it to be a replacement CRT but probably not.

I call my cousin: Do you want the TV? It is fixed. "No kidding, how?". So I told her: There was a short in the picture tube but I rewired the set. "It won't blow up or anything?" Nope, just not something every TV repair shop would do. "Sure, I can give the one in the living room (Repair Brief #12: Sylvania TV with no Horizontal Sync) to the nanny and this one will be fine for use with the VCR (Repair Brief #21 - Sharp VC7864U VCR Erratic). The kids will like a bigger screen." This is also convenient as there is already a universal remote at that location being used with the VCR which will be fine with this set.

Comments: The owner probably called a TV repair shop (or perhaps lugged it in) and was told that with these symptoms the CRT was shot and fixing it would not be worth the time and money. However, there is really nothing wrong with the isolated filament. In fact, the stress on the red and green guns is actually less as the difference in voltages between the cathodes and heaters is on the average smaller and the maximum voltage difference is less as well. As long as an H-K short does not occur with the red or green, there should be no problem.

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Repair Brief #63: Sony Boombox CD Player - Erratic Shutoff

Patient: Ralph's Sony boombox AM/FM/CD/Cassette.

Symptoms: CD player erratic - sometimes won't recognize discs, sometimes shuts off and resets in the middle of a disc.

Testing: Tried multiple discs (classic to rock) just to make sure it isn't just a matter of the player not liking Ralph's tastes in music (which most other humans don't like either.

Ralph was our 'Nedrie' type (from the movie 'Jurassic Park'). Visualize a Sun workstation with Coke stains all over the keyboard, empty Coke cans and half eaten week old pizza, manuals and other stuff cluttering his desk and the immediate area. He is, however, an excellent software engineer which is why all this is tolerated.

Anyhow, Ralph treats his boombox about like the two vicious dogs he keeps locked in his basement at home - firmly. :-) Perhaps, I will discuss the ruggedness of old Realistic portable CD players at some point in the future. One of his (previous) dogs thought it was a bone. The CD player looked pretty beaten but continued to run. I don't know about the dog.

He used to have a pet iguana as well.

Anyhow, Ralph keeps a typical small Sony boombox in his office (2 doors from mine). Thankfully, the volume is turned down and/or he uses headphones. Otherwise, I *would* be very creative about seeing to it that the CD never worked quite right. Oh, your CD is acting up - again? That is really a shame.... ;-)

I had taken a look at this boombox once before, even partially disassembling it, but then the problem went away. This time, the top is squashed in about 1/2 inch due to Ralph's constant beating in an effort to get it to cooperate.

The main problem is gaining access to anything. In order to remove the CD player assembly, one must remove the front cover (six recessed screws - at least the locations are more-or-less marked), LCD display/LED/button card, cassette deck, power supply, and part of the audio/radio section. The CD player including the optical deck and electronics board can then be extracted but actually running it in this condition is difficult or impossible. However, I did manage to set everything carefully propped up and run the player sitting on the table. It, of course, ran fine all day in this configuration. Well, maybe Ralph would not notice the additional disarray......

At first, I thought the erratic problem was due to marginal power as the display LEDs fluctuated slightly in brightness while the CD was seeking. However, the line transformer is built into the boombox rather than being an external adapter so at least there is no way to use an improper adapter. Testing voltages internally seemed to indicate that power was fine.

Next, I removed the CD player completely and went over the solder side of the electronics board carefully looking for bad solder connections. On one connector, there was a suspect joint or two which I repaired. These were probably the source of the erratic shutoff problem. I also tested the interlock switch for intermittents - it was fine. I then ran it for another few hours without incident which, of course, proved little.

Reassembly required another 15 minutes or so but was straightforward. The interior is relatively open so cable routing, at least, was not a problem. I installed only two cabinet screws and left the cassette deck in my desk drawer for a few weeks so access would be easier should the problems return.

Ralph never noticed.

It has been a couple of years now and I have not heard of any complaints. One time I thought there was a problem when I went into his office and attempted to play a CD but it must have been a bad CD because he has seemed happy (at least with respect to the boombox). Ralph has recently left for greener pastures though I am sure I will hear from him if the CD fails again!

Comments: One wonders why product engineers cannot take a few more minutes to design an enclosure that is easily serviceable. I suppose the quick answer is that these are deliberately designed to be throwaway products in any case. There is no way that anyone can justify the cost in time to gain access to fix a miserable cold solder joint. The whole thing probably cost $100 retail. Of course, one wonders further why cold solder joints are still so common even on ordinary (not large pins) components. Then again, Sony's manufacturing engineers haven't met Ralph!

Now I see that an AM/FM/cassette/CD boombox is on sale for $60. I wonder what kind of construction it uses....

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Repair Brief #64: Book Tape Player - Missing Channels 3 and 4

Patient: This is one of those portable tape players often used by the severely visually impaired to listen to 'books-on-tape'. It has oversize buttons with tactile function impressions, a wide range speed control, and the ability to play any of the 4 channels on a standard cassette.

Symptoms: I was told that the player would not finish the tape. In fact, what was happening was that it would not play channels 3 and 4 resulting in a high noise level but no proper audio.

Testing: I tried the tape provided as well as a regular stereo audio cassette. Only 2 of the 4 channels worked properly.

This 'customer' has provided me with quite a lot of 'business' in the past (keep in mind, I don't charge for anything beyond parts in these cases). Mostly, previous problems were due to unintentional abuse. These have included bad solder connections on a classic as well as more modern Radio Shack multiband radio and a sprung reel clutch on a cheap boombox.

This tape player is a nice well designed unit with large rugged controls. There is no sign of external damage but that may not mean much.

Since I at first thought that this was a case of the tape not finishing rather than not playing properly, I first checked for takeup reel and capstan motion and torque. Both were fine and thus I rather doubted that it simply stopped playing a tape. Then I tried the tape channel selector.

Recall that a standard stereo cassette has 4 channels of audio - L+R forward and L+R in reverse. Book tapes use all 4 channels individually. A switch selects between the L (1 or 2) and R (3 or 4) channel is being played. (OK, it might be the other way around.) Flipping the tape over selects 1,3, or 2,4.

Anyhow, after a little testing, it was obvious that channels 1 and 2 were loud and clear but 3 and 4 resulted in some background noise - greater than the tape hiss of channels 1 and 2 but not hum or oscillation.

What could it be?

Keeping in mind that there is only one channel of amplification in this unit and the switching is done mechanically, not much.

One might suspect the electronics - but this is probably impossible as the same electronics is used for both channels.

One might suspect the tape head - easy to check.

One might suspect the wiring - quite likely given a well used possibly abuse tape deck.

To test for output from each tape head channel, all that is needed is a small pointed tool like an awl or jeweler's screwdriver. Touching each of the 4 terminals on the tape head should result in hum or buzz on at least one of them - depending on the channel selector setting. (This also works for normal stereo cassettes - you should get a hum or buzz out of the appropriate channel when its tape head terminal is touched.)

I didn't even need to go that far as the cause came immediately into view once I was able to access the tape head terminals.

The designers of this tape player did a good job. Unlike many similar devices, there is a pop out plastic piece which covers the tape head - presumably to allow access to the azimuth adjustment screw. As soon as this was removed, the broken wire came into view. Since the entire tape head assembly moves, some slight flexing must take place at the point of soldering. It should not be much as the cable is clamped to the moving part but there may still be some flexing so over time, the wire simply broke off.

Someone searching for an electronic fault would have had the guts of this thing strewn all over the workbench and shop floor before finding the true cause! It was tight, but just barely possible to strip and solder the wire back in place. I probably should have put a drop of semi-flexible sealer over the connection to stabilize it but did not. Well, in another 10 years I will know what to do!

Comments: This is not one of those 'cast of thousands' repairs. Nonetheless, for those who depend on talking books for their education and Pleasure, a working tape player may be more important than a high tech entertainment system.

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Repair Brief #65: Aiwa CSD-707 Boombox CD Player - Doesn't Recognize CDs

Patient: Aiwa 'Compact Disc Stereo Radio Cassette Recorder CSD-707'. Wow, what a mouthful! Don't the designers of these things give people credit for at least minimal powers of observation? It's a boobbox, for goodness sake. Geez!

Symptoms: Everything works fine except for the CD player. Insert a CD and close the door. The disc starts spinning clockwise (correct), then changes its mind, reverses direction, and goes into warp drive in the incorrect (counterclockwise) direction. Eventually, it shuts down with a 0:00:00 display.

Testing: Multiple discs behave in a basically similar way. None succeed in reading the TOC.

Jeff brought this beauty to work. "Sam, I have something to keep you busy". Not the printer...? (The previous week, he showed me this Apple LaserWriter NT that was making a horrendous noise. Since I concluded it was from the fan in the power supply underneath, I really did not want to deal with it. It would require half the day just to get at it Apparently, the printer was behaving - Jeff now only turned it on when needed. "No, my dad's boombox."

This boombox appears to be in excellent physical condition (unlike the one described in Repair Brief #63: Sony Boombox CD Player - Erratic Operation which was slightly crunched. Indications are that it just stopped playing CDs without an provocation. No scratches or dents.

Well, since it is not even possible to view the lens without some disassembly, I warm up my screwdrivers...

It requires removal of 8 long screws to separate the front portion with the all the CD player components, speakers, and cassette door (yes, just the door) and the rear half with the rest of the electronics. Four cables link these two sections: speakers, CD power, CD control, CD display/button panel. Four more screws and it is possible to separate the optical deck from the CD electronics board. It is just possible to arrange everything such that the unit can be run with access to solder side of the CD electronics board. This is definitely much easier than that Sony boombox which required removal of almost everything to gain access to the CD player.

With the system disassembled, it is possible to observe the following as it attempts to read the TOC of a disc:

- Sled moves about 1/4 of the distance along the track and then resets to the inner stop. Sled motor stops. This indicates that the limit switch is working.

- Disc starts spinning clockwise, hesitates, then reverses direction. Sled motor spins attempting to move the pickup *past* the inner stop. This continues until shutdown takes place. The limit switch is being ignored.

- It is possible to hear the 'gritty' focus/tracking noise which indicates that the optical pickup is at least partially working - focus must be nearly correct. Tracking may be messed up. Only a scope will determine this.

With such behavior, my first reaction is that something must be really really screwed up since the disc spins at warp speed in the wrong direction and the sled isn't bothering to recognize the inner limit switch when it gets into this state. However, I have come to realize that small problems can result in bizarre behavior from CD players!

So, first I clean the lens -- no change.

Next, I disconnect the optical deck from its intermediate circuit board and go over all the solder connection on it -- no change.

OK, bring in the heaving equipment - I drag a scope into my office.

There are marked test points including RF, TE, FE.

The RF test point is - well - strange. When power is applied, it jumps, then momentarily is of high amplitude but then decays to a much lower amplitude signal with somewhat random characteristics. In fact, I cannot make any sense of it.

At this point, I decide that other tasks are of more immediate concern (like lunch) and will button it up and take it home to work on at my leisure. I tell Jeff. "So what are you going to do." Oh, probably stare at it some more, a little cursing, then give up. Jeff knows better but just laughs.

Next day, I start by disassembling it once again (of course, I had only installed 2 of the 8 cabinet screws) but going further this time:

- Remove the front panel as well (in hindsight, this wasn't needed).

- The clamper disk with the magnet so that I can have access to the disc itself.

- Stuff a wad of paper into the interlock to keep the switch closed.

- Solder wires to the RF test point and a convenient ground for my scope.

Now I can work without having to juggle the front panel, electronics board, optical deck, and scope probe all at once.

The connections to the optical deck look to be the same as for some of the optical pickups I have been accumulating but no cigar - nothing that I would risk swapping until I get desperate. I could easily blow the laserdiode or electronics if they are not quite the same and I don't even know for sure that those other pickups work. After all, they were guaranteed to be dead. :-) I will postpone that decision.

Confirming that nothing has changed - nothing has. The RF test point which should have the eye pattern is still strange. With easy access to the disc to stop it from spinning by hand, the 'gritty' sound is unmistakable - the focus servo, at least, appears healthy.

My test disc is one of those zillions of AOL free 15 hours CDs. While I don't expect to be able to listen to the data, most CD players will recognize the TOC of a CDROM - though the resulting display will be meaningless. Thus, I don't need to worry about damage to the disc - there are a semi-infinite supply of these! Of course, should I succeed reading the TOC, I will need to use a music CD for audio tests and adjustments.

OK, well, Mr. AOL CD behaves the same as the others.....

Now, do I dare tweak anything? There are three readily accessible adjustments: Laser Power, Focus Offset, Tracking Offset. (There is also a Tracking Gain pot which I noticed later. However, the gain controls are usually of secondary importance so I never do bother touching it.)

I generally do not touch laser power adjustments until I am sure there are no other options.

What about focus or tracking?

This smells like a tracking problem. However, the fact that the eye pattern's amplitude doesn't remain fairly constant suggests that there may be some sort of focus problems. Toss a coin.

Normally, this is the point at which I would insist anyone doing any adjustments mark the positions of all controls. Yep, you guessed it, I violate rule #1. What the heck...

Starting with T.OFS, just a hair in each direction - and what a change!! The RF signal remains at high amplitude for much longer AND the disc now tries to spin clockwise for a much longer period of time. My goals now are twofold: (1) to get the disc to spin in the correct direction at roughly the correct speed of 500 rpm and (2) to maximize the amplitude/length of time that the RF test point signal remains at high amplitude.

Then I realize something else that is in the FAQ: I really should use a non-metallic screwdriver as the slot seems to be electrically connected to high impedance circuitry and the behavior is changing when I touch it with my cheapo jeweler's screwdriver. A quick remedy which seems to be adequate is to wrap electrical tape around the handle.

A few minutes of going back and forth between F.OFS and T.OFS finally - I see the display change to what is obviously it pathetic attempt to interpret the time/tracks of the AOL CD. Of course, not thinking, I press PLAY and am greeted with a loud hum/buzz - the 80X86 object code of the AOL SETUP program or something. Hit STOP.

OK, so how about a proper music disc.

I have an 'I don't really care much about this disc' disc for just this purpose. One of those 'Intro to the ballet' or something. You know, it sounds like the Salvation Army orchestra on a bad day. But serves my purposes....

Although the TOC is read with a bit of hesitation, the player seems unable to locate track one. OK, so the current settings may not be entirely satisfactory.

A little more tweaking. Still just some whining and clicking sounds once I hit PLAY. Well, maybe it will like an outer track better. (I have no idea why it had no problem starting to 'play' the AOL disc.)

This seems to do it. It is finally successful at locating track 5 or 6 and starts playing - a bit scratchy. Now that it is stable, I can carefully adjust both F.OFS and T.OFS for maximum amplitude of the eye pattern. After a couple of false starts where it got confused and shut down, I have both set optimally and the player now seems to work normally.

I also note that touching the metal frame seems to cause some static but I assume this is due to the poor ground through the cable - normally the electronics board is screwed directly to the frame of the optical deck.

I finally did risk tweaking the laser power to obtain a 1 V p-p eye pattern at the RF test point. Without service information to know what the proper setting is, this can be risky (even a dirty pot could conceivably blow the diode). I just adjusted it up from about .9 V to 1 V p-p. It was clear from the response to my screwdriver - I could have increased it much further, probably to the point of burning it out - that the laserdiode was not weak. If the laser was dying, the power would have topped out about where it had been set as the feedback would be doing all that it could to maintain constant power.

After fine tuning the focus and tracking adjustments yet again, the behavior seems relatively normal. I rather suspect that there may still be some kind of problem as the tracking adjustment did not have as distinct a peak as I would expect, but who knows?

I will have to embellish the repair description for Jeff. I cannot just tell him I adjusted something. Maybe: "Well, I transplanted the laserdiode from an extra 25X CDROM drive - I figured you would consider the boombox more important than such antiquated technology" or something juicy like that. :-)

Comments: Would Aiwa Service have replaced the optical pickup? Perhaps. I have no idea why adjustments were so far off as to render the CD player useless or why this happened suddenly (as far as I know) without any warning. Perhaps it was dropped and there was indeed a change in the optical alignment. Perhaps a bit of dirt caused one of the controls to change value and my twiddling really just cleaned the track on that pot. Perhaps the original adjustments were marginal. Whatever the cause, It now works and appears stable. The eye pattern looks fine. The music sounds fine.

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Repair Brief #66: Sony KV-13TR-20 Color TV - Erratic Reception

Patient: A Sony 13" color TV model KV-13TR-20 in excellent physical condition.

Symptoms: Initially, all channels resulted in a white screen. After some warmup, overdriven video (AGC bad) appeared on one channel. After some more warmup, a couple of channels were fine.

Testing: Let it run for a while. Whacking on the cabinet didn't seem to have much effect.

A little tag came with this TV: "Tuner/IF Block, $99". I assume the owner took it in for an estimate (or maybe just called someplace on the phone). Obviously, $100 to repair a $150 TV is a bit steep. Now my usual rates, on the other hand....

These are classic symptoms of the Sony bad solder joint problem afflicting many models of middle aged TVs - not to be confused with the GE/RCA tuner bad solder/EEPROM problems which are similar. :-) See the document: "Sony TV Tuner and IF Solder Connection Problems".

Fortunately, on this set, getting to the tuner and IF boxes is pretty easy once opening the case is overcome - snaps are used in four spots rather than screws. Give me screws any day! On the other had, you cannot lose snaps. Note that on some larger screen Sonys, the engineers in their infinite wisdom placed reinforcing plastic at exactly the wrong place to block access to the pins on the solder side of the mainboard. :-(

The tuner module has about 8 thick pins and 5 shield connections to the mainboard. The IF module has about 11 thin pins and 4 shield connections. Both come off easily (no bad connections visible on the mainboard pads.)

I resolder all the edge pins (though most did look fine), all shield connections, and anything else that appeared marginal. I wasn't convinced that I had located the cause of the problem. There was no smoking gun...

Indeed, the symptoms are essentially unchanged.

Now, I start prodding each of the metal boxes. The tuner box is rock solid but I can get the problem to come and go by pushing gently on the IF box.

Out it comes again. Now I get out the heavy artillery - bright light and magnifier. Then I spot *it* - one lone pin not particularly noteworthy in any respect except that there is clearly a broken solder connection and the pin even moves visibly. This is apparently a common location for these problems - one pin of a coil. I check over everything else once again but I am confident that this is *the* cause of the erratic behavior.

Indeed, once reinstalled, reception is flawless - even playing bongo on the TV has no effect.

Comments: As I have noted before, you would think that after several decades of manufacturing consumer electronics, soldering would not be an issue. But, this certainly seems not to be the case. The demands of the bottom line as well as manufacturing issues of mixed through-hole and surface-mount technology combine to make reliable assembly quite a balancing act. At least the Sony and RCA/GE bad solder problems are well documented and straightforward to repair.

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Repair Brief #67: Magnavox Phonograph - Record Changer Problems

Patient: This is a Magnavox 'Stereophonic Phonograph Model 3P2515', age unknown but likely at least 25 years old. I bet the feature length name sounded really impressive at the time.

Symptoms: Record changer load and eject functions totally inoperative.

Testing: Cycling mechanism results in no change. It does play records if the tone arm is positioned manually. The stylus also wants to eat the vinyl.....

Since the changer did not respond, I directed my attack to this mechanism. Unfortunately, the owner was not available to explain if this was the main problem - it could possibly be something else.

On an older mechanical device, be it a dinosaur such as this or reel-to-reel tape deck, lubrication, deteriorated rubber parts, or broken parts, are the prime suspects.

But how is this one supposed to operate?

A large metal cam gear actually moves and raises and lowers the tone arm. This is engaged by a smaller nylon idler gear which is moved into position by the OFF/ON/EJECT knob or the movement of the tone arm to the end of the record.

In this case, the idler was failing to engage most likely due to gummed up grease. Once it was freed, the large cam gear was so tight that either the motor slowed and stopped or the gears teeth were skipping - thankfully without lasting damage.

To free up the large cam gear, required removing a bracket and using some WD40 to loosen the dried grease. Once this was accomplished it was worked free. The shaft and bearing surfaces were cleaned. That seems much better.

Darn, the eject is now ignored.

Oops, not the correct timing - there are two possible positions for the relative relationships of the cam and idler. Try the other one.

Well, although it now cycling correctly, the record does not drop. The spindle mechanism is - what? Totally frozen!

Upon closer examination, it would appear that the load/eject mechanism had been glued into a fixed position - the parts of the spindle that normally drop the record were immovable. At first I thought this was simply dried up grease but I am quite sure it is really some adhesive - possibly Epoxy.

Disassembly requires removing the entire platter bearing assembly from the changer, clamping it in a vise, and twisting and pulling to free the spindle. It would appear that this, too, was glued in place!

At first, I try freeing it up with WD40 but this proved inadequate so I use a punch to remove the roll pin. The assembly now comes apart easily - and I promptly forget how it goes back together! One would think that something so simple would not be a problem but it took another 10 minutes or so to come up with a logical arrangement of all 6 parts and several more minutes on the floor searching for a 1/16" shaft that popped free.

However, once cleaned, lubed, and back together, it does appear to be much happier.

Replacing the platter bearing assembly goes smoothly except for accidentally stripping the hole of one of the 3 mounting screws - replaced with machine screw and nut.

At first, everything appeared to work correctly but then the motor shut off before cycling. In fact, it will only stay on erratically, sometimes only when the control knob is held in the EJECT position. While I was tempted to suspect that I didn't get something back together correctly, sanity prevailed and I examined the motor switch. It seemed that the lever that operated it did not quite push far enough and the contact was marginal. After disassembling the switch and cleaning the contacts - and bending one slightly - operation is reliable.

Perhaps, this was the actual complaint since there is no way the changer could have ever worked in modern times!

Another quirk seems to be that when cold, the motor takes a few seconds to come up to speed. At first I thought this was an idler rubber problem but then discovered that the motor seemed to be running at half speed even with no load.

There is no starting or running capacitor to go bad, it is simply a shaded pole motor. Interestingly, it acts as the power transformer for the amplifier with an isolated center tapped low voltage output. I cleaned and lubricated the motor but

I do not believe this is the problem. The speed does seem to recover so I am not going to lose much sleep over it.

One final adjustment: The tone arm tracking force was set so high that I was afraid the stylus would dig a trench entirely through the record on the second or third playing. It took a minute or two but I located the tracking force screw and set it to a more reasonable value - high by audiophile standards but a 3000% improvement.

Comments: There are still many people who depend on this sort of ancient technology for their listening pleasure and are probably better off than many of us who worry about signal-to-noise ratio, dynamic range, and whether Shannon and Nyquist really knew what they were talking about. They are much happier to have their old record player restored to health than to have to learn or afford new-fangled technology like compact discs and (gasp!) DVDs.

Repairing this equipment is generally going to be a seat-of-the-pants affair due to lack of easy or convenient availability of documentation - which is generally not needed in any case if a few brain cells are assigned to the task. Causes are nearly always simple in principle - dried up grease, deteriorated rubber parts, broken parts (hope you can fabricate replacements!), or previous attempts at repair.

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Repair Brief #68: Clocks, Clock Radio, and Cordless Phone - Smoked

Patients: Two LED clocks, 1 clock radio, and 1 cordless phone, all really and truly dead.

Symptoms: Dead. What more can one say?

Testing: Plugging into the wall outlet results in no action of any kind. No display and no sound.

So Sharon walks in with this bag of stuff. "I have some presents for you. Larry was working on the wiring in his house."

Is Larry the same guy who toasted the CD player? (See: Repair Brief #61: Sony D14 Portable Compact Disc Player - Smoked). "Yep, he accidentally connected the 220 to the 110...."

Geez, you really have to work at screwing up to achieve such a spectacular disaster. Then again, Larry does have a track record. :-)

What happens when 110 V devices are connected to a 220 V line?

Actually, it is quite predictable as I found out. The transformer primary melts and opens. That is it. Period.

I tested each device by providing my own low voltage AC from a Variac feeding a 24 V center tapped transformer substituting for the original smoked power transformer.

In all cases, there was absolutely no damage to the electronics despite the application of an input voltage twice what was specified. In the case of the clocks and the clock radio, there are is no internal voltage regulation. I can only assume that either the components were able to withstand the excess voltage - which must have lasted long enough to burn out the transformer primary - or that the transformer core saturated and limited the output voltage to something much less than double.

The cordless phone was too good to pass up. Instead of attempting to locate a UL approved transformer to install inside like the original, I located a 9 VAC wall adapter of suitable current capacity and wired this into the phone circuit board. It has been operating this way for several years now.

I didn't bother actually repairing the clocks and clock radio. All I did was confirm that they worked with my jerry-rigged power. The clocks I keep as reminders. I cannot easily use the wall-wart trick on them as a center tapped transformer is required. The clock radio required at least two separate center tapped power inputs.

Comments: I, at least, would have expected more damage from such an overvoltage. However, it would seem that just-good-enough design has its merits if indeed core saturation saved the electronics.

Obviously, this should be a lesson to anyone doing major rewiring: don't do it live - both for your own safety and the risks to your appliances! Have the main power disconnected (by a licensed electrician or the utility company if necessary). Turn all the breakers to the 'off' position or remove the fuses. Before applying power, double check the wiring. With main power restored, check the voltages on the circuit feeds and subpanels. Then energize the branch circuits one at a time and check for proper operation.

I can only guess that one of the power line Hot cables touched the Neutral bus feeding the branch circuits. It wouldn't need to be there very long.

Interestingly, at least one VCR survived with only a blown fuse - similar to an incident where a lightning strike totally obliterated a TV but only blew the fuse in a Panasonic VCR.

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Repair Brief #69: GE Portable Color TV - Dropped

Patient: GE Model 13GP235 color TV in generally good physical condition but Susan explains that it fell off of a bookcase.... I don't ask.

Symptoms: Dead. Normally, I would not plug a piece of dropped equipment in until I had inspected it but apparently, this had already been done. What the heck. In any case, nothing.

Testing: NA. Inspection comes next.

Indeed, it was not necessary to go very far to locate the problems, many problems....

First, one of the case fastening tabs was broken off. Otherwise, there is no visible external damage. At least it doesn't rattle!

Next, the mainboard was visibly bent around the area of the flyback transformer which of course is the heaviest component. Depressing a lock lever allows the mainboard to be slid about half way back and out of the chassis before stopped by some cabling. But that is quite enough! The major damage comes into view - a crack clear through the board running about 3 inches from the rear near the center. It is obvious that numerous traces have been severed.

At this point I drag Susan in to see the extent of the damage. I explain that even if I can repair all the traces - which I expect would take several hours - there is no assurance that the CRT has not suffered some trauma which would result in the color purity being messed up (popped or deformed slot mask). She says "keep it". Lest you think I am taking advantage of her, Dave and I have just repaired a nice 19" Sony of hers with the classic bad tuner solder connections problem. Now, if she would only get it off our lab bench....

Of course, you know, I am not going to let it go to the dumpster (actually my parts bins/boxes/cabinets/piles without a fight!

About 6 months later, I finally manage to drag it home. I remove the back and them turn it upside-down with a cardboard box under the rear to prevent a, shall we say, unfortunate accident. To get at the full extent of the damage, I only need to pull off the degauss connector and the mainboard slides out far enough for my soldering iron.

Where through-hole pads connected to the broken trace are conveniently located on either side of the crack, I run a short length of #24 tinned wire to the pads. Where there is any chance of shorts, I use insulated wire.

If this is not possible because the pads are nowhere to be found - too far away - I scrape off about 1/2" of soldermask (the green coating) on either side of the break and use a 1" length of tinned wire to bridge the gap. This isn't as hard as it might sound since the surface tension of the molten solder tends to align the wire on the bare copper. These should be quite strong. Since the board is actually supported from the rear edge by the plastic cover (at lest under normal conditions), I believe no additional reinforcement is needed.

Where there is a convenient pad close to one side of the break, I wrap the wire around that but still remove the soldermask and solder to the copper on both sides of the break.

I think I have found everything. One last inspection. No shorts. Time for the smoke test. In order for the front panel power button work, the mainboard must be pushed all the way back into the cabinet. Grrrr.

And - yes! We have snow. With the addition of a pair of rabbit ears, we even have a - totally messed up picture. :-(The colors are all wrong and not uniform across the screen. Could the CRT be ruined? Well, not to give up yet. It is still sitting upside-down (though I did remember to plug the degauss coil back in). There are no field adjustable ring magnets for purity and static convergence. Better hope these are not messed up! Waving a speaker magnet around the screen seems to help some. OK, turn it over. That seems to be much better. Some more waving (I am too lazy to drag out a degaussing coil) and the picture is not half bad.

Is the repair solid? I start pressing on the circuit board and - oops - the set goes off. Then comes back on when I release it. I must have missed at least one.

Out comes the mainboard.

Oh, the crack passes under a surface mount resistor apparently lifting one side loose resulting in a bad connection. To fix this, I add a bit of wire looping over the resistor end cap and connect it to a nearby through-hole pad.

Lights! Camera! No change. Pressing on the mainboard results in exactly the same behavior, maybe a little worse. @#$%@

Out comes the mainboard once again.

Now, how could I have missed that?! A second crack, nearly as long as the first, runs from the edge of the board near the flyback under the flyback severing a half dozen more traces. For that matter, how did it work at all?

A half hour later, I am sure it is finished.

Sure enough, pressing and prodding now have no effect. The edge of the board even seems straight enough to not require reinforcement. The plastic back of the TV has prongs which will support the board. I am confident that the repaired traces will resist anything short of another 5 foot fall - and perhaps even that (but I don't intend to find out).

When testing the next day, I thought a new problem had developed - I was getting 2 bands of snow drifting up the screen mostly on VHF channels. What is this? A power supply problem? After poking, prodding, and cursing, I went to plug it into my isolation transformer to do some probing and guess what? The snow disappeared! It didn't return even when plugged directly into the wall. Flakey EEPROM? No, it turned out to be interference from a power massager being using elsewhere in the house! That device must use a non-RFI protected interrupter.

Comments: You have probably seen the TV advertisements - I don't recall what they were for, an insurance company, perhaps - where a late model TV is dropped out a many story window on a bunjie cord. The set rebounds once undamaged and without hitting a baby in a stroller passing under the window but then smashes to smithereens on the sidewalk once the stroller had moved on. Needless to say, this is generally not a recommended way to treat a TV set!

Ok, so your set survived in slightly better condition.....

If you take it in for service, the estimate you get may make the national debt look like pocket change in comparison. Attempting to repair anything that has been dropped is a very uncertain challenge - and since time is money for a professional, spending an unknown amount of time on a single repair is very risky. There is no harm is getting an estimate (though many shops charge for just agreeing that what you are holding was once - say - a TV, or was it a fishtank?)

When making repairs on printed circuit boards that have been cracked or broken, do not be tempted to just bridge the breaks with solder even if the board has been glued and reinforced. Solder is not compliant, bad connections will develop over time and you *will* be returning to your handywork many times in the future. In the case of this set, the total time to repair was about 3 hours - time well spent to assure reliability.

Stay tuned for "Magnavox 31 Inch TV - Fell on its Face". :-(

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Repair Brief #70: Nutone RF Wireless Chime - No Response to Button

Patient: Nutone RF Wireless Chime model LA-99N - otherwise known as a wireless doorbell.

Symptoms: No response to button. Owner claims new batteries installed in both button unit and base station.

Testing: No amount of fiddling with the buttons has any effect. The battery contacts seem springy, clean, and free of corrosion.

This unit is similar in many ways to a garage door opener Tx/Rx pair. The button unit has a five position DIP switch, presumably to set codes (and as I discovered later, to select between chime sounds for front and back door use). A 9 V battery powers the code generator (a single chip Motorola SC41343) and the RF transmitter (all contained in a little shielded box) except for a trimmer capacitor (which I don't dare touch).

After checking to make sure the batteries were indeed fresh and checking that the button was indeed operating its contacts, the next step is to determine whether the problem is in the button unit or base station.

How to do this?

The operating frequency is not marked and I don't really have anything to conveniently detect a low level RF signal at no doubt hundreds of MHz anyhow.

Therefore, I punt and go on the the base station!

This is powered by 4 D cells and a single AA - what this is for, I have no idea. There is no backup memory as far as I can tell! Removing 4 screws from the bottom allows the cover to be removed exposing the solder side of a 2-1/2" x 7" circuit board. The antenna is connected to a point at one end.

Running my finger along some pins near the other end results in some faint clicks from the speaker. OK, it is not totally dead.

Time for Magic Spit(tm).... Moistening my Mark 1 thumb and using this as a probe evokes some more clicks. Placing it on suspect transistors finally results in triggering the chimes. Therefore, I expect that this transistor is the gate from the RF/decoder circuitry. I can fairly repeatably trigger the chimes in this manner. A 56 K resistor from the base to collector will also do this. Thus, I know the chimes are working.

Now for the front end. There are several ICs on the non-chimes side of the circuit board. The two that seem to be interesting are an MC1776 which is an op-amp and a Motorola SC41342 which appears to be the decoder mate to the IC in the transmitter. It is connected to a four position DIP switch.

That op-amp looks promising. Even with just a DMM on pin 6, the output clearly jumps when the remote button is pressed. Time for the scope.

The waveform at pin 6 is clean and stable when the button is pressed. It is 9 low pulses followed by 7 high pulses repeating. How does this change when the DIP switches settings are altered?

Answer: Not much. At least, not every switch setting produces a unique bit pattern. In fact, most of them are the same as this one which probably isn't really even valid.

The op-amp signal goes into pin 8 of the SC41342. Pin 10 goes via a resistor to the base of that 'trigger' transistor. As expected, there is nothing on this pin.

Next, I decide to try all combinations of the four common DIP switches on both transmitter and receiver as well that lone fifth switch on the transmitter. The majority produce the same waveform. However, 3 other combinations of the 4 switches prove interesting:

- Two settings result in codes being transmitted only when the button is released. The bit rate of this code is lower as well.
- Several settings produce 9 low and 3 high pulses.
- One and only one setting produces an alternating pattern of long and short pulses - AND a response from the chimes!

It is erratic, however. As is apparent from the scope display, the bits are not stable for this one 'useful' pattern. However, a good percentage of the time, the chimes will trigger. It is at this point that I discovered the effect of the 5th DIP switch - to change the pitch of the chimes presumably to distinguish between the front and back doors. There are only 6 components in the code generator - the SC41343, 3 resistors, 1 capacitor, the pushbutton, and the DIP switch. Three of these parts obviously determine the bit rate - jumpering them with similar valued components affects only this. I check them all anyhow. Nothing seems amiss. The soldering is perfect.

I decide to check the battery once again - it is a little low, perhaps 8.5 V. The owner did mention something about putting in a new battery but the button being stuck in the depressed position. So, maybe the battery isn't so fresh after all. This really should not matter but what the heck. However, a new battery seems to clean up the erratic pulses.

So, in all likelihood, the SC41343 is bad resulting in a whole wad of missing codes - only one pair seems to work - and marginal operation with a slightly weak battery. Can a chip wear out from being on for too long? :-)

Unfortunately, an initial check shows that my usual haunts don't seem to carry this chip. Then I email Paul Grohe: I was just wondering if you had any datasheets for either of the following Motorola chips: SC41342 and SC41343?

> "AH! Never blindly trust Motorola's search engine! (Ya gotta know where to dig!). Here ya' go:
> - MC14502 Product Summary
>
> This datasheet contains the RC Tx/Rx parts. The 'SC' #s are low-power versions of the 'MC' parts."

Sure enough, the pinouts match perfectly and Dalbani and Allied list the MC145026 transmitter chip. With an actual datasheet in-hand, I go back and scope all the pins but this only confirms that the chip is almost certainly bad.

It is likely that these chips are used in a number of garage door openers as well. With a total of 9 possible input bits, each of which may be set to any one of 3 states (low, high, open), this results in 19,683 possible codes. That number of combinations seems to ring a bell (no pun...) with ads I have seen.

Comments: This is not the first time I have come across a situation of this type. My cousin's Sears garage door opener decided to ignore at least one of the 8 DIP switches. It would work fine as long as that switch in the transmitters and receiver was set to a 1. In the case of this doorbell, it would appear that a much more drastic failure has occurred.

For now, I will return it to its owner but will order the replacement part. The only problem with selecting the only working code would be if a neighbor has the same model set to the same code! At least, it is not the default.

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Repair Brief #71: Tandy Color TV/Monitor - Intermittent Shutdown

Patient: Tandy color TV/monitor model #16-232. This unit was described in Repair Brief #14: Tandy Color TV/Monitor with Hum Bars. Since that initial repair after being rescued from curb-side, it has been in daily use for about 5 years.

Symptoms: The set will randomly shut off and then come back on after a few seconds. There appears to be some correlation with high temperature or high humidity but not much.

Testing: The appearance of symptoms is so infrequent that I do not do anything until it seems to quit for good....

Finally, it goes off and stays off. Oh well, something finally died....

So I unplug it and take it down to the workbench.

Plug it in - still dead.

Whack it once, whack it twice - and - it springs to life! Ok, where are the bad connections on this one?

The previous problem had to do with startup drive to an SCR based power supply. Once started, however, the circuitry involved was not active so the new problem must be, well, new.

I remove the back and start the hunt.....

Soldering is pretty good except for a few spots - one is a just visible crack around the base pin of the horizontal output transistor. Hey, that looks promising....

Unfortunately, I am unable to confirm that soldering this pin is *the* solution since it is so erratic. Although I was able to restore operation with my special whack(tm), I have never been able to make it go off in this manner. While I am in there, I also resolder a few other power components and the video source select switch because it had such an ugly soldering job. :-(

I also replace my startup resistor since the one I was using seemed to have a power rating just a tad too small.

However, the cause of the erratic behavior was almost certainly the crack at the HOT.

Operation *is* now solid but only time will tell if the problem returns. FWIW, the TV has been running for several months without incident.

Comments: This isn't a standard bad tuner solder shield problem but similar nonetheless. Large components heat and cool stressing the solder connections ever so slightly each thermal cycle. After awhile it is just enough to break the solder bond to the single sided circuit board. Then, this expansion and contraction cause the two parts to shift ever so slightly sometimes breaking the connection. With some kind of stress relief or reinforcement, this would not happen. But that might cost a few cents....

I was initially prepared for a long troubleshooting adventure with this set. There is no Sams' Photofact for this model - none even close. I just checked the Tandy info at http://support.tandy.com/video.html and a model that might be this one (the number is slightly different - 160-232A - but everything else checks out) is there. However, only a parts list seems to be available. I was thinking at first: HV shutdown or heat or humidity sensitive component and was not at all disappointed when it turned out to be something simple.

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Repair Brief #72: Braun Quartz Clock - No Movement

Patient: Braun table-top quartz clock (don't they manufacture coffee makers)?

Symptoms: Clock does not run even with fresh battery. No audible signs of life either. These don't go 'tick-tock' but there is usually some faint click each second.

Testing: Battery is fresh and contacts are springy and clean. Gently whacking and twisting will not start it going.

I know, most people would toss a clock of this type when it started acting up. This one is important to the person who owns it. Some people have rabbit feet; she has a favorite clock!

The problem with these things is that everything is small, made of plastic, and fragile.

Anyhow, To get at the guts requires removing the back (2 screws) and popping out the plastic 'crystal'. This done, the hands can be removed and set aside, Now, the solder side of the circuit board is accessible.

First test: check the solenoid for continuity. I had one where the fine wire broke - thankfully at the terminal and it was repairable. This solenoid is fine.

Without it mounted in the case, I need to locate a substitute battery holder to apply power.

Next, I look for pulses on the solenoid. I have already noted that the alarm works by moving the hands to set it off. This confirms that the quartz crystal is oscillating and the huge 8 pin chip is working, at least to some extent.

Putting a scope across the solenoid terminals reveals alternating positive and negative nearly 1.5 V (the battery voltage) pulses at what I presume to be a 2 second rate for an entire cycle. This would seem to indicate that it should be working.

Therefore, the problem must be mechanical. In fact, gently rotating the second hand shaft seems to point to a problem with the gears.....

I have to go deeper! Popping the gear cover finally reveals the problem: the rotor of the motor is a teeny tiny cylindrical magnet glued to a plastic pinion gear. The glue has failed. Can you believe it wasn't constructed to military standards! A 1/4 drop of household cement and it should be as good - no - better than new.

It is interesting that while this is a 2 pole single phase motor, the starting direction is not ambiguous. How? It seems that there is a little plastic tab on one side of the rotor. When the clock is mounted in the normal upright direction, this is just enough unbalance to force the rotor into a known orientation when unpowered and between pulses (it will be settle with this tab at the bottom or perhaps just balanced at the top but not on one side). From this, the N-S pole relationship is guaranteed to force the proper clockwise rotation of the hands (at least in this part of the universe). Clever and simple.

Reassembly is not as difficult as I feared - the gear shafts are guided to the holes by conical bevels on the cover.

And - it works! I even got that little plastic tab oriented correctly.

Comments: OK, so you are saying "Why bother?". Maybe it is the challenge. Maybe it is not being able to say no. Maybe I have too much junk already and I would never throw it away if I couldn't fix it. The owner will be happy. And, I (and perhaps, you as well) have learned something about quartz clock movements. Not a bad deal for 1/2 hour's work.

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Repair Brief #73: Sony D88 Portable CD Player, Part 1 - Does Not Recognize Discs

Patient: Sony D88 'Dual Size' portable CD player. This really cute miniature CD player was designed mostly for CD 'singles' and is only slightly larger than a 3-1/2" disc. Normal CDs hang out on 3 sides.

This is the first of the "Request for (dead) optical pickup series" of Repair Briefs. This classic Sony was donated by Zev Berkovich (ah392@freenet.toronto.on.ca).

Note: I am still looking for additional samples of this model and other portable CD players, CDROM drives, optical pickup assemblies, and other optical disc technology technojunk. I will pay slug mail shipping (e.g., UPS Ground Commercial).

Symptoms: Inserting a disc and pressing PLAY results in the pickup moving toward the center but the disc directory is never read and the player gives up after 10 seconds or so.

Testing: The behavior is the same with several discs. It doesn't appear as though it is even focusing correctly....

First some history - here is the dialog between Zev and myself:

From Sam: Original posting (summary):

Newsgroup: sci.electronics.repair Subject: Request for (dead) optical pickup assemblies.

I am interested in complete or partial optical pickups or optical decks, portable CD players, CD ROM or optical drives for parts. I will be slightly disappointed if they are fully operational. :-(Obviously, I do not want to pay much so no offers of new Sony pickups at retail prices please! Since I do not not make money on most of my repair activities (family, friends, charity, the Internet, personal amusement), I am only willing to pay for slug mail shipping and perhaps a wee bit more if there is enough fascination value in it. In return, you *will* get priority replies to your repair problem postings! :-)

From Zev:

> "I have a non-working Sony portable CD player (it is designed for 3" CD's, but will also play 5" CDs with part of the disc sticking out of it). I have the complete service manual with schematics.
>
> Since this unit would be of little use to me even if it worked, I have not really put too much time into it. However, I have used it to play around with and try different things on my scope. The laser, BTW, is fully operational and is drawing exactly the right amount of current. I am pretty sure with some time put into it the thing will work perfectly, I just have no use for it, and I would be happy to let you have it.
>
> The laser unit is not compatible with later sony discman models."

From Sam:

Thanks, that sounds perfect - it satisfies my criteria for optical pickups and would appear to be a really interesting item. What is its current status?

From Zev:

> "Originally I had very carefully adjusted the focus and gain settings, and I did manage to get it to work. After it played for a few hours though, it just quit on me. I may have gone a little wild after that tweaking the dials, so it's possible that they are all out of adjustment."

After I received the package...

From Sam:

When one compares the newer models to these, it is amazing how far the manufacturing has come - a couple of ribbon cables/connectors and the entire optical deck pops out - none of this flying lead stuff! BTW, that pickup looks to be similar to those used in a number of quite new non-Sony model portables and boomboxes including Emerson (whoever makes them -- Mitsumi?), Aiwa, etc.

The other portables I have received based on my request for dead optics have all had good optics! :-(They have seemed to have power problems - one was smoked by too much voltage, another has an overheating problem.

From Zev:

> "Hmmm. I never thought about comparing the optics to other brand names. I just compared it to the newer Discman models (D121 and up), which use a totally different connector (one ribbon cable and a couple of two prong snap on connectors) which I can pop in and out in a matter of seconds.
>
> What is also quite amazing is that when you look at the evolution of Discmen even over the past 5 years, they have gone from multiple circuit boards that take up all available internal space, down to a tiny board which only inhabits a fraction of the interior."

Initial testing confirmed that it failed to access the disc's directory (TOC). An internal inspection, revealed that the unit was still set to test mode but was behaving more like normal mode. Interesting....

Since Zev sent along the original Sony service manual along with supplements, I at least have a starting point. Given that it seems to not want to go into test mode now, I figure I will check some basics from the service manual.

Resetting the test mode jumpers was a royal pain! This was just the start of pain. The jumpers are itty bitty solder pads, already slightly abused from Zev's previous efforts through no fault of his. I proceeded in further damaging one trace and had to add a jumper wire to bypass it.

Changing the jumpers made absolutely no difference! I double checked the soldering... Everything appeared correct.

It didn't take long to identify an anomaly: One of the adjustments is for +5.4 V. Once I located the test point, it measured only 4.1 to 4.2 V and the adjustment had no effect. Hmmmm.

From Sam:

I started to measure some test points and found that the 5.4 V was not being generated and the 5.4 V Adj. has no effect. This is produced by a charge pump running off of the servo chip - it seems that the servo chip thinks the voltage is enough but it is only 4.1 V. Reducing the input voltage results in the DC-DC converter running but never getting up to any reasonable voltage. Unfortunately, since it will not now go into test mode, operation is only for a few seconds at a time.

I checked the jumpers. You left it in service mode but I guess with the inadequate +5.4 V it behaved as though in normal mode and putting it into normal mode made no difference.

BTW, don't you love how much pain it is to go back and forth resulting in lifted pads etc. after awhile? Why couldn't Sony put in a switch or at least a single jumper?!

From Zev:

> "I did have it in test mode to repair it. When I got it running again, I put it back in normal mode. Then when it stopped playing, I remember trying to achieve test mode again, but it was stuck in normal.
>
> How about providing an external +5.4 V supply to see if that helps?

I guess you can see now why I got rid of it. I've repaired quite a few of the newer Sony Discmen, but those older ones are a real pain."

I considered the idea of testing with an external power supply but decided to use this as a last resort - I have no idea what would happen if main power were removed with the external supply still on. There could be, shall we say, unfortunate consequences with sneak paths through the chip protection diodes.

How are the various voltages generated in this thing? Quite cleverly in fact: After some careful examination of the schematics (that is, once I located the set that corresponded to the PCB revisions for this model), it appeared as though a little circuit boosted the 4.4 V source to 5.4 V. This simplified circuit is shown below:

```
                   +4.4 V in
                        o                          +---o +5.4 V out
                        |                          |
                        C                  +-------+        +----||----+
                        C L703             |       |        |          |
                        C          L704    |       \ R708   +---/\/\---+
                        |  D701    ::::    |       / 62 K   |          |
               2SD1048  +--|>|--+---^^^^---+       \        |  |\      |
                  Q704  |       |          |       | +5.4 V +--|- \    |
      |\      R706    |/ C     _|_ C705   _|_ C706 \  Adj.  |  |    >--+---o P
D o---|  >o--/\/\--+--| X-6    --- 10 uF  --- 4.7  /<----------|+ /
      |/       1K  |  |\ E      |          |  uF   \        |  |/
       IC701       /    |       |          |       | R701   /
      TC7S04  R707 \    +-------+----------+-------+ 22 K   \  (The amp is
              10 K /    |                  |       |        /   part of IC504)
                   |    |                 _|_      |        |
                   +----+                  -       +--------+
```

One of the large chips is the controller for this switching DC to DC converter. Of course, I at first suspected this many legged surface mount chip! However, I should have known better. The voltages associated with the converter were way off and the drive output to the boost circuit appeared mostly dead. This came directly from the large chip, IC504.

The regulator includes a difference amp (reference-fraction of output voltage), pulse width modulator (sawtooth clock and comparator), and a driver. I finally was able to convince myself that the amp was working since it output and feedback components are external and I could see the output change when the relative values of the two inputs were adjusted.

The leaky integrator provides the control voltage to the pulse width modulator that drives the DC-DC converter. The op amp circuit is internal to the motor driver chip, IC504). The output, P, is compared with a sawtooth derived from a clock signal. The result is the charge pump drive.

Then, I thought the driver was dead. However, upon close examination, there appeared to be an occasional burst of activity - but no corresponding change in output voltage. The inverter was the complement of the driver output. So, maybe that boost transistor circuit is not working.

Unfortunately, Q704, R706, R707, and C704 are all mounted on the underside of the circuit board - all surface mount and inaccessible from the top. Getting to the bottom is a real treat mainly because two printed cables and numerous thin wires interconnect the main logic board with the optical deck and microprocessor board (the control panel in the hinged top of the case). However, after undoing a bunch of black tape and pulling one of the printed cables, I can *just* get to the required components without needing to unsolder anything.

Tests with DMM: Resistors - A-OK, Capacitor - Not shorted.

Transistor - What have we here??? Finally something that is a bit strange: The B-C junction has a normal .682 V drop on my DMM but the B-E junction is 1.29 V? I double check. Yes, indeed, the junction seems to be bad. Joy! It is an SO23 surface mount part, barely visible let along replaceable.

Now, where can I find a replacement? It is probably just a vanilla flavored transistor - a 2N3904 would probably be fine. (In fact, I checked while writing up this Repair Brief and the 2SD1048 is a general purpose switching transistor). However, I would rather use an exact match to be sure.

Now, where can I find one? Hey, remember that smoked Sony D14 (Repair Brief #61 - Sony D14 Portable Compact Disc Player - Smoked)? I bet it has some usable body parts that were not damaged. After all, most of its circuitry was on the output side of its DC-DC converter module (but not the controller, unfortunately.

Sure enough, there are numerous similar transistors - type X-6.

I manage to mangle one of them because they are glued in addition to being soldered to the board. Finally, using a combination of my soldering iron, SoldaPullit, jeweler's screwdriver, Xacto knife, and needlenose pliers, one comes free in good condition. Confirming this with a multimeter is fun as well since it is barely possible to even hold the thing without it popping out of existence.

The broken transistor is removed more easily since it is not glued - heating the solder while prying on one side frees it.

I use a set of tweezers to position the replacement and a wooden clothes pin to hold it in place while soldering. You would have to see this setup to believe it. :-)

Now for power!

At first I thought there was no change. Did the new part blow already? But then I realized that I had been playing with the +5.4 V Adj. pot and left it where the two inputs to the op amp were just about equal - which would yield around 4.1 V even with the DC-DC converter operating properly.

And, indeed, now the +5.4 V adjustment has an effect. I would have been surprised if the player had actually started working as you will recall that the internal adjustments are probably way off. In fact, the behavior doesn't appear much changed at all. :-(

However, now, I can try some experimenting with the adjustments. I solder a wire to the RF test point for my scope.

Nothing. OK, let's see if Focus Bias (offset) does anything. Nothing. What about Focus Gain? Nothing. How about back and forth? Oops, what was that? Is that an eye pattern? Well, of sorts. Can I persuade it to stick around.

Adjust. Adjust. Adjust. Adjust. Adjust. Tweak. Tweak. Tweak. Tweak. Tweak.

Finally, it seems to be fairly stable though not the prettiest eye pattern I have ever seen. Will it play? I have been using my trusty AOL CD which really leaves something to be desired in the audio department... Of course, it isn't much use for getting on-line these day either. :-)

Sure enough, my 'Strauss Greatest Hits' disc does play - a bit noisy but recognizable. It seems to have some trouble locating and playing outer tracks so a little more tweaking is in order. A slight shift to the PLL free run frequency and it now is somewhat happier.

Someday, I will perform the proper servo alignment though I do not think any of the adjustments are far off. Nonetheless, I might as well take advantage of the luxury of having an actual service manual!

Unfortunately, another disc played with a lot of noise and it seemed to be touchy about my even going near the player! I checked to make sure the +5.4 V had not died again - nope, exactly correct. Oh, well, enough for now. Stay tuned for: "Sony D88 Portable CD Player, Part 2 - Erratic Audio Noise".

Since I did not attempt any adjustments prior to replacing the transistor, I really don't even know if the correct voltage on that +5.4 V bus really made any difference but I am not complaining. I also do not know what caused the original transistor to blow - it might fail if the drive were on for more than a few microseconds as the inductor is the only thing limiting collector current. I left if playing on repeat mode to see how robust it is.

Comments: This is a really cute CD player - not really very practical but probably one of the neater examples of solidly built Sony technology which still contains some metal in its structure!. I would be very interested in obtaining other samples of this or similar vintage CD Sony players.

Would a repair shop ever have taken the time I did to analyze the circuit and locate and replace a surface mount part? No way. Only a Sony service depot would likely get that deep into anything of this sort and then again, probably not even there.

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Repair Brief #74: Sony D88 Portable CD Player, Part 2 - Erratic Audio Noise

Patient: Sony D88 'Dual Size' portable CD players. This really cute miniature CD player was designed mostly for CD 'singles' and is only slightly larger than a 3-1/2" disc. Normal CDs hang out on 3 sides.

This is the second of the "Request for (dead) optical pickup series" of Repair Briefs and is the continuing saga of this classic Sony CD player donated by Zev Berkovich (ah392@freenet.toronto.on.ca).

Symptoms: After locating and replacing a bad SMT transistor and retweaking the servo adjustments, the player works but playback with some discs in particular is noisy at times - sometimes very noisy. Seek times are sometimes excessive. Moving near the player seems to have a significant effect as well - often to the point of killing tracking and playback entirely.

Testing: I substituted another AC adapter just to make sure it wasn't at fault. Tweaking the servo adjustments has minimal effect.

As you will recall in Repair Brief #73: Sony D88 Portable CD Player, Part 1 - Does Not Recognize Discs, this player was totally dead when given to me. Zev, the original owner, said that he had tweaked the servo adjustments and it worked for a few hours and then died. He then did some more tweaking without success.

After a feature length troubleshooting session, I was able to locate a bad surface mount transistor - part of the +5.4 V boost DC-DC converter - and replaced it. I was then able to get the player to work somewhat even if it does appear to have an attitude problem......

A few days after the initial success I decided to try another disc and was greeted with terrible noise which seemed to correlate with the disc rotation rate. What's up? The eye pattern didn't look great. In fact, come to think of it, the eye pattern looked terrible. Therefore I decided to do a little more investigation. (As it turned out, a lot more investigation - an entire afternoon's worth!).

With service manual in-hand, I checked the laser current and eye-pattern amplitude;

- Laser current was 50 mA - the sticker said 47 mA - well within the acceptable range of +5,-11 mA).

- Eye pattern amplitude was .7 V - just a tad short of the lower limit of .75 V but probably acceptable.

Since there doesn't appear to be anything wrong with the optical deck or pickup, there is no point in pursuing it. The laser power is at its correct setting (there is no adjustment in any case) based on the current measurements. The lens and its suspension appears well within normal limits. I did test the spindle motor which seems fine with no evidence of shorts or dead spots (the symptoms do not really apply to a bad spindle motor anyhow).

However, on closer examination of the eye-pattern with a better scope (350 Mhz bandwidth), its ugliness became even more apparent. In fact, there seemed to be a 100 MHz oscillation superimposed on the signal. Is this an artifact of my scope probe? I do not think so. Could the laserdiode actually be oscillating at 100 Mhz? Oh come on, that is grasping at straws.

Another interesting behavioral quirk was that the disc didn't like me! Recall that this is a strange player - 5-1/4 inch normal CDs hang over the side. If I moved my finger *near* the spinning disc, the audio becomes noisier and will cutoff entirely when close enough. This did not appear to be mechanical - I could be 1/2" away from the disc and still detect a significant change in the audio. At first I thought this was a problem with a component in the player but it was the disc - placing a strip of aluminum I was holding near the disc produced the same result! Well, after some thought, the only conclusion could be that my finger was capacitively coupling to the aluminum of the disc's information layer and *that* was capacitively coupling to the metal parts of the optical deck. Shouldn't these be connected to an analog reference point or analog ground? Of course - and there was even a hint staring me in the face - a taped unconnected wire. However, there is no mention of this in the service manual or schematic!

There is a shield which is part of the printed flex cable which carries the laserdiode power/feedback and photodiode signals and this is soldered to the metal cover plate of the optical deck. However, it wasn't connected anywhere else! At first I ignored that dangling wire and soldered it to what I thought was a suitable ground.

Wrong! That connection didn't work at all - it must have been a noisy digital or power ground. In fact, I wasted another hour tweaking the servo adjustments and then ripping the player apart once again suspecting (incorrectly) that my efforts to attach the ground wire and clean the optics while I had the unit disassembled had damaged something else! All was not well (at least as well as it was before) until I removed my original ground wire completely. The player came back to life but as expected was just as noisy and tempermental.

If I had followed Rule #45123 - never change or fix more than one thing at a time without testing, I could have saved a lot to time and aggravation.

Finally, I came to my senses and connected a wire to the proper solder pad and - presto! - the audio noise completely disappeared and the RF test point now looked like a much more respectable eye pattern - quite nice in fact.

Obviously, the sheet metal of the optical deck cover was picking up all kinds of crosstalk from the electronics - perhaps even forming a feedback loop of sorts - and totally corrupting the RF signal (and who knows what else).

A little more tweaking to optimize the amplitude and appearance of the eye pattern (With the player in the upright position and the controls accessed from underneath - joy!) as well as adjustment of the PLL free-run frequency (according to the service manual, no less!) and I do believe the player is in pretty good operating condition. Since even the service manual doesn't provide procedures for adjusting focus and tracking gain, I left these at their midpoints. This may not be optimal but seems to be quite acceptable for all the discs I tried. (Gain of these servos affect mostly the performance with dirty, scratched, and/or warped discs.)

Comments: I still do not know if the original problem with the +5.4 V would result in a totally dead player. It seems to mostly feed the audio circuits and somehow also is involved in the selection of TEST mode. Maybe someday I will tweak it back down to 4.1 V and see what happens (yeh, sure). Perhaps it would totally kill audio or simply result in screwball behavior.

This is a case where the previous attempted repair probably resulted in this entire problem - no fault of Zev's). Without a mention in the service manual or schematic, it required a visual inspection to finally identify the missing shield connection. However, this does underscore the nature of possible difficulties in servicing equipment that has been worked on by others.

I have seen erratic behavior caused be a missing shield in CDROM drives (see Repair Brief #52: Aztech CDA-268-01A CDROM Drive - Drawer Continuously Closing.) In that unit, even audio play was noisy until a circuit board metal shield cover was replaced. Thus, whenever you repair a CD player, CDROM or similar device, pay attention to the ground strap, jumper, or spring clip when you remove the optical deck!

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Repair Brief #75: Panasonic CT-714 Color TV - Dead

Patient: Old but solid state at least - Panasonic 19 inch color TV model CT-714.

Symptoms: Totally dead.

Testing: Tried different outlets, nothing.

I didn't locate the circuit breaker until much later - probably just as well. Other components may have let out their smoke if I had pushed the button.

First, I searched for any fuses. I only found one on the mainboard and it tested good.

Then, I tested resistance to ground at HOT - dead short.

Removed HOT - tests good. Still dead short at socket.

Removed red wire (whatever that it) - still shorted at socket.

In order to get at the components on the HOT socket requires removing the HV multiplier/focus block (4 screws, 3 push-on connectors - better remember where they go!) and popping the socket from the heat sink where it snaps in place.

Once this is done, I unsoldered damper and snubber - these are shorted.

Removing the capacitor shows that the damper is shorted.

I tested other power semiconductors - a transistor near the main filter capacitor tests good. A T03 package device which turned out to be an SCR (probably part of power supply regulator) tests strange G-K low in both directions; A-K, high impedance in both directions. Maybe it is good. Perhaps, there is an internal resistor that is confusing my meter.

Before proceeding, I go get the Sams' Photofact from the library.

Unfortunately, this set is at least 20 years old and the Sams' folder is on microfilm - an actual spool! (Or so I was led to believe. A later visit resulted in the hard copy magically appearing from a back room. Grrr.) This was actually not too bad as the microfilm reader had variable zoom and pan so with the assistance of the person in charge, I could get exactly what I wanted (after waiting for all those other people to copy old newspaper and other articles). The bad part was that the copies were only marginally legible but probably good enough though some identifying numbers could only be guessed.

I decide to replace the HOT and damper with a transistor that has a built in damper diode. I keep some in stock for general replacement in TVs (though I would not do this for an SVGA monitor). One nice one is a 2SD871D. The advantage of this is that if there is still a problem, I don't have to take out the tripler and socket - just pop the transistor.

I will power it using a Variac AND series light bulb and check the HOT for excess temperature rise periodically.

However, first I will leave the HOT out entirely just to make sure the front-end of the power supply works.

I connect the the Variac to the output of my isolation transformer in series with the light bulb.

At first - nothing. Series light bulb remains dark.

Then, I found the circuit breaker and pushed the reset button. There was a satisfying click. :-)

Now, my series light bulb (100 W) glows brightly (degaussing) and then nearly goes out. This is the correct behavior with almost no load (horizontal deflection not running).

Checking voltage at the regulator with my multimeter - it doesn't come on at all until the Variac is 2/3 of the way up but then stabilizes close enough to what it should be - 110 V - that I feel confident in proceeding.

I pull the plug and set about installing my replacement HOT/damper combo.

At least the main filter capacitor bleeds off in only a few seconds. Just double check - no need to discharge it.

It is somewhat difficult to get at the pins to solder in the cramped quarters between the CRT yoke/convergence board. This is one of those TVs where there are zillions of convergence adjustments which I have no intention of touching!

Finally, it is done (so I think). Snap the socket back in place, install the HOT and tighten the screws securely. No heat sink compound was apparently used - perhaps before I button it up, I will add some if it seems to be needed.

Replace the HV multiplier/focus block. Oops, where did THAT lead go. Oh, but there are two pins, now who added that second pin? :-) I was just able to make out scrape marks on one and stuck the wire there. (It seems there are two possible locations for the focus wire, for whatever reason.)

All set?

Power - slowly ramp up the Variac. Light bulb glows brightly and then settles back to still glowing somewhat brightly though not full on (which would have indicated a short). The voltage on the power supply now reads 60 V.

I am not ready to try a larger light bulb - 100 W should work.

I try disconnecting that red wire - still don't know what it is - but that makes no difference. Removing the HV multiplier/focus block also makes no difference. Could the flyback be shorted?

There is one thing - my combination of the Variac powering the isolation transformer is not what I usually use so I put the isolation transformer first.

Now, for whatever reason, at nearly full voltage, I suddenly get a burst of static and a few seconds later, just a hit of a raster and picture - about 1/2 size and rolling.

I power down and check the HOT - cool as a cucumber.

OK, what about a larger light bulb?

I find a 150 W PAR floodlight bulb.

Now, I get something much closer to normal. A little squashed top and bottom but nearly or totally full width.

Go for it!

Leaving out the light bulb but still using the Variac, a not too terrible picture appears at about 90 V or so and is fairly independent of input voltage. An antenna helps quite a bit but the picture is still pretty ugly. The vertical is squashed top and bottom and pulsating apparently along with some hum bars rolling up the screen.

I let it run for a few minutes and pull the plug.

HOT is still cool. OK, so it, at least, is happy. What about that ugly picture.

Adjusting V-height and V-linearity are not able to get it full screen top and bottom simultaneously and there is still that pulsing behavior.

Well, probably a bad capacitor.. There are only about a half dozen electrolytics in the vertical output stage. Locating part numbers is a bit of a pain with the poor quality copies but the forth one I test reads way low on my capacitor checker (part of one of my cheap Radio Shack DMMs). It is a bypass cap on the collector of the vertical output pair (yes, discrete transistors).

Jumpering a good capacitor across this returns the vertical deflection to something respectible and the adjustments now are able to completely restore normal operation of the vertical.

Then, I notice a slight double wiggle moving up the screen. No obvious hum bars but just a 1/8" or so wiggle. I check the obvious - main filter capacitor (actually after the SCR regulator) and a couple of other bypass caps in the power supply but jumpering across them with good capacitors has no noticeable effect.

There is a linear regulator (called Automatic Picture Stabilizer - APS - or something like that) after the SCR regulator. The output of the SCR regulator according to the Sams' should have about 6 V of ripple. I check it and indeed, there is about 5 V of ripple. However, there is exactly the same ripple on the *output* of the linear regulator. As a matter of fact, the output of the linear regulator measures exactly the same as the input! I thought I checked that transistor.....

Testing on the circuit board, B and C are shorted. So, either it is now bad or some other component is shorted. It didn't take long to locate the problem. A zener diode apparently there to protect against too high a voltage drop on the transistor was a dead short. At first, I was not able to identify the part from its markings but a 5.1 V 1 W zener seems to work fine and ran cool. The wiggle is gone. Ripple on the 110 V output is almost undetectable on the scope. (Later, I went back to the library and confirmed that it was supposed to be a 15 V 1 W zener - which fortunately, Radio

Shack stocks - and even a genuine Motorola part!

I was all set to return it to its owner when the next morning I noticed what could only be called an instability - for the first couple of minutes after power-on, the raster would tend to jiggle or perhaps change size and brightness erratically. After it warmed up, everything would be fine as though the TV was taunting me - "You think I am repaired. HeHeHe". I hate those sorts of problems! Not enough time to probe anything.

One reason I did not notice it before was perhaps that I had been switching power to the TV rather than using its on/off switch. This is one of those 'instant-on' TVs. The picture really does appear within 2 seconds of pulling its power knob as it keeps the CRT filaments hot at all times. Using an external power switch, of course, killed power to the filaments as well and thus the worst of the jiggling was probably gone before the picture appeared.

Only when I put the set on a Variac was I able to actually see the supply going into a low frequency oscillation (about 10 Hz) at high line voltage even after it warmed up (though it was less susceptible after warmup). And, I had actually seen some hint of it before on the scope but it went away quickly and there were no operational symptoms. Only when this added ripple really became large was there any evidence of it in the picture.

Assuming it was a bad capacitor, I systematically removed and tested each and every electrolytic in the power supply regulator. Well, it wasn't so bad - there are only half a dozen or so - except that since my photocopies of the Sams' sheets are almost illegible, it takes a little creative parts identification to find each one. Of course, it was the last one! A 1 uF, 150 V capacitor was reading between .01 and .3 uF depending on what capacitor range my meter was on. An organ donation of another dead set took care of that. Regulation stabilized throughout the relevant range of my Variac.

There is still a little bit of video noise - a slight pattern of vertical undulations - at the left side of the screen on some channels but I could spend the rest of my life checking capacitors in this thing. I suspect more are on their way out......

Comments: It could be that these four problems were totally unrelated though the zener probably failed at the time the damper shorted. Certainly, the bad capacitor in the vertical deflection just died of old age and the owner probably never noticed. If there was a cause for the failed damper diode in the first place, it could have been the bad capacitor in the power supply totally messing up the main B+ output. Perhaps, it really got out of control if the set were off for an extended period of time. In fact, the TV had not been used for about a month prior to its failure though I do not know if it died the first time it was turned on after its vacation.

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Repair Brief #76: Emerson VGA Monitor - Dead Doggy

Patient: Emerson 14" VGA Color Monitor. This was Ed's PC monitor until he was forced to 'upgrade' to a NEC 3D. It then was used on the PAL burning PC which meant that it was often forgotten and left on all day and all night.....

Symptoms: While on and unattended, this monitor started making a high pitched whine with loss of picture.

Testing: Connections to the PC were verified and a substitute monitor worked fine on the PC. This is standard DOS boot and VGA on a nothing-to-write-home-about video card so there is no issue of incompatible scan rates.

Most often, a dead monitor emitting a high pitched whine indicates a short circuit in the secondary of the power supply, horizontal output transistor, flyback transformer, or one of its secondary loads. In many cases, this would also result in failure of the SMPS chopper and/or horizontal output transistor but not always.

This monitor has a separate switching power supply connected to the mainboard via a removable cable. Although no schematics were available, measurements were made of the voltages on this connector both with the mainboard connected and removed. On average, the values were about half the unloaded values when attached to the mainboard. The whine disappeared when the mainboard was unplugged.

While this most likely indicates a fault on the main board, it could also indicate a power supply that has (very) poor regulation.

A quick check was made of all the visible semiconductors on the mainboard including the horizontal output transistor (HOT), I did not locate any shorts. One diode that was initially suspect turned out to be in parallel with a 4.7 ohm resistor as part of the HOT base drive circuit.

Without schematics, there was no way of knowing the correct voltage values. I decided to do a little reverse engineering of the primary output of the switching supply - the one connected to the feedback optoisolator. This took roughly 10 minutes and revealed that the open circuit voltages were correct. The reference was supplied by a 6.2 V zener diode and a simple transistor controlling the optoisolator - turning it on when the output voltage exceeded 120 V. While the supply could still be bad, the probability of this is small based on this new information.

Next, the flyback transformer was removed from the circuit (after verifying that the CRT anode was discharged). Using my chopper based flyback tester, no faults were found. However, since this device does not test at full voltage so a breakdown failure was still possible.

Next, the flyback was connected via a pair of wires to only the HOT collector and B+ source to guarantee that no secondary loads were the source of the failure. Behavior in this case was unchanged.

Probing the collector of the HOT with a scope showed a grossly abnormal waveform. (Note that probing of the collector of the HOT is usually to be avoided in a working monitor or TV since the flyback spikes can exceed 1 kV. However, with the reduced power supply voltages due to the fault condition, this was considered safe). The 'on' portion of the waveform starts out near ground (correct) but starts ramping up toward the end of the sweep. The 'off' time shows a great deal of ringing. It was thought that this now pointed back to a bad flyback.

The base drive signal looked fine in terms of shape and levels. With normal drive signals, the ramped up 'on' portion of the waveform indicates a flyback of greatly reduced inductance and Q permitting excessive current to flow toward the end of the sweep - no doubt due to a short or internal arc.

Although the possibility of a bad HOT is small, it was an easy thing to substitute a similar transistor. There was no change.

At this point by the process of elimination, it was thought that the flyback transformer was the only other possibility. A closer inspection - actually a closer listening - revealed that in the instant that power is applied, there is a brief snap as though something is arcing internally following by a very faint sizzle indicating a continuous internal arc. Perhaps it was wishful thinking....

On the basis of this, a new flyback transformer was ordered. With great expectations, the new flyback is installed but what is this - no change. Same low voltage, same screwy waveform - darn. :-(

What next? Well, we have not tried substituting parts around the HOT. So, one by one, the caps and damper diode are removed. Using the Variac should be safe as an indication of a major improvement should be obvious before the HOT can be destroyed by lack of the snubber caps or damper diode. There, however, does not change in behavior in the least.

Give up for a while....

OK, there is only one more major item that has not been checked - the deflection yoke. A shorted yoke is always a possibility. How to test? Well, it is on a plug - remove it, no interlocks.

Running the voltage up on the Variac - poof. Oops, too late realizing that the parts around the HOT have not been replaced. However, this is progress. If there was no problem with the yoke circuitry, there should not have been a major change in pulling the yoke. Now, there was enough flyback kick on the HOT to have blown it.

OK, rummage around for a replacement. A BU508A should be an acceptable replacement for a BU508V at least for testing.

Replace all components and solder in new HOT. Monitor B+ while running up line voltage. B+ climbs nicely through the 60 V barrier and stabilizes at 120 V. While watching both front and back of CRT - after all there is no deflection and the screen can get a permanent navel quite quickly - there is now filament power with normal brightness of the filaments. This indicates that the flyback is probably running at a normal power level. Nothing on the screen yet. Maybe the monitor has a shutdown circuit that prevents anything from showing up without a video signal. Connect PC. Still nothing. Try user brightness and contrast. Still nothing. Finally, try the flyback screen knob. Now I can get a spot indicating that there is HV. Quickly turn it back down to protect CRT.

Next: deflection yoke testing. (Actually, about a year passed.)

So, how does one test a deflection yoke?

Here is a brief tutorial:

The deflection yoke consists of the horizontal coils and vertical coils (wound on a ferrite core), and mounting structure. There may also be some additional windings on the same assembly in some designs for various functions like pincushion correction and raster rotation. The following deals only with the actual deflection coils - the others can be tested in a similar manner.

If possible, compare all measurements with a known good identical deflection yoke. Of course, if you have one, swapping is the fastest surest test of all! Note: it doesn't have to be mounted on the CRT which would disturb purity and convergence adjustments but see the caution above about drilling holes in the CRT face plate!

- Horizontal - the horizontal section consists of an even number of windings hooked up in parallel with half of the windings on each of the two ferrite core pieces. In rare instances there may be other components (like the S-correction capacitor) on the same assembly.

  The horizontal windings will be oriented with the coil's axis vertical and mounted on the inside of the yoke (against the CRT neck/funnel). It may be wound with thicker wire than that used for the vertical windings.

  - Resistance check - This may be possible without removing the yoke from the CRT if the terminal block is accessible. Disconnect the individual windings from each another and determine if the resistances are nearly equal. Check for shorts between windings and between the horizontal and vertical windings as well.

    Typical resistance of the intact windings (at the yoke connector assuming no other components): TV or NTSC/PAL monitor - a few ohms (3 ohms typical), SVGA monitor - less than an ohm (.5 ohms typical).

  - Inspection - Look for charring or other evidence of insulation breakdown due to arcing or overheating. For the horizontal windings, this will require removing the yoke from the CRT since little if any of the windings are visible from the outside. However, even then, most of the windings are hidden under layers of wire or behind the ferrite core.

  - Ring test. See the document "Testing of Flyback (LOPT) Transformers". This deals with flyback transformers but the principles are the same. Disconnecting the windings may help isolate the location of a fault. However, for windings wound on the same core, the inductive coupling will result in a short anywhere on that core reducing the Q.

- Vertical - The vertical section is usually manufactured as a pair of windings wired in parallel (or maybe in series).

  The vertical windings will be oriented with the coil's axis horizontal and wound on the outside of the yoke. The wire used for the vertical winding may be thinner than that used for the horizontal windings.

  - Resistance check - This may be possible without removing the yoke from the CRT if the terminal block is accessible. Disconnect the individual windings from each other and determine if the resistances are nearly equal. Check for shorts between windings and between the horizontal and vertical windings as well.

    Typical resistance of the intact windings (at the yoke connector assuming no other components): TV or NTSC/PAL monitor - more than 10 ohms (15 ohms typical), SVGA monitor - at least a few ohms (5 ohms typical).

  - Inspection - Look for charring or other evidence of insulation breakdown due to arcing or overheating. The accessible portions of the vertical windings are mostly visible without removing the yoke from the CRT. However, most of the windings are hidden under layers of wire or behind the ferrite core.

  - Ring test - Since the Q of the typical vertical winding is very low, a ring test may not yield much useful information.

End of Deflection Yoke Testing 101.

In the case of this Emerson, the horizontal winding is actually 4 pairs of windings in parallel. It measures about .6 ohms. I use the first approach and unsolder the individual windings at one end to measure resistance. This is easy since the terminal block is at the top of the yoke under a plastic cover which snaps off.

Almost immediately, there is indication of a major anomaly: 4 of the windings measure about 4.7 ohms but the other 4 vary from 3.3 to 3.7 ohms. OK, so there ARE some shorted turns somewhere. Now, this is progress!

Since nothing is visibly charred on the outside, I draw a diagram of the precise position and orientation of the yoke and purity/static convergence magnet assembly and remove the yoke.

Wow! That is surely the problem. In one corner, where the windings are possibly near the tube DAG coating, there is a black charred spot. It seems to involve a number of individual wires.

Can I repair it? Possibly. With a pointy jeweler's screwdriver, I was able to separate approximately 8 or 10 wires from the windings that appear to have their insulation burned off. Oops! One broke - possibly due to excess force, possibly due to prior damage. Oh well, I will have to jumper that one.

Once they were all separate, I used a Q-tip and alcohol to thoroughly clean everything in the vicinity. There did not appear to be any other damaged wires. Then, I wrapped each one with a layer of plastic electrical tape. I repaired the broken wire with a piece of bare wire and then wrapped it with electrical tape. The repair is now well insulated though I do not know how well the plastic tape will hold up to heat, if any. I may go back and replace the tape in the future if this repair turns out to be successful.

Getting the yoke and magnet assembly back in place is no problem - there was some glue originally holding the yoke to the convergence wedges and the break in this showed exactly how it should be positioned. The magnet assembly is probably close enough. In any case, these can be adjusted later.

Ready? Power!

Guess what? No whine and big bright screen - way out of focus - appears almost immediately. Well, I don't know what it should do without a signal, so I move the whole affair over to the PC on which it was on originally.

Boot the PC, then power the monitor! Same behavior. Then, it occurs to me that the focus and screen (G2) pots on the flyback were never really adjusted after the initial test of the flyback because there had never been a raster with the replacement flyback.

Sure enough, a little twiddling and there is a picture. Then some fiddling with the yoke orientation to get it straight and the convergence magnets to eliminate fringing. Ouch! What was that? A stray wire bit me... It looks like one of those windings was never reconnected. (Maybe the picture was a bit narrow..) I will fix that and try to be more careful.

For the first time in a couple of years, this monitor is working - better than new.

Comments: Had a substitute flyback transformer been available, this process could have been shortened considerably. In this case the tester should have been believed.

One nice feature of the design of this monitor (whose specs are really nothing to write home about) is that the switching supply is fairly well short circuit protected and current limited. Therefore, it is probably virtually impossible for any fault to destroy the HOT through overcurrent (though apparently not through overvoltage) or other power components on the mainboard. Even with the shorted HOT, the power supply just whined a bit but was perfectly content despite that fact that the B+ line was dragged down to 3 V.

What caused the yoke to arc? There is no way of knowing but the location at a corner suggests damaged insulation. Magnet wire insulation is very fragile to begin with so any kind of scuffing during manufacturing is a failure waiting to happen. Perhaps it was bent too far at some point and then straightened out or scraped against something. Perhaps, expansion and contraction from thermal cycling caused it to rub against the CRT. Given the characteristics of magnet wire, it is quite amazing that these types of failures are not more common.

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Repair Brief #77: Sony KV-2675R Color TV - Will Not Power Up

Patient: Really BIG fairly old 25 inch Sony console.

Symptoms: Pressing the power button results in a relay click and some evidence of high voltage (a bit of static on the screen) but no picture and only a slight hum from the speaker. Releasing the power button results in it shutting off. The standby LED is flickering.

Testing: No additional tests possible without getting inside.

When Frank asked me if I would take a look at a TV for him, I had no idea it was such a BIG TV. How will we put it up on the bench? And, for that matter, how will be hide it in the lab when those VIP types come around? After all, TV repair is not supposed to be our main occupation. (The latter problem was easily solved at least - it ended up in my office!)

Than I find out that it is Frank's landlord's TV....

This is most likely a problem in the standby power supply. Best to go get the Sams' Photofact before poking around. Checking the Sams' Technical Publishing (formerly Howard Sams') web site (http://www.samswebsite.com/, of course everything is done on the Internet nowadays even if checking the hard copy Sams' index is easier) reveals that there is no Folder for the KV-2675R. The closest is the KV-2670R. Well, that will have to do. Hopefully, the Sony engineers didn't get carried away with 'improvements' between those two models. I only photocopied the AC input/standby power supply and microcontroller pages assuming that since there were indications of HV, the deflection and signal circuits are probably fine. Hopefully.

First problem: how to get at the circuit board? Well, it isn't finding it or even the available free space around it - the cabinet is *mostly* empty space. Rather, working on the floor is just not convenient! So, Dave and I clear some bench space and man-handle this console up onto a regulation lab bench. I put some blocks underneath to prevent it from rolling off (it is on wheels). Now, it looks kind of strange but access is perfect. At least no VIPs are expected that day!

A couple of snaps, release a few cables, and the solder side of the mainboard is accessible. The components are even labeled.

Hey Dave, check the voltage on C114. "Uh, I don't see a C114". How about C115? "No, wait, yes. Around 1.5 V". It should be +5.1 V. OK, how about across C609? "Wait...... 47 V." Are you sure you are on C609? It should be 129 V. "Yep, 47 V." What is connected to it? "Just a sec.... From the plus side, D603 bar, C608, C114 plus,..." What about the minus side? "Let's see, L604, C114 minus,.." OK, that checks out. Here, I brought some caps just in case... Put this in place of C609. 10 uF, 150 V.

A couple minutes later. Ready, plug it in.

At once, there is lots of static on the screen and few seconds later, snow appears. As usual, reception even with our rabbit ears is terrible in the lab. We finally find a UHF channel that has a signal-to-noise ratio greater than about .1. A broken VCR (at least the blue screen wasn't broken) worked fine. Later, we would leave it on Channel 57 or something playing the usual afternoon cartoons.

I later tested the original C609 and found it to be totally open. Its rating was 10 uF, 250 V. A dead TV contributed one that was 10 uF, 200 V. That will have to do since Frank is leaving the country in a week (I wonder why!) to return home and there is no time for an MCM order. The maximum voltage on it should be less than about 160 V under any conditions so this should be fine.

At this point, the only remaining problem is that the TV seems to be finicky about powering on and off. Not due to any power supply problem but rather it appears to interpret the button press erratically. Suspecting contact bounce due to a dirty pushbutton switch, I had Dave swap two of the switches but this made no difference. Once it comes on, it is solid and once it goes off it is solid. Just, sometimes it will decide not to cooperate. This seems to be worse when it has been on for a while. Another capacitor?

I asked Dave to bring in a Sony remote control to see if it behaved the same way with that. I wasn't around when he did so but claimed that "it 'worked well enough for me' so I left it at that and told Frank to get the BIG TV out of the lab"! Well, at least Dave knows when to quit.

Comments: The flickering standby LED kind of guaranteed that it would be a problem with the standby power supply. Since there was some power, it had to be a simple problem like a dried up capacitor. Fortunately, this Sony was close enough to the model for which I has service data - most of the part numbers seemed to match - that finding the culprit was very easy. However, even if it had not been the case, some quick checks of the parts in the vicinity of the AC line input would have found the bad cap in short order.

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Repair Brief #78: Magnavox 31 Inch TV - Dropped and Fried

Patient: Magnavox 31" TV. This is what one would call one unlucky set. :-(First, it was used for a jungle gym by a colleague's 2 year old and fell off a low platform smack on its face (fortunately, no one was injured). About 6 months later, a truck hit a substation transformer resulting in excessive voltage on the 110 VAC lines. The resulting county wide power surge blew electronic equipment in dozens if not hundreds of residences. I am sure the insurance companies just loved it! (No claim was filed on this set, however, because it was already in bad shape - there are still some honest people in the world.)

Symptoms: Originally, colors were messed up across the screen resulting in areas of colors shifted between red, green, and blue. After the power surge, it was totally dead... I am not sure which was really the worse situation.

Testing: The front bezel was slightly cracked and there was an ominous rattle from inside. After the power surge, well....

When I first saw this disaster - the first time - the complaint was that all the colors were messed up. Once I was told the story, it was nearly certain that the cause was something mechanical - unfortunately likely to be in an inaccessible location inside the CRT.

First step: Remove back. Actually, let Tom remove the back. :-)

The only visible damage appears to be that the mainboard broke loose and is just sitting on the bottom of the cabinet. No real damage to the board itself or the circuitry.

Powering the TV reveals serious purity problems. A roughly vertical band in the middle has the correct colors which then transition in a rainbow pattern toward the upper left corner (red-green-blue). Similarly, toward the right edge, the colors transition once or twice. Not promising.

Manual degaussing does absolutely no good.

External degauss was attempted with power on to confirm that it was not a magnetization problem. Similarly, this does absolutely no good.

The yoke and purity magnet assembly seem to still be solidly locked in place and adjustment of the purity magnets has no useful effect.

The only conclusion can be that the shadow (slot) mask inside the CRT either deformed or popped loose due to the impact.

At this point, the TV was pronounced incurable and sent home to be used for video games hoping the kids wouldn't notice the weird colors or think that they were abnormal.

Six months later, a large truck hit a substation transformer. This apparently resulted in a 12,000 V feed falling across a low voltage line sending mucho excessive voltage to an unsuspecting neighborhood. It made the news in a big way.

Many many houses were affected with lots of blown stuff. Geez, if I could have driven around there for the next few weeks on trash days, I could probably have collected all sorts of late model electronics - much of it (as you will see) having easily corrected problems (as opposed to this TV).

Tom comes in one morning mentioning the power surge and I volunteer as usual. Sure, bring the stuff in (not really knowing what to expect).

So, this unlucky TV shows up again. This was a couple weeks after his toasted Panasonic VCR was brought in only requiring a new fuse.

In the case of the TV, it turned out that a fusable resistor sacrificed its life to protect the fuse. For testing, a jumper was used in its place but a proper replacement was ordered for the permanent repair. Sure enough, the set comes back to life. Unfortunately, the colors are still messed up...

There is one other possibility to at least reduce the severity of the color problem: refrigerator magnets. If a compensating magnetic field can be created, the beams might be convinced to hit the proper phosphor dots! The next day, Tom shows up with a bag of all sorts of small magnets and by the time I take a look, there are numerous warts pasted around the perimeter (as well as further back) of the CRT.

"Hey Sam, why do these magnets vibrate when they are brought near this thing on the tube"? This of course is due to the 60 Hz field current being pumped through the vertical deflection coils. The effect is very noticeable up to several inches from the yoke.

"Hey Tom, did I mention that the fat red wire here has about 25,000 V, this thing with the coils (the yoke) has 1,200 V pulses on it while the set is on, and that you probably don't want to let the TV fall over again with the picture tube all exposed like that?"

Well, Tom survived somehow.

However, poor Tom was only using a VCR's blue screen to position the magnets for a pure blue screen. What he didn't realize (and I forgot to mention) was that the geometry was being quite thoroughly messed up while the purity was being repaired. Thus, when we played an actual tape, the colors were now more or less correct but shapes were distorted. Oh well, you can't have everything. Tom will have to decide which will keep him (or his kids) happier.

Comments: On a 31 inch CRT, the shadow mask is a thin sheet of metal 2 feet across. Drop the tube on its face and it is likely to distort or pop free. This wasn't a slight bump as the bezel was cracked and the mainboard broke free. It has been suggested that in this case one should then drop the TV on its back to reverse the effects of the original fall. I don't think Tom is quite willing to try this....

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Repair Brief #79: ConairPhone Desk Phone - Almost Dead

Patient: Basic Tone/Pulse dialing 'Princess' phone clone made by Conair, Model SW-204. Don't they make blow dryers and back massagers?

Symptoms: One can just barely make out a dial tone - very faint. Buttons do seem to produce tones or pulses depending on the switch setting but these do not make it to the phone line. Side-tone does work.

Testing: Tried different cords (both base and handset), whacked and pounded it - no change.

Rich brought in both a Fisher VCR that eats tapes (boring - bad idler tire) and this cheapo phone. Well, it takes all types.... He said he was trying to determine why the phones in his house went dead and tried in the 'test' jack, wherever and whatever that might be. Then this phone stopped working everywhere else.

Indeed, plugging it into a known good phone line results in just barely being able to make out the dial-tone. Nothing else works.

I figure it is probably not worth spending a lot of time on this thing. After all, it is not what you would call valuable in any sense of the word. Check for bad connections, test semiconductors for shorts, clean the keypad. That is about it. Maybe I will get lucky. It has happened in the past.

First, the base unit. One screw to remove the cover. Not much in here. Just the bell (a real genuine gong, none of this piezo buzzer stuff). There is nothing here that is the least bit suspicious - the on-hook switch seems to be in good condition and does function even though you cannot really hear it too well.

The handset is more interesting. A bunch of transistors, diodes and rectifiers, other stuff, and a single chip.

Prodding the circuit board has no effect. Even my Magic Spit(tm) is utterly worthless - can you believe it?! No change except a couple of pops from the earpiece.

I check all transistors and diodes for shorts - none.

I remove the keypad rubber pad and check for stuck keys - none.

I was about ready to pronounce it dead-dead when a lone part on the bottom of the circuit board caught my eye. What is this? A blue diode? What sort of diode would dress up in *blue*. Checking across it reads about 50 ohms on my VOM. That doesn't sound right so I unsolder one end. Still 50 ohms. I can just make out the part number - ITT ZPD120. My ECG Guide shows this to be a 120 V 1 W zener diode.

For testing, I just leave it out since I don't expect any phone calls that might produce a ringing voltage (which is the only situation where there could be anything approaching 120 V outside of a lightning strike).

Sure enough, the phone now works perfectly.

I don't have anything like a 120 V zener in my junk box. However, a neon lamp would probably work in a pinch to protect against the ringing voltage or voltage spikes. An NE2 would have a breakdown voltage of about 90 V (and sustaining voltage of about 60 V) - close enough for now.

Later on I had second thoughts. Was that really a 120 V zener and not a 12 V zener? Unfortunately, I misplaced the bad diode on the basement floor and by the time I located it, the printing had been obliterated. Therefore, I did a little circuit tracing.

The zener was across the output of the bridge rectifier connected to the phone line. From the types of transistor (HV - 300 Vcbo sort of things) and high value resistors (100s of K ohms) I conclude that indeed the 120 V is probably correct. In fact, it would appear that a voltage divider is set up (100K/2K) such that one of the transistors would just turn on in response to the ringing voltage.

Just to be sure (well, for peace of mind - other parts would have blown if my conclusions had been incorrect), I dialed the phone from my computer line a couple of times to check that it rang correctly and didn't explode.

Comments: There is no way of knowing what caused the zener to go bad. Maybe ESD (Electro Static Discharge), maybe Rich's electrifying personality. Nah, forget that option! More likely he somehow managed to plug it into a power outlet.

The diode actually looks like an afterthought - mounted on the bottom of the circuit board across two pads with no component marking of any kind. The designers probably found out the hard way that such protection was needed!

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Repair Brief #80: Sharp 13KM15 Color TV - Dead

Patient: Nice little older 13 inch color TV. Nothing fancy but probably worth some time, effort, and (someone elses) money.

Symptoms: Dead-dead-dead.

Testing: Not a cord or outlet problem.

Actually, Dave had been talking about buying a bunch of horizontal output transistors (as in 3 just in case) from MCM Electronics for several weeks. Seems this TV blew the HOT and a fusable resistor before I saw it. Finally, we placed the order....

The day after the parts arrive, he comes in. "Well, the flyback is arcing". So I asked him if he had tried taping over the location of the arc.

One week later. "Well, I put a bunch of layers of electrical tape over the cracked area of the flyback and then it started smoking".

OK, bring it in. Without knowing whether anything else has been fried by the bad flyback, it is probably not worth investing in a flyback. If the arc got into the signal circuits, anything could be fried.

The following week, the TV shows up. Without powering it up, I open it and then connect my series light bulb AND Variac gizmo. I really was just doing this for the entertainment value (not the shows) rather than seriously fixing the set. The friend of a friend of Dave who was our 'customer' had already decided at that point not to pursue a repair since there was no assurance that a new flyback would not be just the first of a long line of replacement parts.

My plan was to confirm that the flyback was beyond redemption and strip the carcass for parts (like the still surviving replacement HOT).

Now for the action! As the voltage is brought up, the light bulb glows brightly (from the degauss circuit) and then goes dim as it should but sure enough, the set starts smoking. Some closer examination shows that the smoke is not coming from the flyback but from somewhere *under* the mainboard. What do you know!? There are a couple 1/4 watt resistors tack-soldered in place. It looks like the location where a fusable resistor would live. What the heck. I remove the resistors and put in a jumper wire. As long as I use my series light bulb, it should not be a problem. And this is just for fun anyhow!

Now, no smoke, but there is indeed arcing under the bandage (electrical tape) Dave has installed on the flyback.

Now I cannot resist the challenge. I would really like to be able to get it working well enough to confirm that the rest of the set is undamaged. Well, first step is to rip off the tape and see what is actually there. Now, when power is reapplied, it appears as though the arcing is from within the area of the focus and screen pots.

I then unsolder the flyback from the set and pull off the jerry-rigged focus connection (no solder of course!).

So, I get out my hacksaw and Vise-Grips (OK, no Vise-Grips but a rather large screwdriver used as a pry-bar. You guessed it. I cut around the periphery of the focus/screen pot cover and pry it off. Interesting low cost design. The 'pots' are just screened on resistor material. The knobs just seem to have a sort of conductive plastic or rubber for wipers. Probably good enough.

After a little cleanup, I give it another try. Now, no arcing but of course, no picture either as the CRT screen (G2) is not connected. I can solve that! Some careful positioning of the focus and screen wire ends (hanging off of the CRT neck board) in contact with the resistor material on what is left of the flyback! This should work. However, adjustments will be really tricky. :-)

Sure enough, it is now possible to power up the TV and even tune in our favorite channel 57 broadcasting the afternoon cartoons.

I must have guessed pretty close - the focus isn't too bad and the brightness is about right.

Hey Dave, the TV is working... "Uh, yeh, sure." Really. Adjustments are touchy.... BTW, what was the value of that fusable resistor. "Probably 2 or 3 ohms." Why were there a couple of 22 ohm resistors installed? No wonder they smoked! "I noticed that.....a little too high, huh?"

Of course, Ed came over to watch all of the clowns at play (but from his usual safe distance, being a 5 volt TTL type).

As it turns out, the 'customer' reconsidered and has now decided that it would be worth springing for a new flyback now that we knew nothing else is broken.

Comments: No, I would not recommend this as a permanent repair. Even taping or insulating a flyback is somewhat risky if a new breakdown path develops. Had I known exactly where the arc was located, I probably could have done less of a hatchet job on the flyback retaining use of the focus and screen pots - knobs and all. The actual path of the arc seemed to be from a corner of the cover via the surface of the rest of the flyback to the core.

It was important to confirm that nothing else had been blown by the arcing (the original HOT and missing fusable resistor had been the first casualties). Having done this, one can confidently order parts knowing what to expect.

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Repair Brief #81: Sony KV-19TR20 Color TV - No Reception

Patient: Ravi's Sony color TV.

Symptoms: No reception. A/V input works fine.

Testing: Tried with antenna and output from VCR.

There apparently was a history to this set....

Ravi came in and said "I have a Sony TV that doesn't work."

Right, so what else is new? This isn't the same one Dave and I repaired before, is it?

"No, a friend had borrowed the TV and it broke about six months ago. He attempted to repair it by replacing the IF box, whatever that is."

How did he know to do that? Did he see it on the Net?

"Uh, perhaps. Now it doesn't work at all."

OK, bring it to the lab.

Sure enough, there is nothing when using the RF input. Connecting it to a VCR's RCA jacks results in a perfect picture. So, maybe the problem wasn't the IF box or maybe the repair wasn't done correctly. I, of course, expect that the original cause were the infamous bad solder connections Sonys are known for.

It didn't take long to determine the problem - nearly every pad to the IF box had been ripped off of the circuit board!

Hey Ravi, what did he use to repair this thing? A blow torch? I have never seen a worse soldering job. It took a minute or two, but Ravi finally realized what I was talking about. Hey Dave, you have to see this....

Hopefully, the new IF box wasn't actually damaged by the attempt or by being only partially connected (mostly not connected).

It required about 20 minutes to install jumper wires to the nearest component pins on each trace. Even where there was some sort of pad remaining, I added jumpers to be sure there would be no problems in the future. I just hope this IF box doesn't develop internal bad solder connections. Whoever ends up working on it will be in for a real treat. Guess who that might be? :-)

And, presto! Reception is now perfect - at least to the extent that can be tested in our lab which is to say, at least there is now snow and the VCR's channel 3 and 4 output works fine. Ravi later told me everything else was fine as well.

Comments: One assumes that those reading the repair guides have some minimal desoldering equipment. However, this episode prompted me to add a section on the need for proper tools to both the GE/RCA and Sony FAQs.

In this case, I am sure Ravi's friend didn't get his advice from the Net as there was a problem report form from "Tom and Joe's TV Repair" or some such place (hope not anyone reading this). So, the set was probably taken in for an estimate but Ravi's friend figured he could save some money..... Too bad I don't charge for this stuff - I could have cleaned up!

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Repair Brief #82: Emerson CGA Color Monitor - Dead

Patient: Andy's friend's cast-off Emerson Model 1400EMA RGB as in CGA monitor.

Symptoms: Dead as a brick.

Testing: Tried with and without a source of video. Of course, coming up with a CGA output was a bit of a challenge but a classic Toshiba laptop came to the rescue.

So I found this thing sitting in the middle of my office floor one morning. As usual, I just stepped over it and went on with my business until the donor came around to say something.

So Andy, what is this thing??? "A friend of mine was cleaning up and was going to throw it out. Of course, I said I knew someone who would probably take it. He thought it could be fixed." How? "I don't know and I haven't tried it."

Of course, Andy is a MAC person so the last comment, at least, is not at all surprising. :-)

The monitor is indeed very dead. Getting at the mainboard proves to be quite a challenge. There are many shields. Even just being able to probe the bottom of the mainboard requires 20 minutes to remove countless screws.

No fuses blown.

B+ appears to be present on the output of something that looks like a linear regulator. It is also present at the collector of the horizontal output transistor (HOT). Nothing appears overheated. Since there is absolutely no response of any kind - no initial static or even a tweet - it is not likely in HV shutdown.

Checking at the base of the HOT, there is no drive of any kind at any time.

To determine how base drive is obtained requires tracing back from the base of the HOT. This goes to the usual driver transformer. The primary side of the driver transformer appears to go to a multilegged chip - likely a combined H/V deflection processor.

There is nothing on the pin of this chip that goes to the driver transformer but there is apparently power to the chip. The output appears stuck low. Wait... There is just a hint of a pulse at the horizontal frequency (around 15.7 kHz) free running. What about on the supply side of the driver transformer. Is the chip shorted? I unsolder the pin. Still almost nothing on either the isolated pin or the transformer. That cannot be right - that transformer pin should now be pulled high. Double check - yes, there is power to the other side of the winding.

We have an open transformer primary!

Unsoldering the transformer (4 pins) and testing out of circuit confirms an open winding. So, how could that happen? It really could only be a case of a manufacturing defect. There are no signs of overheating or other stress.

Now for the repair.....

This is a simple straight core ferrite design so it is easy to get at the windings, at least.

The primary of the transformer is wound *under* the secondary. First, I peel off the mylar insulating tape and unsolder the start of the secondary. After noting the direction of the winding, I remove the wire saving it as I will just replace it when the primary is fixed. It is only about 20 turns.

I then peel off the mylar insulating tape between the two windings.

Fortunately, the break is just about at the terminal so that it is not necessary to unwind the entire primary (which has many more turns - the ration is probably at least 4:1, perhaps much higher.)

I inspect the other connection as well but it seems fine.

After unwinding one turn (no one will ever know) I carefully resolder the wire making sure not to nick or damage it.

Then, I replace the mylar tape, secondary winding, and outer insulation.

That should be as good as new.

Sure enough, the monitor comes back to life.

Just when I thought I was done and about to button up the case, I try is once more. What is this? No vertical sweep. OK, must be a service switch inside somewhere that got knocked to the service position. Yep, after a couple of minutes of panic, I find it toward the front of the mainboard. I probably bumped it when replacing the transformer from the top of the board. No, I really did not want to disassemble this thing again.

Comments: The only possible explanation for this sort of failure is that the wire was nicked during assembly and eventually, the small but persistent vibration of the transformer at the horizontal frequency and/or thermal cycling finally caused it to break free. Considering the wire size (probably #34 at least), such damage could happen quite easily. At first I was concerned about some cause like a shorted chip resulting in overcurrent but I do not believe this was such a problem.

Although this monitor is much much simpler than modern SVGA monitors, this sort of problem could occur with either.

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Repair Brief #83: Tatung CM1495 Multisync Color Monitor - Dead

Patient: My cousin's VGA monitor. OK, actually my cousin's 3 kids' VGA monitor. OK, actually my Tatung CM1495 on loan to my cousin's 3 kids.

Symptoms: Dead-dead. Not much info. "The computer doesn't work" is about as much as was forthcoming.

Testing: No response of any kind when plugged into computer or wall outlet.

I had put this state-of-the-art 386-20MHz system together from spare parts for my cousin Kathy's three kids (ages 8, 8, 9) to use. Kathy knows next to nothing about computers though she does somehow manage to use a Mac Plus for letters and rumor has it that she has even logged onto AOL at least once from the PC.

I originally found the Tatung monitor along the curb with some cast off Atari PCs and an EGA monitor. I grabbed the monitors, too bad about the computers! Both monitors worked fine - no Repair Briefs material at that time.

About 3 months after giving them the system, I get a frantic call from the oldest: "The computer doesn't work. The screen is dark but it makes some noises like it wants to work." Did you see what happened? "No, it just wouldn't come on." OK, I will be over. Just in case (actually a sure thing), I take a spare NEC Multisync II to be used in place of the likely dead monitor.

Sure enough, not even the power light is lit. Swapping the monitors makes the kids happy and Kathy as well since she doesn't need to keep hearing their whining.... I have offered repeatedly to give them another pair of computers but there really is no room......

Getting inside this monitor isn't too bad and the power supply is a separate unit which is easily removed - 4 screws or so and 4 or 5 connectors. It will also be possible to test the supply outside of the chassis which will be convenient.

One problem appears immediately - a blown fuse on the AC input to the power supply. Testing shows a dead short. The posistor is on a separate fuse and it is fine - darn, that at least would have been easy. :-(

It takes a few minutes of unsoldering various components to discover the problem - the main switching transistor of an STK7406 switching regulator is shorted. Unsoldering that single pin restores resistance to normal.

There are actually two virtually identical sections to the power supply board. Both use similar STK parts and have their own apparently independent feedback for regulation. However, only one of these is controllable via a signal from the mainboard - this is likely the deflection B+ which must vary based on scan rate. I considered swapping the STK7406 for its mate but decided that not only was that risky but I really would be sure of what I was seeing with only one side active.

So, I at least need to order a new STK7406 but what caused it to go bad?

This is where not knowing the actual events that led to failure will always leave a lingering doubt. There are no other obvious problems. Was it left on overnight? Perhaps, without video input? Would this matter? Did it overheat? Were the kids screwing around with Windows or switching screen resolutions? (The last one I rather doubt as they have strict instructions which appear every time the PC boots not to mess with it!)

I test nearly every electrolytic capacitor on the power supply board with an ESR meter - all appear fine. No bad solder connections are in evidence. There are no other shorted semiconductors.

OK, I will order the parts and just be very careful in the initial testing.

Three weeks later......

The new STK7406 and fuse are installed. I am going to start with a Variac and 100 W light bulb to be safe. The power supply board is propped up next to the monitor with suitable insulators to prevent shorts.

Power! The light bulb comes on brightly and then dims out as it should. There are some erratic flashes on the screen at around 100 V - jumpy vertical as the scan seems to start up and die. Well, that could just be too small a light bulb.

Next, I try a 150 W PAR floodlight. Not much different. At low line voltage, bulb glows quite brightly as though there is a bad region of input voltage where excessive stress may exist. It doesn't seem to recover at normal line voltage.

I will give it one more chance before declaring there to be other problems. Now, with a 300 W light bulb, there should be no excuses! Hear that?

Sure enough, bringing up the voltage slowing results in the bulb glowing brightly at lower voltage but it recovers when full line voltage is applied and a normal raster appears. Watching the glow of the bulb is instructive as my test PC boots - it increases in brightness just a bit. Then, when switching into Windows at 800x600, the brightness increases another notch. Still just barely glowing.

I put a clip-on AC ammeter in the line circuit but this really doesn't show anything more than the light bulb. Current is well within specifications. Only a comparison with an identical monitor could truly show up any difference.

Removing the Variac and using the power switch results in no sudden increase in bulb brightness except due to the degauss coil (the first time after having been off for a while). Thus, it really doesn't like low line voltage. Could a brownout have been the original cause of the failure? How about flipping the power switch quickly off and on again?

Comments: This is a case where the failure is obvious but the cause may never be known. I am tempted to leave the light bulb in place all the time when it is used. Whether that would save the STK7406 from subsequent failure should the same conditions arise again I do not know. In the meantime, the kids are using the NEC which interestingly appears to use a very similar design as I found out when swapping a mainboard on one of these for my friend Bill. The external controls and internal construction are too alike to just be a coincidence. The Tatung is probably a reduced cost knockoff of the NEC MSII.

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Repair Brief #84: Sony Portable CD Player - Dead

Patient: Arnold's portable CD player (I don't recall the exact model but it is one of those that still would set off a metal detector). The optional battery pack is missing.

Symptoms: No response of any kind - not even the display - using the AC adapter.

Testing: The AC adapter tests fine. I even tried another one without any better success.

The first real test is to determine if the CD player will work from the battery input rather than the AC adapter. The normal battery pack is a 4 V rectangular lead-acid type.

Four volts is close enough to 5 V minus a diode drop so I connect the battery contacts to a logic supply in series with a handy diode I found sunning itself on the floor...

Sure enough, all functions are normal. Hey Arnold, it works fine with this nice 100 A power supply but it may be just a bit too heavy to carry around. :-)

So, the problem is in the power circuitry. I suspect that the AC adapter output is supposed to be converted to 4 V from which all the CD players circuits operate.

The bottom comes off after removing just a few micro-screws but this is one of the all metal super thin Sony Discmen - and impossible to access for repair.

The power input/regulator/converter is all crammed on a 1/2" x 3/4" circuit board with lots of very very tiny surface mount parts. Only the solder side is visible. Thus, the surface mount parts cannot be probed without additional disassembly. There are no obvious cold solder joints or other evidence of bad connections. The DC jack seems in good condition and checking voltages with a multimeter reveals that power is making its way onto the board. Something is faulty in the power conversion circuitry.

So, I have two choices:

1. Spend a semi-infinite amount of time riping the player apart and attempting to check microscopic surface mount components, reverse engineer the circuit, or attempt to locate a service manual or, :-)

2. Hey Arnold: do you care if the battery pack can be used at all - ever??? "No, It died after a few weeks and I

never bothered with it again. Why?" I can rig a regulator to fake out the thing into thinking it is running off battery power when it is actually running from the wall adapter. "Sure that would be fine. Whatever works."

So, I added the following regulator circuit and mounted it inside the battery compartment.

```
                D1           I +-------+ O          D2
    Vin (+) o----|>|---+-------| 7805  |-------+----|>|----o Vout (+)
              1N4007   |       +-------+       |  1N4007
                       |           | C         |
   Sony 9 V          +_|_ C1       |          _|_ C2      Battery
   adapter            --- 10       |          --- 1 uF    terminals
                     - |  uF       |           |
                       |           |           |
    Vin(-) o-----------+-----------+-----------+-----------o Vout (-)
```

An aluminum plate (a piece of roof flashing) was attached to the regulator to serve as a heat sink. D1 provides reverse polarity protection. D2 reduces the output of the 7805 by one diode drop. This produces about 4.3 V under load which is close enough to the output of a fully charged batter pack.

Wires were soldered directly to the DC jack and routed into the battery compartment. The original connections to the internal voltage converter were cut.

OK Arnold, it seems to work fine. "What do I owe you?" Only charge is that if you ever decide to dump it, send it to me. It is a nice example of Sony equipment when the Sony name meant something. "Sure."

Comments: I could have made this into a major time consuming repair or opted for a short cut. Since the battery was never used, why spend a lot of effort when a simple regulator could replace the functionality of the defective circuitry? In principle, the original wiring could be restored - and then the original problem could be remedied. For now, it works fine as far as I am aware.

Somehow I don't think I will ever see this player again as Arnold has since moved to Japan. :-)

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Repair Brief #85: Lambda LUS-8-12 Switching Supply - Fried

Patient: Surplus Lambda LUS-8-12 12 V 1 A switcher - a cute little supply that I was using to test an automotive radio/cassette when something went horribly wrong. :-((There was nothing wrong with this unit that a new belt didn't cure - boring.)

Symptoms: Fuse blew. Of course, what did I do? Put in a larger fuse! Then other stuff blew.... I just figured it blew due to the overload, not to its parts shorting out. Right. :-(

Testing: It doesn't take a series light bulb, Variac, or rocket science to now see that this is a very blown power supply with a dead short on the power line!

OK, so this was from my younger days and was the first switchmode power supply I had ever attempted to repair other than bad connections and the like. It was also the first (and hopefully, last) such supply that I blew so completely and in such a spectacular manner! (I won't mention that other one that billowed smoke from its main filter/doubler caps after blowing the switchmode power transistor due the slip of a scope probe....).

The original problem was a result of miswiring of the power inputs to the radio/cassette: a clip lead was shorting +12 to ground. No problem - these supplies are short circuit protected, right? WRONG! Or, at least, not entirely. I may have been operating it on a Variac and increasing the voltage gradually without realizing that there was no voltage across the power inputs to the radio/cassette. At some point - POW, the fuse blew with a bright flash. It was all down hill from there!

This is a really cute little cased switcher which is the only reason I spent several hours and $10 or so for parts to repair it. It was more a challenge than anything else. I may never use this supply for anything again before the Sun becomes a red giant. :-)

Known casualties in the parts department:

- Line fuse.
- Switchmode power transistor.
- Fusable resistor.
- HA17339 (LM339) quad comparator.
- 5.6 V zener diode.
- 1N4148 signal diode.
- 2SD467 transistor.

There may have been others - I lost count.

I suspect that only a couple of parts blew at first but the rest of the components let out their smoke when powering up for the second time. There is no way to know for sure at this point and I am not about to recreate the disaster!

All the fried discrete semiconductors were dead shorts so it just was a matter of checking each with a multimeter. The HA17339 wasn't totally shorted but had a low resistance on its power-ground pins so I guessed that it, too, was bad.

I traced out the entire circuit which wasn't fun or quick. It took a while to determine that the HA17339 was just a common LM339 clone - Internet search engines didn't exist back then.

I replaced the HA17339 with an LM339 in a socket. Removing the original part wasn't easy even with my SoldaPullit - I damaged a couple of pads which needed to be jumpered.

For testing, I substituted a BU406 which I had handy from a long stripped video display terminal.

Using a Variac (no light bulb at that time), the supply came up properly and ran without smoking. I then installed the proper transistor. Next power-up it worked fine but when I removed the Variac and plugged it directly into the wall, it was lifeless again. I feared the worst but as it turned out, only an underrated resistor had opened (the fusable resistor I had temporarily replaced with a 1/4 watt film type). After installed the proper resistor, it seemed happy as before. I just will now know not to attempt to drive short circuits!

Comments: This was my first exposure to SMPS repair and also to 2S part numbers. When I first ordered the 2SD467 it was a guess - that the part in the MCM catalog was really what I wanted. Well, everything has to have a first time. If this weren't such a cute little supply - and I wasn't to angry at myself for blowing it up, the time and effort would not have been justified. In fact, it was relegated to the scrap bin until I saw the light with respect to parts identification.

Many SMPS designs are robust only near full line voltage. At lower voltage, the pulse width modulator struggles to achieve regulation and succeeds or kills everything unless the designers specifically took these conditions into account and provided appropriate current limiting. Just claiming that a supply is short circuit or overload protected is not enough. This is one reason brown-outs can be hard on equipment.

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Repair Brief #86: Fisher Power Amp with Blown Channel

Patient: Derek's friend's Fisher component 80 W/channel power amp. It looked kind of nice with those LED power meters. No comments about Fisher quality, please. :-)

Symptoms: The right channel is stone dead. No hum, no noise - not a thing.

Testing: Double checked inputs and tried several, whacked it (to wake up any speaker relay) or bad connections, switched input selector back and forth. No effect of any kind.

With absolutely no hum or noise on the dead channel, the problem is probably not in the input circuitry or preamps. There would be some evidence of life in those cases - some low level hiss at least.

The nice thing about stereo equipment is that there are two of nearly everything. Thus, comparing signals, voltages, and resistances can be effective even without a schematic.

Unfortunately, these assumptions led me astray......

Big audio amps are often designed along the lines of power operational amplifiers. They have several voltage gain stages and a final power/current gain output driver - with negative feedback around the entire thing. One implication of such a design is that intermediate signals may look strange even when the unit is operating properly.

In this case, the intermediate signals on the good channel looked like hum and noise while the similar signals on the dead channel appeared to be normal audio.

Among the problems found were bad solder connections on the pre-driver transistors due to their running hot (no heat sinks) but repairing these had no effect on the original problem.

Fuses were all good. Checks of major power rails showed them to be healthy.

Finally, I was convinced that the most expedient approach would be to swap the finals - STK0080 hybrids. There is always a slight chance that swapping power components can blow the previously good part but since everything else appeared normal, what the heck. They are only 10 pin devices and less than $20 in any case.

Five minutes later, sure enough, the right channel seemed to be working normally and the left channel - was, well, missing a hybrid!

However, now there appeared to be some noise and erratic behavior when powering up. One or both channels would not come on as soon as the speaker protection relay clicked but at some random time later. The input signal source selectors did not appear to have any effect on the noise but tapping the relay revealed that it was at fault. Fortunately, the top poped off easily and some contact cleaner and burnishing restored it to health at least temporarily.

Comments: As noted, most stereo equipment has a distinct advantage when troubleshooting in having duplicates of nearly everything but the power supplies. Therefore, it is pretty easy to locate obvious shorted discrete parts by simple comparison measurements. Even testing of the hybrid modules may have been possible in this way though I did not think to try. However, with a design depending on a closed high gain feedback loop around nearly the entire system, actually looking at signals can be misleading unless you are aware of the possible implications of what is being observed. In this case, the power supply rails had substantial hum (normal) and signal points did not have anything resembling a signal on the working channel - rather it was just low level noise and hum. Buried in there somewhere was the actual signal. The similar test points on the bad channel had a reasonable audio waveform because without proper feedback they were operating at a much higher level than was normal. It was probably highly distorted but was more recognizable as an audio signal.

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Repair Brief #87: Mac Plus and Original Apple 20 MB Hard Drive - Multiple Problems

Patient: Garage sale Mac Plus with original Apple HD20 (non-SCSI). It was marked $50 but before I could make an offer, the price somehow dropped to $25. OK. No keyboard or mouse, however. Well, can't have everything. At least with a Mac, basic functionality can be determined without any user input devices!

Symptoms: Powering without keyboard or mouse seems to result in attempt to boot from diskette which is stuck in the internal drive. However, without a keyboard or mouse, it is not possible to attempt to eject from software. The paper clip in the eject hole doesn't work either - it is jammed. The hard drive does not spin up.

Testing: I borrow a mouse and determine that the computer itself seems ok except for the uncooperative diskette drive. The hard drive remains dead.

This poor little Mac was sitting by itself along the side of the driveway at this garage sale that also had other interesting items but the Mac seemed almost useful. I probably would have gone higher than $25 but wasn't about to argue. (Recently I picked up a Mac Classic at a flea market for $5 but that is another Repair Brief!) They did say the hard drive probably didn't work either....

In fact, it came in handy when my cousin was given a Mac Plus system with a dead flyback. A flyback transplant confirmed that nothing else was broken and got her up and running nearly instantly. :-)

First step is to see what is wrong with the diskette drive.

Of course, opening any of the single piece Macs is always a joy unless you have the proper foot-long Torx (or hex) wrench to get at the two screws under the handle. I did not and so was forced to improvise. I ground down the end of a triangular metal file to a shape approximately a Torx. As they say "If it works, use it." And, no, you don't need an Apple approved 'case splitting tool' to get the back off. With care, a pair of wide flat blade screwdrivers work fine without damaging anything.

With the cover removed, it is a simple matter to remove the diskette drive. A close examination reveals that a little bracket that is part of the eject mechanism was somehow bent out of shape - short work for my needlenose. The grease - a common problem with older Mac diskette drives - appears to be in as good as new.

It doesn't appear to be defective or weakened in any way. My guess is that someone attempted to pull a diskette out of the slot by using a pair of pliers rather than the paper clip or software. I cycle it a few times using the slightly abused but still serviceable diskette and a paper clip - as good as new!

After replacing the diskette drive I confirm that it will boot with a known good system disk. It even ejects on command. What more can you ask?

Next, the hard drive. There seems to be no sign of life from this. The power switch does nothing as far as I can tell. Possibly the ready light flashes on momentarily, but that is about it. No spinup sounds at all.

After removing the cover it is necessary to blow out several years worth of accumulated dust before checking anything electronic. The controller and drive itself do appear to be receiving power - the chips get warm at least. :-)

Could it be sticktion? This system probably has not been used in a quite some time. Fortunately, this is one of those drives ('some user serviceable parts") where the spindle motor flywheel/magnet is readily accessible once the drive is removed from its mounting.

The flywheel is quite stiff. Actually, this is probably not actual sticktion where the heads glue themselves to the platters but just dried hardened grease. I spin the flywheel back and forth a few times by hand. This seems to loosen it up considerably. I then reinstall the drive on its mounts.

Sure enough, it now spins right up and the Mac even boots - slowly but what do you expect? - revealing some useful word processing programs, tons of games, and a database of horticultural information. Not bad for an hour's work.

I can hear you all saying: "Joy, a computer with the power of my digital watch and the features of a boat anchor!".

Sure, but (1) this was a few years ago and (2) this became the one of the Macs for my cousin's three kids (who now have a state-of-the-art 386-20 as well)! I still have the hard drive but really don't know the location of the system unit as we have played musical chairs with the Macs several times at this point (but I would have heard if it stopped working).

Comments: Whether you like Macs or not, one cannot deny that the Mac Plus was a cute little computer that could do useful work and had a user interface that surpassed anything from Bill Gates at the time - perhaps even today. Most of the time, problems with these computers were easily diagnosed and easily repaired - burnt Molex connector pins and blown flybacks are two popular failures.

I have not had a reoccurrence of either the diskette or hard drive problem despite it not being used all that much but I guess 'not all that much' beats 'not at all' by a wide margin.

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Repair Brief #88: HP DeskJet 500C Color Ink-Jet printer - No Printing

Patient: Color version of my HP DeskJet Professional. This is an older but nice little printer. The separate black and color cartridges make it much more convenient than some of the newer models.

Symptoms: Goes through all the motions but nothing appears on the paper. Cleaning/priming doesn't help. Both cartridges are not likely empty!

Testing: I use the built-in test initiated by holding down the FONT button while powering up. Nothing on the paper.

So Joe comes by and mentions that this printer has been acting up for several months now. This is on his son's computer so I imagine Joe is not that eager to have it working properly - considering the high cost of color cartridges.

He did tell me that he called some place and got a flat quote of $140 to repair it excluding any needed cartridges.

"OK, drop it off but I don't know when I will get to it."

The printer shows up a few days later - no scrap paper to test it with. At least he provided the power pack!

Fresh from my experience with my DeskJet, it takes about 30 milliseconds to locate one problem: the rubber boot that seals the priming station is nowhere to be found. I am not at all surprised that printing is erratic without this. Priming would be useless without the suction seal. Now, I wonder where it went.....

As with the original DeskJet, the top pops off after releasing 4 catches near the corners. Ah ha! There it is... Shading itself on the mainboard! Did some overzealous manual cleaning cause it to pop free? Nah, I doubt anyone in that house would realize that such things need cleaning. It may have just popped off from one of the automatic cleaning cycles - it does seem a bit lose. However, in all my subsequent activities, it stays put just fine.

I clean the contacts on the cartridges and the ribbon cable as well.

Since this hasn't worked for a few months, I clean the cartridges by hand just to be sure - some warm water, patted dry with lint free paper towels. A little blowing in the vent hole on top of the black cartridge, no vent holes visible on the color cartridge.

Ready?

Sure enough, the basic test patterns come right up. Only a couple of nozzles not firing. More cleaning, blowing, priming. OK, now B/W seems to be fine but there is only a hint of color - maybe yellow.

Even when executing the ALIGN command, almost no color (magenta) shows up.

I try more washing of the color cartridge. Now, there is a hint of the magenta alignment marks but they are spread from here to kingdom-come. In other words, a vertical line prints as a scatter diagram of dots!

I try some cleaning cycles. These prime the cartridge and then should print stripes of each color. At first, only yellow shows up. After 4 or 5 attempts, there is some evidence of cyan (blue) and magenta (red) appearing at the start of each line but they then tend to die away.

OK, that could just be an empty cartridge. Yellow seems to be fine and there really isn't anything different about it. (This is not surprising as yellow is the least used color.)

So I call Joe: "You know how they were going to charge you $140 to service the printer (hint hint - never works with him! Maybe if I didn't make it sound so easy....), well it appears to just be that a rubber part popped loose and the color cartridge appears dead." You mean it prints in black? "Yep, as good as new."

Two hours later, a new color cartridge shows up.

And, sure enough, this works just fine out of the box.

I recommend that he obtain replacements for the two rubber boots, at least, as they do seem to be on their way out.

Comments: Once again, a simple cause with dramatic consequences. I am still amazed that ink-jet technology works at all given the simplicity of these printers. Of course, that simplicity masks some very sophisticated and precision technology that goes into the cartridge/nozzle construction and controlling firmware.

Nothing serious ever seems to go wrong with these older DeskJets. Now all I need to do is locate a parts source for the plastic guide bar that broke in the DJ855C at the office!

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Repair Brief #89: Craftsman Eager 1 Lawn Mower - Rod Disaster

Patient: Garage sale Craftsman Eager 1 - 4 HP, 22 inch, self propelled, electric start. $10. Seems to have had some hard use but not bad, I was thinking.

Symptoms: Although there is plenty of gas in the fuel tank, it will not start and shows no signs of even wanting to start.

Testing: Doesn't start at all - no way, no how. There is no sign of even a weak attempt at turning over.

The seller mentioned that all it needed was to have the carburetor cleaned. This made sense though I wouldn't have trusted him as far as I could throw him. :-)

After yanking on the starter cord for a while, I removed the spark plug - dry as a bone. Squirting a couple teaspoons of gas in through the spark plug hole, replace the plug, then crank - and it will sputter to life and run for a couple of seconds. So, the carburetor is a good bet.

Removing the float carburetor on a Craftsman engine is a simple matter - two screws, the fuel hose, and the throttle/governor linkage.

Before taking it inside, I unscrew the bolt at the bottom and drain the remaining gas in the float bowl.

On the bench (actually, on top of a wad of newspapers on top of the washing machine), I disassemble the carb. What a mess! This must be 10 seasons of neglect - icky disgusting green caked on muck. After removing the rubber gasket (as it may be damaged by harsh solvents), liberal use of carburetor cleaner and a roll of paper towels are able to remove most of the build-up. I recall that there are critical holes - orifices - in that bolt. Using some wooden tooth picks, I am able to clear it down to the shiny brass.

There, that should do it.

Reassembly is straightforward - or should be. Now, which hole did that throttle governor wire go into???? Well, that one looks correct but I wonder...

Tighten the screws, replace the fuel hose. Ready?

Wow, that started right up. Might it be running a little fast?

A quick check of the oil. Maybe a bit low. Let me test the mower a bit. Then I can change the oil and check out the air filter, spark plug, etc.

So I mow the back yard. This is a self propelled but the drive engage-lever doesn't seem to stay in the selected slot. Well, something else to take care of later.

Is it running fast??? Even on slow speed, it sounds more like my other mowers on fast. Try fast. That isn't right - sounds more like a 2-stroke. Back to slow.

Bang! Ding! Clunk! Arggggg! Ever get that sinking feeling? Well, I got it.

Something bad happened. Or, as Luke Skywalker liked to say in Star Wars "I have a really bad feeling about this." Or was it C3PO. Well, no matter.

After checking for something under the deck (I didn't really expect to find anything), I had to come to the conclusion that there was a major mechanical failure inside. :-(

That is when I took a closer look at the oil level. Dang - it was much worse than I thought at first. In fact, one could say that all that was left really was the sludge! Geez, what a disaster.

Without even moving it from the spot on the lawn where it died, I start to do the disassembly (or perhaps, autopsy would a more accurate term).

Off comes the cylinder head. Rotating the blade or flywheel no results in no movement of the piston and it is not possible turn it through a complete revolution. I never did find one of the head bolts amongst the weeds....

Unbolting the engine and taking it into the basement:

Off comes the blade. As expected, the blade shear key is broken. Later I discovered that the flywheel shear key was also - sheared.

To remove the front wheel drive pulley requires some careful filing of the burrs on the keyway slot. This will also prevent damage the main bearings when the crankcase (sump) cover is removed. At least I as thinking rationally enough to take these precautions.

Unbolting the cover and a little tapping - darn, the gasket tore. Oh well, it probably would need to be replaced anyhow.

The extent of the damage is now clearly evident (amid the icky disgusting dripping black sludge). Maybe more newspapers would be nice.

The connecting rod is partially broken off from the cap. One bolt is still hanging loosely but the other bolt is laying in the bottom of the crankcase. There is a chunk of the rod laying there as well and a big ding has been taken out of the soft aluminum of the crankcase when the broken end impacted (but that is just cosmetic damage).

Arggggg. This won't be cheap.

Was it lack of oil? Was it the apparent overspeeding? Was it both?

Close examination of the broken parts reveals:

- There was some overheating - there are brown deposits on the rod and cap in the vicinity of the crank bearing.
- The bolt that was sitting by itself had backed out on its own and just dropped off - the threads and hole where it mounted were undamaged. It was not ripped out.
- Without the second bolt, the constant pounding of crankshaft/piston actually distorted the cap until it mashed

into the crankcase and broke into three pieces.

- There is scoring on the crank pin but it does not appear to have been caused by the current problems but would seem to be a result of normal wear and neglect. There is no evidence of overheating (blue tinge, etc.).

So, I tried Sears for a replacement. Unfortunately (or perhaps, fortunately, as we will see), I didn't have the 27 digit engine number so I couldn't get the time of day let alone an estimate of what a new rod and cap would cost.

Probably about $25 was the closest they would come. Though, I wasn't exactly sure they even knew what a connecting rod was! Fan belts was more their speed.

Well, I am not going to spend $25 on a $10 lawn mower.

I also tried a lawn mower repair shop. They were even worse (still would't give me the time of day) but quoted $45 anyhow.

That evening I emailed to a fellow Netter among other things that I was thinking of writing a lawn mower FAQ (not actually describing the disaster of the afternoon).

> "Speak of the devil.... I swapped cranks in an 'Eager-1' (Craftsman) mower this weekend for a friend. His wife ran into the curb and, well, the shaft was about 9 degrees bent. :-/ He picked up another mower that was 'stripped' but the crank was there... So, it was pretty simple actually. Started the first pull too. :-)"

Hey, where did you get the replacement? What did you do with the rest of the carcass? You wouldn't happen to have a connecting rod by any chance???

> "I'll check. Does it have a slant gate or a perpendicular to rod? I ask because there are two types, the straight and the slant type."

Thanks. It is the slanty type. Here are the dimensions....

> "I got the piston+rod for you. The part # is 25-0-25 (rod), 30-0-?4 (cap), 5-0-66 (piston, includes shaft but not clips, sue me. :-) It's the slant-gate one. Let me know if the numbers jive..."

Perfect. The '?' in the 30-0-?4 even matches. The piston isn't the same but my piston is fine (send the piston along anyhow, though, you never know when these things will come in handy.

Well, that wasn't so bad. The price was right - just shipping.

The parts that arrived were in perfect condition!

Hey, how many hours on that mower?

> "Only about 25 hours before the incident with the curb. :-("

I did some rough measurements of clearances using the new rod+cap on my beat up old crankshaft. The crank pin clearance is marginal (large) but no way I am going to hunt down a new crankshaft. It will have to do.

In order to assure that no metal chips are hanging around anywhere, I completely strip my engine, wipe down the inside of the crankcase, and blow out the oil passages, etc.

Everything goes smoothly until I realize that I didn't make note of which way the piston goes (there is a right way and a wrong way) but the Chilten small engine manual comes to the rescue. (Pistons are not symmetric - the piston pin is slightly off-center to account for the direction of crankshaft rotation and the direction and center of force. If it is installed the wrong way, at the very least, there will be excessive piston slap; at worst, parts will just bind outright.

Tightening the rod bolts - the most critical as far as proper torque is concerned - is always fun. It is just possible to get my torque wrench with a 3/8" to 1/4" adapter and a 1/4" socket in place into the confines of the crankcase with the crankshaft in one particular position and alternately tighten the bolts to specification.

All the other parts go together easily. I obtained new gaskets (actually bought them at that lawn mower repair shop) but reuse the old head gasket until I am sure everything inside is fine. Later, I will install a new one.

Timing is obvious since there are marks on both the crankshaft and cam gear.

To assure that the oil pump passages are clear and the pump is working before total reassembly, I add a little oil to the sump, remove the test port screw, and frantically crank the engine with no spark plug installed. After what seemed like the 199th or 200th pull, I realized the darn thing had electric start. Plug it in, push the button, oil starts trickling out of the hole almost immediately. I then replace the screw and then tighten the sump bolts.

I also repair the front wheel drive shifter while I am at it - mostly some careful rebending of the sheet metal but getting to it meant drilling out some rivets and that was not fun.

I replace the carburetor now actually comparing it to one of my other mowers (what a concept) to determine which hole the governor linkage goes in. What do you know, it was the OTHER hole. :-(

Total damage: Broken rod and cap, broken blade shear key, broken flywheel shear key, gasket set, bruised ego.

Finally, I top off the oil.

Now for the test: Not too shabby. It started on the second pull. It seems to run fine (now at a more normal speed) without any excessive vibration or noise. Only time will tell.

Comments: Whether it is a lawn mower or an automobile engine, oil is its life blood. That is why even if you don't do any sort of maintenance on your car, at least you should check the oil periodically and head the oil idiot light should it even come on - pull over, stop the engine, get a tow. Running without oil for a couple of minutes can ruin the engine. Ever seen that TV ad where they drain the oil and then run a bunch of engines till they seize? And, no, synthetic super-duper oil won't save you.

This whole episode was likely preventable if I had actually taken the time to check the oil and had realized that the overspeeding was a danger sign.

How long will it run? I don't know. If it weren't for that clearance on the crank pin, it would be as good as new.

In the end, there was some benefit to this whole affair. It was the stimulus to write Notes on the Troubleshooting and Repair of Small Gasoline Engines and Rotary Lawn Mowers.

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Repair Brief #90: Harman-Kardon Model 520 Stereo Receiver - Multiple Problems

Patient: Our first stereo receiver - Harman Kardon model 520.

Symptoms: Burnt out Stereo Beacon(tm), noisy left channel, weak right channel, tuner stuck on one station, intermittent stereo reception, erratic controls (not all at the same time).

Testing: Where applicable, checked multiple audio sources or stations.

This receiver is from the days when one could buy stereo equipment at record stores (yes, records, vinyl, remember those?). Yes, it is solid state. :-)

Fortunately, Harman Kardon 25 years ago was willing to sell service manuals. I do not know what their policy is today. And, even in 1970 dollars, it was cheap - $3 including postage!

This series of problems occurred over the course of 25 years or so - it isn't as though the whole thing turned to you-know-what one day. :-)

Problem 1: Stereo Beacon(tm) doesn't work.

This one is easy - the usual underrated incandescent lamp has bit the dust. Rather than replacing it with (1) an overpriced part from Harmen Karden that will (2) burn out in a couple of years, I locate a bright LED and 220 ohm resistor. Since this actually runs on DC of about 5 volts from the stereo detection logic, no additional components are needed. The LED will last well into the next century.

Problem 2: Noise on FM only, left channel.

This took a bit little more work. Since only one channel is affected but no other audio sources, this limits the possibilities greatly. It cannot be in the tuner itself nor in anything common to Aux/Phono/Tape inputs. However, it appears as though there is a clump of circuitry unique to FM mode just beyond the tuner. It is apparently an amplifier between the tuner and the source select switch. Why would they need an additional amp? I have no idea but in any case, it is only 4 or 5 components for each channel. The active element, a transistor marked with an HK house number, seems to be sensitive to vibration. At that time, I was more conservative than I am today (and didn't have an ECG cross reference book either) so I actually ordered the exact replacement. Can you believe it? Problem solved.

Several years later, a similar problem developed with the other channel (or maybe it was the same channel - faulty replacement) and guess what? I just threw in a 2N4401 or something like that. Indeed, it sounds every bit as good!

Problem 3: Weak right channel.

This one developed over the course of several months and affected all audio sources but not the Tape Out suggesting a fault in the power amp. The fact that it didn't happen suddenly meant it was probably something like a dried up electrolytic capacitor. Since there were only a few of these in each channel, I simply jumpered across each with a known good cap until the problem went away. (Actually, I picked the big ugly one first - which happened to be the culprit!)

Problem 4: Tuner stuck on unknown station.

While just about to settle into the Evening Concert, what happens? Reception of my classical station is lost and some rock station replaced it. In fact, the tuning knob had no effect whatsoever.

My initial thought was that the tuner was hosed which would be bad news since I really don't like troubleshooting tuners! The service manual does include actual tuner schematics. Since other audio sources work just fine, this would point to the FM tuner.

However, first things first: check power supply voltages. It turns out there is one that is unique to the FM tuner. And sure enough, what should be 10 V reads 0 V!

Well, this isn't anything fancy: resistor->10 V zener->capacitor filter. The zener is a dead short. The resistor doesn't look so healthy either. In fact, while it tests within tolerance, it would appear to have seen better days being somewhat discolored. There are signs of long term overheating on the circuit board as well.

Since nothing else really seems faulty, I replace the zener and resistor with ones rated at twice the power just to be safe. Like the Stereo Beacon(tm) light bulb, these appear to be somewhat underrated as well. I wonder how many cents they saved!

Problem 5: Intermittent stereo.

At first I thought the station I was listening to was not broadcasting in stereo for some reason but after checking a few others dial locations, it would seem that the stereo selection circuitry in the receiver wasn't working. However, prodding and pressing of components on the MPX circuit board resulted in the stereo coming back and staying there. As best as I can determine, this turned out to be a polystyrene capacitor with an intermittent internal connection. Pulling on this component only resulted in restoring correct operation the next time the stereo dropped out.

Problem 6: Erratic volume, mode, speaker select, etc.

Another easy one: contact/control cleaner in the various pots and switches.

Comments: If you get the idea, this receiver has been a problem, you would actually be wrong. It dates to 1965 and has been in continuous daily use since then with no plans for early retirement. While not trouble free, name something you could buy today that would have a 30+ year service life with so few problems and no major failures? My total cost of maintenance over the years has totaled less than $10.

Yes, new audio equipment tends to have control panels that would look more at home in the cockpit of a 777 but that really doesn't make the music sound any better. This receiver is a case study in simplicity and I would be happy to have something modern which is as easy to use and maintain. Speaking of which, my Yamaha R8 now has a case of amnesia - forgetting its settings when powered off. Probably a bad SuperCap but that is for another Repair Brief!

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Repair Brief #91: Multifunction Desk Phone - Erratic Operation

Patient: ExecuFone(tm) multifunction desk phone - 20 button memory, clock with alarm and timer, speaker phone, etc.

Symptoms: Pickup of handset results in static rather than a dial tone. Repeated attempts may result in dial tone eventually.

Testing: Tried replacing cords and using different phone jack - no change.

This rather nice full featured phone was given to me by the original owner in working condition - this wasn't a problem originally. (The owner, a typical CEO type, isn't happy if his toys are more than 6 months old. OK, he probably didn't actually pay for it either). However, the erratic behavior developed over a period of a few months (a couple of years later) to the point of the phone not being usable.

No doubt a bad connections problem somewhere but where?

Internally, there are several small relays as well as leaf/microswitches for on/off hook. It didn't take long to determine that one of these microswitches was at fault.

Under the lever operated by the handset is a bank of 3 separate microswitches. Two of them seem to be fine but the other would appear to have burnt contacts.

In an ideal world, I would hunt up a replacement - and of course there would be a service bulletin on a modification to prevent the same problem from reoccurring - but this was not to be.

Instead, I carefully unsoldered a pair of the microswitches from the circuit board and popped the top off of the bad one. After cleaning the contacts as best as I could, I replaced the original switches swapped in position. (Unfortunately, I also ripped a couple of pads off with the switches so this complicated the reassembly slightly.)

This did restore operation for a couple of years. I knew I shouldn't have passed up the same model phone at that garage sale! It would have yielded two good microswitches - no doubt the reason it was being sold was this same problem.

I still use the phone for its autodialer and clock but have another (ATT) phone on the same line to grab the dial tone! :-)

On a separate note, interestingly, the phone's instruction manual recommends replacing the NiCd battery pack used for memory and clock backup every two years. That same battery pack has been just fine for the last 13 years!

Comments: This isn't rocket science but how many phones are cluttering up land fills due to just these sort of simple problems? In this case, it is almost certainly a design fault - there is nothing funny about my phone lines. Since the problem didn't occur suddenly, it is also not due to a lightning strike or other one time event. Just, gradual deterioration of an underrated set of switch contacts.

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Repair Brief #92: Aiwa Boombox - Dropped

Patient: Slightly battle worn Aiwa Sports AM/FM/Cassette boombox. Well, it doesn't appear very 'sporty' but I suppose styles change...

Symptoms: The cat did it! Fell off window sill. The cassette works fine but there is absolutely no sign of life from either band of the radio.

Testing: Sure enough, not even a peep (or meow) out of the radio on AM or FM.

Jeff comes by my office: "Wanna fix a boombox." This isn't that Aiwa disaster is it? (Repair Brief #65: Aiwa CSD-707 Boombox CD Player - Doesn't Recognize CDs). "No, this is mine. Fell off a window sill. The radio doesn't work." OK, sure bring it by.....

So, a couple weeks later, Jeff walks in with this vintage boombox. You really want to fix that thing? It is also an Aiwa, but probably at least 15 years old. "Yep, I opened it up but didn't see anything wrong." Sure Jeff, open it up again. "A couple of the screws are missing and one of the plastic post thingies broke off in the fall." Right.....

At first, there didn't appear to be anything obviously broken so I decide to power it up (after all, Jeff had already done this so the additional risk is minimal). Fortunately, it can be powered easily with the two halves of the case separated.

Sure enough, the radio is dead as a brick. Pressing and prodding produces absolutely no change.

Then I notice something... Uh oh, it looks like the corner of this circuit board is cracked off. OK Jeff, you will have to remove it and it doesn't look like fun as the dial cord seems to run from the main case to the variable capacitor pulley on the circuit board. Better make a detailed diagram of exactly the way this is run so that we can replace the string if it pops loose. "Yeh, sure."

I come back 5 minutes later to find the board removed. "No problem, the dial cord didn't need to be disturbed." Chalk one up for Aiwa - intelligent design. It turns out that the pulley engages a keyed shaft so the string and all the other dial cord stuff remains in place.

With the board removed, the extent of the damage is evident - not really that bad, just two traces that run around the corner of the board. These are easily jumpered from wider expanses of copper near their destinations.

Then, Jeff notices that the other corner is also broken - another pair of traces, possibly extensions of the same ones.

Inspecting the remaining two corners indicates that these survived intact.

Power! Sure enough, the radio now appears to work fine.

Jeff, close it up.

"Sure boss. :-)"

Five minutes later: "I even managed to anchor one of those corners with a the broken piece so that at least 3 of the corners are attached AND I won't let the cat near it again!"

Comments: It could have been much worse - many fine traces run really close to the corners but they were spared. A better mounting arrangement to reduce stress on the circuit board could have been designed (either by Aiwa or for the repair) but these things are only supposed to be subject to reasonable bumps - not total abuse.

I don't know about Jeff. A while ago, there was another boombox - or maybe a clock radio - that had been dropped with similar consequences.....

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Repair Brief #93: Kenmore Microwave - No Heat and Dead Buttons on Touchpad

Patient: Mid size Kenmore microwave. 'Customer' just said it doesn't work and is willing to pay 'whatever it takes'. Really must like it - nothing special.

Symptoms: About half the buttons on the touchpad are dead and even when it is started, there are normal sounds but no heat.

Testing: Not much more can be done without removing the cover.

As usual, the cover comes off easily. It is somewhat gunked up from lack of cleaning but not excessively so. There is a schematic of the microwave generator but as expected, not of the controller.

Since the unit is not totally dead, the main fuse must be ok.

A quick examination of the power circuitry reveals the likely cause of the no-heat problem: a deteriorated lug and terminal on the filament of the magnetron. This likely occurred over time as a slight resistance due to corrosion or the lug just being a little loose resulted in heating and eventual failure.

Rather than attempting to install another FastOn(tm) type lug, I elect to drill a hole in the tab on the magnetron itself and then use a ring lug, nut, and bolt, to attach the wire. There is ample metal for this and once filed clean, it results in a secure connection to a magnetron that would otherwise require replacement.

I inspect the other connections to the magnetron and high voltage transformer (secondary and primary sides) but they appear to be fine.

A quick test with a cup of water shows that the microwave generator is now functional.

To prevent accidental operation of the HV circuits while testing the touchpad and controller, I unplug the connector for the AC input to the HV transformer from the controller board.

Now, for the touchpad. This is not going to be nearly as easy. In order to determine if the problem is in the touchpad (as expected) or the controller (which would be bad news), I need to reverse engineer the touchpad matrix.

For some unfathomable reason, manufacturers never seem to like to use a nice orthogonal logical layout. Each 'row' or 'column' line snakes its way all over from here to yonder. Of course, there is also printing or other opaque paint in random locations to further stymie this activity.

However, there do appear to be two distinct sets of buttons with different behavior when pressed:

- The working buttons result in a dramatic drop in resistance.

- The dead buttons result in erratic or no change in resistance.

Eventually, it would appear that one of the row wires is damaged somewhere in an inaccessible location inside the touchpad. In fact, careful examination of the front of the touchpad reveals a very tiny dent - possibly a break - in the plastic cover. Perhaps, a knife was thrown at the panel? While it doesn't seem to account for the problem, this is the only evidence of damage.

To confirm the diagnosis (though I am pretty sure at this point), I go back to the ribbon connector and use a 10K resistor to manually jumper a row and column pin that correspond to one of the bad buttons. Sure enough, that function now responds.

The touchpad is only available from Sears parts at a cost of about $30 but the 'customer' is quite happy to pay this even when informed that the magnetron may be on its way out of this world in the not too distant future. (As it turns out, I have not heard of any problems with this oven and it has been a couple of years now.)

Comments: I have not really figured out the sequence of events accounting for these failures. Perhaps, the no-heat symptom occurred first and the user attempted to convince the oven to cooperate by whacking at the touchpad. If the touchpad problem happened first, the entire oven would have been virtually useless as some of the numbers and other functions were affected.

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Repair Brief #94: Hoover Vacuum Cleaner Doesn't Pick Up

Patient: Paula's vacuum cleaner. One of those newer 'mostly plastic' things. This is not like the good old days where a vacuum was so heavy that a fork lift was needed to carry it up the stairs. OK, so maybe they weren't such 'good old days' after all. :-)

Symptoms: No air flow at all. This vacuum really doesn't suck.

Testing: The official Corn Flake test is not required to evaluate this one!

"Sam, do you want to look at a vacuum cleaner.". Sure, what is wrong? "It doesn't seem to pick up the way it used to." OK, maybe it is just a belt or clog. "OK, it is in my car. I will get it later."

Trying the vacuum on Paula's office floor, it indeed really doesn't do much of anything. The brush does spin - so the belt is good. The bag is not full. In fact it has nothing in it. The air passages appear clear. So much for those theories.

This will require some disassembly.....

Removing the bottom (or was it top?) cover doesn't reveal anything new. For all intents and purposes, it would appear that while the motor makes the normal very impressive 'mega horsepower' sound, there is no airflow - zero, zappo, nadda.

Naturally, Hoover uses Torx screws for all internal parts. At least it is modular and easily disassembled - two screws to remove the entire motor unit and four more to remove the blower cover.

Ah Ha! Paula, Paula, where are you? Look at at this: The blower wheel has come loose from the motor shaft and indeed is not spinning at all despite the motor noise.

"Can you fix it?"

I can attempt to reattach the blower to the motor but eventually, a new blower will probably be needed - I have no idea how much that would cost.

So, I pile the remains of the vacuum in a corner of Paula's office and will take the motor/blower unit home to work on it. Unfortunately, since the Hoover isn't in any condition to do its thing, the pile of dirt and dust dislodged during disassembly will have to be cleaned up the old fashioned way. Is there a broom in this place? :-)

Well, I thought it was just the plastic blower. Wrong! After some additional disassembly of the motor itself, it would appear that the bearing at the blower end of the motor has entirely disintegrated - balls, race, covers, everything. This was likely the actual cause of the blower failure causing it to rub and then bind resulting in its loosening and becoming detached from the shaft.

Well, I don't keep a collection of ball bearings for nothing!

Rumage..rumage..rumage.... Ah, here is one that has the correct ID and OD but it is sealed on only one side. Oh, well, cannot have everything. I locate a metal washer and file out its hole so it will fit the shaft and protect the bearing - somewhat. I orient it so that this improvised shield in toward the inside of the motor - hopefully, a less hostile environment. I check end play (because of the additional washer) to be sure that there is adequate clearance - there is.

Now for the blower. Due to the effects of the shaft spinning inside the stuck blower, the mounting hole is totally distorted. Therefore, I use a reamer to enlarge it symmetrically and then make a bushing out of some roof flashing to center the blower on the shaft. It was mounted by a nut and this will still work but for good measure, I drip some windshield sealer (similar to Duco Cement) into the assembly to prevent the assembly from working free and then tighten the nut securely. Then some more adhesive to seal the nut.

After allowing this affair to dry overnight, I am ready for the big test!

Using a Variac, I can run the speed up from 0 through normal line voltage to the 140 VAC limit of the Variac with no obvious problem and no excessive noise (well, in a relative sort of way) or vibration. The air flow is really quite impressive!

A few days later when I return to reinstall the motor: Paula, I think it will work for a while - have no idea for how long. If it dies again, we will need to order the proper part. "Great! Now I can clean my apartment."

After putting everything back together, I then proceeded to vacuum up the new pile of dirt and dust dislodged during reassembly as well as my office which was in much worse condition! :-)

This vacuum really sucks now!

Comments: At first, I was going to blame the excessive use of plastic for this problem. However, it would actually appear that the cause was the failure of the blower-end ball bearing. This, then caused the blower to bind and be literally ripped from the motor shaft.

How could a ball bearing fail? This isn't subjected to excessive loads of any kind and I doubt that the vacuum had seen that much use - it just isn't that old (no reflection on Paula's housekeeping). I have a 45+ year old Filter Queen (well, they haven't existed for decades - built 'em to last!) that still runs fine. Ball bearings do not fail that often! Thus, one can only assume that either the bearing was defective or its seals permitted dust to enter.

The much greater use of plastic in modern appliances has indeed reduced weight and cost (or boosted profit margins depending on your point of view). In this case, flimsy plastic probably wasn't a factor but one can point to many instances of parts being under designed for the application resulting in premature failure.

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Repair Brief #95: Subaru Auto AM/FM/cassette - Intermittent Reception

Patient: Paul's wife's car stereo. Subaru stock in-dash AM/FM/cassette.

Symptoms: Reception would come in and out. Paul noted that BIG bumps seemed to affect the radio. Also problems with rear speakers.

Testing: No BIG bumps handy. Tapping it didn't seem to do much.

Paul had been bugging me for several weeks to look at this problem. In general, I don't like dealing with car stereos as removal is a pain, powering on the bench is a pain, and reinstalling is a pain. The key work here is 'pain'. :-)

However, I reluctantly agree to at least take a look at this one.

The first step is to figure out how to remove the radio (I tend to call anything in a car dash a radio even if it will mix drinks and is DVD-ready). Fortunately, the 'radio' is held in by four Philips head screws. On the first go-around, that is far as I got. For whatever reason (I don't recall exactly), I was unable or unwilling to take it to the lab (perhaps, the connectors weren't obvious or there were no connectors).

At the same time I took a look at the rear speakers which Paul had also been complaining about. The right speaker was kind of mushed with a damaged cone. I asked Paul if he wanted to repair or replace it. "No, as long as it makes some sound." (He wanted to sell the car eventually.) I kind of unmushed it but don't expect any crystalline highs. The left speaker seemed to have become detached. Paul, exactly what kinds of bumps have you been going over lately? Pushing the connectors back in place restored its sound.

This doesn't cure the main erratic problems so inspection of the interior of the radio is next on the agenda.

The next week, we are prepared for action. I have Paul park the car near our rear exit for convenience if tools or parts are needed. Then, I remove the radio again from the dash and pull off the top cover. Nothing is immediately visible but touching some vertically mounted daughter boards results in the sound coming in and out.

Sure enough, a careful inspection of the solder side of the main board from the bottom reveals some hairline cracks in the connections between one daughter board and the main board. How the manufacturer expected something like this to survive road bumps and potholes escapes me. However, it would seem that this sort of construction is used in many types of equipment subject to mechanical shock. (I will tell you about the Tandy multi-band radio with the erratic volume control someday.)

OK, so I go back into the office, fetch our Weller soldering station and a pair of 50 foot extension cords...... It doesn't take long to touch up the two rows of pads.

That did it. The reception is now solid and totally immune to as much whacking and wiggling as I could provide. This was actually a lot less traumatic than I had expected.

The clock in this car developed a bad connection problem several months later but that, alone, would not qualify for a Repair Brief though it did take a couple of attempts before the actual problem was found - a corroded cold solder joint that required removal of the old solder, scraping of the pin and pad, and new solder to repair.

And, yes, Paul did unload the car, mushed left rear speaker and all!

Comments: As noted, car radios are not my favorite repair activity. Perhaps they just don't have that entertainment value in addition to being difficult to service - did I mention how everything about them is a pain? :-)

Aside from road bumps and potholes, the electrical system in an automobile is prone to dips and spikes - some quite spectacular. The environmental conditions may be horrible - from arctic to tropical temperatures. There can be condensing humidity and tobacco smoke as well.

Thus it comes as no surprise that many common failures with car radios relate to mechanical problems and to a lesser extent, electrical abuse. In some cases, locating the cause is easy. In others, it can be very frustrating as Dave is currently finding out with a friend's car radio. Stay tuned (perhaps) for a report on that one in the future.

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Repair Brief #96: GE Frost-Free Refrigerator - Reduced Cooling

Patient: GE top freezer 21 cu. ft. refrigerator.

Symptoms: Rising temperature in fresh food compartment. Frozen food may be softening up also but this is not as obvious.

Testing: Checked that compressor was running (continuously). Condenser coils (underneath) have been cleaned. They are moderately warm.

Some possibilities for inadequate cooling:

- The door is not properly closing for some reason.
- Someone messed with the controls accidentally.
- Something is blocking the passageway between the evaporator and the fresh food compartment.
- The defrost cycle is not working and ice has built up in the evaporator coils. This could be due to a bad defrost timer (most likely), bad defrost heater, or bad defrost thermostat.
- The interior light is not going out when the door is closed - that small amount of heat can really mess up the temperature (remove the bulb(s) as a test if you are not sure.
- Low Freon can result in problems of this type but that is a lot less likely. (These refrigeration systems are hermetically sealed (welded). Slow leaks are unlikely.)

Although various convoluted (and expensive) faults are possible, the most likely problems have to do with the defrost system - defrost timer, heater, and defrost thermostat. Door seals are intact and the interior light is out when the door is closed. Controls are set for lowest fresh food temperature.

With the compressor running and clean condenser coils, there isn't much else that is external to the sealed system.

The most common type of defrost system on a no-frost refrigerator or freezer usually consists of:

- Defrost timer - motor driven (typically) switch which selects between the compressor and its associated devices (like the evaporator fan) and the defrost heater (located adjacent to the evaporator coils). The timer motor likely only runs when the main thermostat calls for cooling.
- Defrost heater - resistance element located in the evaporator compartment to melt ice built up on the coils
- Defrost thermostat - closed when the temperature is below about 32 degrees F to allow current to flow to the defrost heater. Shuts off once the ice melts as indicated by the temperature rising above 32 degrees F.

The terminal numbering and wire color code for the defrost timer in a typical GE refrigerator is shown below:

```
                      Black (4)
```

```
    Gray (3)      /o---------o Normal position - Compressor, evaporator fan.
H* o-----+------/
         |        o---o Blue (2)
       Timer          |         Defrost heater  Defrost Thermostat
       Motor (3180    o------------/\/\/\------------o/o----------+
         |    ohms)                31 ohms          32 F          |
         |                                                        |
         | Orange (1)                                             |
         o--------------------------------------------------------+--o Common
```

```
   * H is the Hot wire after passing through the main thermostat (cold control)
     in the fresh food compartment.
```

The entire timer unit is readily accessible once the kick plate is pulled off.

By turning the finger access shaft in the defrost timer, I was able to get the reassuring click indicating the start of the defrost cycle. Sure enough, this was followed a couple minutes later by a variety of melting and sizzling sounds. These are normal as the ice melts and parts expand. Then, a steady trickle of water could be found dripping into the pan below.

I also noted that the timer motor did not seem even moderately warm as it would normally be - running as it should about 90 percent of the time. Could the motor be bad?

Two screws and the timer assembly comes free. After writing down the positions of each of the colored wires, I disconnect them and take the timer to a more convenient location for inspection. The motor is stone cold....

The timer assembly consists of two parts: A synchronous gear motor and a plastic housing with the cam and contacts. Two more screws and the cover to this part comes free. Initially, nothing looks amiss but then I notice a wire just hanging in mid-air. And, it is one of the two wires powering the motor!

Apparently, the wires were tack-welded to the metal strips with the contacts on their end. And, guess what happens when something flexes even a small amount a few thousand times? It breaks!

A quick soldering job and we are back in business.

Once reassembled, I force several consecutive defrost cycles (until no more water comes down into the drip pan) to assure that all the built up ice is gone.

Five years later:

Guess what? Same symptoms. Now, the diagnosis is even quicker. This time the wire broke near my soldered connection. To make sure this doesn't happen in another five years, I solder the wire to a location just behind the outside terminal - a place where there is no movement of any kind!

(The built up ice did a number on the styrofoam insulation between the bottom of the freezer and evaporator compartment but there is no way I am going to pay GE $75 for a 50 cent sheet of styrofoam! A little universal mending material, a. k. a. duct tape, takes care of that!

About 5 years later, 1 week after an extended power failure (1-1/2 days! At least it was the dead of winter).

Same symptoms. However, this time the motor is warm so my previous repair is still intact. :-) The motor is receiving power but nothing visible is turning as confirmed by rotating the cam by hand to the defrost position - where it would happily remain indefinitely.

Upon removing the cover of the gear reducer, the cause is obvious - a split plastic gear hub most likely due to gummed up grease (it hardened after cooling off while power was off) caused excessive stress when restarting.

Well, bite the bullet. Calling in a serviceman would result in a $135 bill. Our local appliance store had the timer assembly for about $30. Just after this episode, MCM Electronics started carrying universal defrost timers for about $12.

Comments: A properly designed and manufactured refrigerator or freezer is a very reliable appliance. The hermetically sealed compressor and coils can last virtually indefinitely as long as they are not abused (like using a sharp instrument to pick ice off of the soft evaporator coils!). There have been instances of early failures (and possible recalls) of some models but in general, several decades is not an unusual life span for the refrigeration components.

The defrost system is another matter. Its parts are exposed to the elements and get a workout several times a day. However, diagnosis and replacement is usually straightforward (except, that is, for finding a place for a freezer full of thawing food!). With luck (of sorts), the timer is the problem and this is a 5 minute repair if you are willing to just replace it.

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Repair Brief #97: Panasonic VCR Power Supply - Comedy of Errors

Patient: Panasonic VCR model PV4820.

Symptoms: Just blinking --:--. No response to any front panel buttons or remote control.

Testing: Nothing much without going inside.

This should have been a 15 minute repair (if you don't count gaining access to the power supply):

- If I had been able to read my ESR meter correctly. :-((No fault of the ESR meter.)
- If I had simply installed a power supply rebuild kit.
- If I had elected to use my scope to check a signal or two sooner instead of later.

As it turns out, it was more like a two hour repair at the cost of a pair of smoked zener diodes.

The blinking --:-- with no response to any buttons is a classic symptom of a power supply problem. In the case of Panasonic PV48xx and other models using similar power supplies, the culprit is usually C21 or C16 (though not all may use the same numbering), or some other electrolytic capacitor in the secondary side of the switchmode power supply. In fact, this turned out to be the case: C16 showed high ESR and I should have found that in about 2 minutes but did not and was led on a wild goose chase.....

Anyhow, back to the story.

With the cover off, the power supply connector is readily accessible. Although there are a number of variations on the power supplies used in the various models, all should show a couple of pins with a voltage of around +5 VDC.

Probing carefully reveals a bunch of much higher voltages (which are expected) but two pins have something around +3.6 to +4 VDC. Checking my reverse engineered Panasonic power supply schematic, these pins should have the +5 V.

No problem I say, remove the power supply, check C21. It should test with high ESR or low uF, replace, and be done. (Actually, the common failure with C21 is to have excessive leakage but no matter, I would just try replacing it anyhow.)

Removing the power supply module in these VCRs isn't too bad (as opposed to some older Panasonics which have apparently been designed specifically to make this difficult). A bunch of well marked screws holding the main board, lift free, unbend and unsolder a couple of tabs. Then unbend a couple of tabs on the sheet metal cover and - presto - access to both sides of the power supply circuit board.

To fully appreciate what is going on in the discussion below, it is recommended that you refer to the typical Panasonic VCR power supply schematic which may be found at Various Schematics and Diagrams.

Here is the important part:

```
 T1     D8                (+3.6)                   L3 ::::   ICP1 _
    +---|>|---+--------+-----+---------+----------+---^^^^---+---_ ---o +5 Out
 ::(          |        |     |         |          |          |
 ::(     D11 _|_.  R14 /     \ R17    __|__ IC1  +_|_ C16   +_|_ C17
 ::(    5 V '/_\   220 \     / 10K    _\_/_ Opto  --- 330 uF --- 1000 uF
    +--+      |        /     \         |   LED  - |   6.3 V - |   6.3 V
      _|_     |   C21  |     |    Q4 |/ E        _|_        _|_
       -      | 1 uF +_|_    +-------| 2SB641     -          -
              |  50 V --- Q3 |(+2.8) |\ C (PNP)
              |      - |   |/ C        |
              +--/\/\--+---|  2SD636   / R22
              |  R15 (-1.5)|\ E (NPN)  \ 220
              |  220         |         /
          R16 \         (-.7)+----+    _|_
         5.6K /              |   _|_   -
              \          R18 /   /_\
              |          18K \   _|_
              |              /    -
              |              |
-V source o---+--------------+
```

Note: Measured voltages shown in ().

C21 does show slightly high ESR, so I find one in my stock and replace it.

No change. In fact, if anything, the output voltage has *decreased* slightly. (It turns out that the replacement cap had lower ESR and actually would be expected to make the problem worse given the actual cause.)

Next, I check all caps in the vicinity with the ESR meter. I even specifically checked C16 which would result in excess ripple and this would feed through C21 if C16 had high ESR. Apparently, I missed it - probably ignoring the absence of the huge decimal point thinking it read .20 ohms when in fact it actually was 20 ohms.

Next, I figured, "Well, maybe my replacement C21 was bad as it wasn't a new cap". So, I removed it entirely for testing.....

Now, C21 serves at least one function I know of and that is to limit the rise in voltages as the power supply is powered up. It couples any AC component of the +5 line back to the regulator to reduce output if there is excess ripple or if the voltage is increasing rapidly. With C21 removed, this protective function is not present......

But I realize this and put the supply on a Variac so I can increase the input slowly and avoid any problems. Right. :-(

Guess what? As I am increasing the input, I hear that high pitched whine indicating an excessive current fault somewhere in the power supply.

Well, maybe it is just the absence of the cap (not really thinking it through). Replace it.

No change.

OK, what happened? Is the supply now badly fried? Could the VCR have been affected as well? Well, at least the latter is unlikely.

It would appear as though something has shorted. Not the main switchmode power transistor as that would blow the main fuse and really mess up my day.

Well, I got lucky - at least in the time to locate the problem. Measuring across the first part I tested - a big fat diode - showed 0 ohms. Unsoldering it made no change but unsoldering a nearby zener diode (D15) showed that it was shorted. D15 is on the +15 V output and protects (by sacrificing itself apparently) against overvoltage since it does not really conduct during normal operation. (It is an 18 V, 1 W zener as I found out later).

Fortunately, I had a replacement known to be good which was removed from a similar supply when I installed a rebuild kit.

After the zener is installed, we are back to square one - 3.6 V on the 5 V line.

With the caps supposedly eliminated, that leaves the feedback network.

A bit of analysis shows that regulation is accomplished by feedback from the +5 line through a 5 V (approximately) zener (D11) to the base of a transistor (Q3). When the output exceeds 5 V, this transistor turns on which turns on another transistor (Q4) which supplies current to the LED of the optoisolator. Its photodiode then conducts and reduces the pulse width of the switchmode power transistor. Got that?!

Checking at the base of Q3: -1.5 V which is nicely .7 V more negative than the emitter. Q3 should be solidly off. However, its collector reads about .8 V less than its supply... Hmmmmm. I replace Q3.

No change. In fact, I replaced Q4, the optoisolator, AND D15 for a second time after I experimentally shorted the input to the optoisolator to confirm that it was capable of increasing the output - it was :-(and D15 blew again.

Not knowing the rating of D15, I replaced it with a 1N4742A, 12 V zener. However, this caused the +5 to read +4.1. At first I thought this was a clue but then realized that it simply was allowing more drive by sucking some of the power by conducting. Installing a 15 V zener remedied that. Back to square one again. (18 V is the correct value but at least the 15 V zener isn't loading the circuit.)

Finally, I do what I should have done early on - turn on the scope! Looking at the base of Q3 it is now obvious that I must have missed something in checking the caps. As the input voltage is increased, a very significant pulse waveform can be seen riding on top of the +5 V (now +3.6 V) output. This is coupling enough signal to the feedback circuit to reduce the output voltage. Since C21 has been eliminated as a possible suspect, the only other possibility is C16. Sure enough, a quick test with the ESR meter and - what do you know - 20 ohms. That is over 100 times what it should be!

Installing a replacement and all is well - only a couple hours more than it should have required!

Frank Fendley identified the correct value for D15 - 1N4746A, 18 V, 1 W but to top it all off, our local electronics distributor is out of zener diodes! Some prototyping house bought up their entire stock or so the story goes. And, Radio Shack only goes up to 15 V! I will obtain an exact replacement rather than cobbling something together from two lower voltage zener diodes since D15 does serve as protection and I don't want to affect that.

Comments: This repair should have taken about 15 minutes. I have no idea now I missed the ESR reading on C16 as I specifically went to that cap as it is one of the two most likely causes of this problem. I guess we all have bad days. On the plus side, the confusing situation forced me to analyze the operation of the power supply in more detail. I even found a couple of errors in polarity on the schematic. (It has only been available for the entire world to see at the Sci.Electronics.Repair FAQ site for about 3 years now. You would think someone else might have noticed!)

In the end, the only damage was about 40 cents worth of blown zener diodes and my ego in return for a little knowledge gained.

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Repair Brief #98: Kenmore Window Fan - No Breeze

Patient: Kenmore 26" window fan - two speed bidirectional with thermostat.

Symptoms: Does not spin in either direction on either speed.

Testing: Spinning the blades gets it going a bit but it never reaches anything approaching normal speed and makes a clicking sound.

This is my cousin's fan and has been in use during the summer months for the past 15 years. I had lubricated it once before but never really properly disassembled it entirely. (That was after the floors had been refinished - the sanding dust didn't help matters any.)

Everything structural in this fan is made of plastic except for the motor, and speed and thermostat trim plate.

Eight screws must be removed to take off the rear grill.

Ah - now that is a problem.... It seems that the blades in this are molded as a single unit with a section on the shaft for the clamp. Well, that section is totally broken off so even if the motor wanted to get up to speed, there is nothing holding the blades to the shaft! The clicking sound was probably the result of the shaft slipping inside the hole.

However, first the motor must cleaned and lubricated (at least) as it seems tight. Disassembly requires the removal of a front cover plate with the controls (speed and temp.) and then 4 nuts holding the motor itself. Then, 4 long bolts which clamp the motor halves together.

The closed-end seems fine - adequate lubrication and no damage.

However, the open-end is dry. It appears to be in basically good condition so a thorough cleaning and then some electric motor oil on the bronze bushing and the felt oil reservoir would appear to do the trick. I add a few drops to the other end as well just to be safe. Testing shows that the motor works as well as the day it was built.

Now for the broken blade problem.....

Repair with adhesive is not possible as the broken pieces could never be reliably reattached. Sears doesn't stock a replacement blade for this model (can you believe it?) and it would probably cost more than the entire fan if they did. So, I will have to improvise.

At first I figure on finding something in my junk boxes that would fit the shaft and screw or clamp to the hub portion of the blades. However, nothing seems to fit or lend itself to modification.

Therefore, I decide to fabricate a mounting assembly from some sheet aluminum and a hose clamp.

This consists of 3 strips of aluminum stock about 3/8" x 2" x .050, bent over 3/8" at almost a right angle at one end. Holes are drilled near the opposite end which will be used to screw these to the hub of the blades.

The source of this material was a long ago cannibalized HDS video terminal keyboard cover plate. You probably already know that I don't throw away much - somewhat less than gets wasted from a typical cow - never mind. :-)

The right angle portions were then attached to the shaft with the hose clamp and while in position, holes were drilled through the hub of the blades (a roughly flat portion about 5 inches in diameter. Screws, nuts, and washers made from the same material were then added and the entire affair was tightened in position.

Since only the clamp portion of the blade hub was missing, there was still a reasonably tight hole for centering and a layer of tape removed any sign of movement. However, a bit of adjustment was needed to correct a slight wobble. Translation: I rotated the blades and noted the high side - and then pressed down on it!

Now, the fan runs smoothly at both speeds in both directions though I will recommend using low as much as possible.

Comments: This represents yet another case of an appliance snatched from the jaws of the dumpster and land fill. There is nothing high tech about either the problem or the repair but these projects are much more satisfying than simply going and buying a new fan. Cheaper as well - $0 in parts at least. How long will it last? The motor is as good as new. The blade mount seems at least as sturdy as the original - only time will tell.

Where the nights are cool, an exhaust fan is a much more energy efficient solution than either window air conditioners or central air conditioning. The fan sucks out stale house air which is replaced by outside air through any open windows.

We still use an all metal window exhaust fan - it is just about 45 years old at this point and runs fine. A few drops of oil every so often (though I must admit to being negligent in this department of late) and it keeps chugging along.

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Repair Brief 99: JVC 20 Inch Color TV - Flat Line

Patient: Dave's neighbor's JVC Model AV20TP3 20 inch color TV.

Symptoms: Single horizontal line - video appears to be present.

Testing: External whacking has no effect, no service switch. Flexing the mainboard, however.....

Dave had been talking about this TV for a couple of weeks. So, finally, I found it with the back off on the bench in the lab. I wander over. Of course, there is just a dim horizontal line (Dave DID turn down the brightness). Naturally, I cannot resist a little exploring...

I flip a switch on the edge of the board that could have been a service switch but it had no effect (I later found out it was the CATV/TV/ANT/etc. switch).

Tapping and whacking don't do anything.

However, pulling up on the mainboard in the vicinity of the flyback transformer results in momentarily restoring a full raster.

DAVE??? Do you know that flexing the board has an effect?

"Um, yes, I think."

OK, let's put the board up on its side - can you do that so it doesn't short out?

"Sure."

So, I rummage around for something insulating - a flux removal brush would seem to be appropriate.

Dave, you watch the screen while I run this over the pins. Oh, I see you have touched up a few joints, huh?

"Just a few."

OK, here goes....

First, I attack the area of the flyback on the chance that the bad connection is for the power to the vertical circuits which probably are scan-derived.

No change.

Next, the area of other power semiconductors - hopefully one of these is the vertical driver.

Still no change.

Finally, just systematically over the entire board.

"STOP - there was something".

Backup, slower this time.

"Ooooo - you had it. Gone now".

This? "No." This? "No." This? "No." This? "No." This? "Wait, yes. Good. Bad... Bad... Good.. Bad... Good."

It is an IC. Let me try each pin....

"Bad. Good. Bad. Bad. No effect."

Pin 2 of this chip. Let me try to locate the crack. Is there a magnifying glass in this place? It took very close inspection but there was a definite crack that would widen as the pin was pressed to one side.

Dave, on Pin 2, jumper a wire to another pin on the same trace. Also, touch up all the other pins on this IC.

"I guess I wasn't forceful enough."

Five minutes later:

"They were all somewhat short of solder - what was there kind of disappeared when I touched them with a soldering iron but I think they will be fine now."

What is the chip ID? 'Uh, IC421, LA7838.' LA7838 is a vertical deflection processor. Pin 2 is 'Vertical trigger in'. Yes, that would explain a lot!

Sure enough, the TV is now solid.

Comments: There was no evidence of heating or other damage. With the meager amount of solder present, just the very slight effects of thermal cycling were likely enough to cause this failure in set which is something like 2 years old.

Dave's neighbor was about to toss the set because someone else had told him it was likely a bad picture tube! Simply amazing. :-)

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Repair Brief 100: Minox ME1 Electronic Flash for Minox B Camera - Dead

Patient: Three-part unit for one of those teeny-tiny Minox spy cameras. :-)

Symptoms: Dead on both AC and rechargeable battery power.

Testing: Not applicable - done via email. :-)

I was contacted about this rig via email and attempted to walk Stan through the diagnostic and repair process. With such an old device, any rechargeable battery was almost certainly dead and any electrolytic capacitors would also be highly suspect.

Since the unit acts totally dead both from its battery as well as the AC adapter, I first suggested replacing the NiCd cells. Having accomplished this, and letting it charge overnight, there is now at least some quite whining to indicate that the inverter is running. However, the ready light still does not come on even after several minutes (cycle time should be under 10 seconds).

I next suggested that Stan should attempt to measure the voltage on the battery as well as the energy storage capacitor to determine how far - if at all - it is charging. I warn Stan to take extreme care around the cap - those can be lethal!

The report isn't promising. On battery alone, the battery voltage is stable at 2.45 VDC and the cap only charges to 48 VDC or so; on AC to 170 VDC. Even the latter is much less than the expected minimum of 300 VDC. What is going on?

Since Stan noted that the capacitors retain their charge for hours, it is unlikely that they are bad - leaky - but just in case, I suggest just replacing them with any sort of capacitor with similar uF rating and at least equal voltage rating (for testing only) - those from disposable cameras would be most appropriate and FREE if you know where to ask!

No change at all. At this point, Stan suggests that he is over his head on this one and is about to give up. So, I volunteer to look at the unit if he pays shipping both ways.

A few days later.....

The flash head itself is about as big as the entire camera with the power supply and charging adapter being somewhat larger. Actually, the power supply is a lot larger. I don't suppose spies generally like to use electronic flash in covert operations too often anyhow!

My first step is to reverse engineer the circuit. I don't expect anything particularly unusual but this will make any troubleshooting a lot easier (also available in GIF format as [Minox ME1 Inverter and Energy Storage Capacitors]()):

```
                                                                      J2-2
                                            +--------------------------o HV+
                                            |  S2 Flash +-----------+
     P1-1  S1 Power            o  T1        | Intensity |     R2    |
  BT- o---+---/ --+-------------+     o     |      High o   330,2W  |
          |       |              ):: +------+-+-------+->o---/\/\---+
          |       /        D 15T )::(         |   Low | o     R3    |
          |    R1 \          #20 )::(         |       +--+---/\/\---+
          |   150 /   +---------+ ::(         |          |  10K,1W  |
          |       \   |           ::( O 1950T |          |          |
          |       |   |        o  ::( #46     |      C2 _|_     C3 _|_
          |-      +---|---------+ ::(         |   260uF ---  260uF ---
    BT1   _       |   |          )::(         |    350V  |    350V  |
   2.4V  ____     |   |    F 15T )::(    D1   |    D2    |          | J2-1
   Sub-C  _       |   |      #30 ):: +---|<|--|-+--|<|---+----------+--o HV-
    NiCd ____     |   |     +---+       BAY90 | | BAY90
          |+      |   |  Q1 |                 | |
          |       |  C \|   |                 | |
          |  C1 -_|_    |---+                 | |  O = Output
          | 47uF --- E /| AD136               | |  D = Drive
          | 10V + |   |  (PNP)                | |  F = Feedback
          |       |   |                       | |
     P1-2 |       |   |                       | |
COM  o----+-------+---+-----------------------+ |
                                                |
     P1-3                                       |
CCAC o------------------------------------------+
```

Note: The BAY90 rectifiers cross to 1000 V, 2.5 A general purpose diodes.

The Flash Intensity switch, S2, selects between 12 W-s and 24 W-s. There are actually three positions. Apparently, you are supposed to pause in the middle one called "Hold 1 Sec" when switching between power levels for at least 1 second (surprise, surprise!) to allow the capacitor voltages to equalize! I would assume that the reason for this is to prevent damage to the switch contacts.

The flash head is separate from the power supply and appears to be very much like any of the other strobes. However, note the adjustment for the ready light!

I was not willing to completely disassemble this unit so some of the actual components and wiring were guessed (also available in GIF format as [Minox ME1 Ready and Trigger Circuits]()).

```
   P2-2
HV+ o---+-------------------------------------------------+
        |     R4                                         +|
        +----/\/\-----+---+--------+                     _|_
             4.3M     |   |        |                    | | |
                      /  +++ IL1   |                   ||   |
          Ready R5 +->\  |o| NE2   |       Trigger     ||   |
           Cal. 5M |  /  |o| Ready |          T2 +-----||   | FL1
                   |  \  +++       |          ||( o    ||   |
             R6    |  |   |        |  C4      ||(      || _ |
        +---/\/\---+--+---+        +--||----+ ||(       |_|_|
        |   4.3M                   | .1uF    )||(         |
        |               Shutter o--+ 250V  o )||(        -|
        |                 Cable o--+      +-+    +-+      |
   P2-1 |                          |      |        |      |
HV- o---+--------------------------+------+--------+------+
```

The wall adapter/charger provides both the current to charge the 2 cell NiCd battery and a high voltage AC output (CCAC) to power the flash when plugged into an outlet regardless of the state of the batteries. When operating from the wall adapter, D1 and D2 in the power supply unit in conjunction with C4 form a voltage doubler that takes the 130 VAC (>80 V peak) output of the adapter and produces over 300 VDC to charge the energy storage capacitors (also available in GIF format as [Minox ME1 AC Line Circuitry]()).

```
                      T3     C5   J1-3
                         +---||----o CCAC (Capacitor Charge AC)
            H o-----+ ||(   1 uF
                     )||(   350V
                     )||(
          110VAC     )||( 130V
                     )||(
                     )||(       J1-2
                     )|| +---------o COM
            N o-----+ ||( 3.3V   J1-1
                         +---|<|---o BT-
                             D3
```

Some interesting features I was not aware of previously - which might have helped to narrow down the problem (and possibly give up - as you will see):

- It is a dual energy flash - a switch selects between low and high power modes. There are two energy storage capacitors. This really doesn't affect anything but at least explains why Stan was referring to two large capacitors....

- The AC adapter generates the high voltage directly via a clever little voltage doubler in the power supply and its own isolated 130 VAC transformer winding. This is significant.... Having two basically independent means of powering the unit both be messed up implies a problem on the secondary side of the inverter since there is nothing else in common.

Since the capacitors (and other sources of leakage) have been eliminated, on a wild guess, I decide to replace the high voltage rectifiers. The are marked "BAY90" which crosses to 1000 V, 2.5 A (probably less but that is what my ECG book says). Replacing with suitable diodes and.... No change at all.

There is only one other thing that can prevent the capacitors from charging from the AC adapter - an open inverter transformer secondary. This would not be fun. Indeed, all efforts check its resistance failed. The transformer is bad. Can it be repaired? I don't think so - not unless the break is at the end of the winding on the outside. No such luck. In fact, after unwinding all 1,950 turns of #46 wire, I never did find it - probably one of the 50 or so times I thought I broke this super fine wire in the process, it was already broken. :-(No way to get that back together anyhow and the ferrite core was in several pieces as well....

So, go to plan B....

I tell Stan to see if he can locate another similar unit at auction or elsewhere to use for parts - even if it doesn't work. Within a half hour, he replies that an eBay on-line auction lists an identical model - with the identical symptoms - and it was still available at $37. No way I said, it may have the same problem as well and thus not be repairable! (That unit finally sold for $83 - Yikes! - and it could be a dud.)

So, I volunteer to perform a transplant......

There is nothing particularly unusual about the requirements - charge some large caps to around 300 VDC. Any vanilla flavored pocket camera needs to basically do this. However, just any unit would not necessarily work:

- It runs on a pair of NiCd cells totaling 2.4 V so the circuitry out of a disposable camera is not appropriate, being designed for 1.5 V operation.

- The inverter may need to run continuously. For this reason as well, the disposable camera solution is unacceptable since they usually are activated by a push button and may only be designed for short duty cycle operation.

- AC operation must not be affected.

- The circuitry must fit in the case.

Checking the schematics for each of the other battery powered flash units in the document: "Notes on the Troubleshooting and Repair of Electronic Flash Units and Strobe Lights and Design Guidelines, Useful Circuits, and Schematics", it seemed that the one described in the section: "Photoflash circuit from Keystone pocket camera" might work if it could accommodate the 2.4 V NiCd rather than 3.0 V Alkaline battery it expects. This is often the case since Alkaline voltage is not really constant at 3.0 V but drops gradually as they are used up (NiCd voltage is nearly constant until the charge is exhausted). Therefore, it probably should work down to about 2.0 V (but with longer cycle time). And, the lower effective series resistance of NiCds would partially offset the lower initial voltage. I have a couple of the Keystone units so it is easy to try.

A simple test jumpering 4 wires confirmed functionality. The actual inverter portion of the Keystone flash occupies a volume of about 1" x 1-1/4" x 3/4" or just slightly more than that of the original dead inverter transformer! Some quick action with a hacksaw and nibbling tool resulted in a cute little circuit board that could be tucked into the available space. Some electrical tape assured that there would be no nasty short circuits. The chopper transistor was left exposed so any heat from it would have somewhere to go.

The excised circuit was attached to the positive terminal of the battery, the negative (center) at the switch, and the two secondary leads of the inverter transformer, taking care to get the polarities correct (the waveform out of the inverter is asymmetric and it would not work well if reversed). Except for T1 (dead) and C2 which I removed, all other components were left in place since they shouldn't affect anything.

It seems to work fine on both power settings and on battery or AC. The voltage on the energy storage capacitors stabilizes at about 315 to 325 VDC in all cases. The battery charges fine. What more can you ask? :-)

At first, I thought there was one slight problem: When plugged into an AC outlet with the power switch in the 'on' position (meaning the inverter is also running - the flash operates from AC with this switch off), I was afraid the voltage will eventually climb beyond the safe limits of the capacitors. Then, about 3 AM the next morning I realized there was a missing plastic piece that Stan had not sent me to prevent the switch from being moved into the 'on' position with the adapter plugged in (or vice-versa).

Comments: There is no doubt this unit would have hit the land-fill had it not been for my curiosity in determining what exactly was wrong - since the behavior didn't make sense given my (initially incorrect) understanding of the basic design. Once the nature of the AC adapter was revealed, everything fell into place. Had stand tested the transformer and found it to be open, I would have probably just suggested a nice funeral. :-(

Fortunately, the original inverter was so huge compared with the replacement that space was not a problem. I also believe that the cycle time is now about half of what it was originally so that is an added bonus. I bet the unit will produce more shots on a single charge as well.

Virtually all small battery powered electronic flash units use circuit designs that are very similar. Over the years, parts - particularly the chopper transistor and transformer - have improved greatly, thus the decreased size and increased efficiency.

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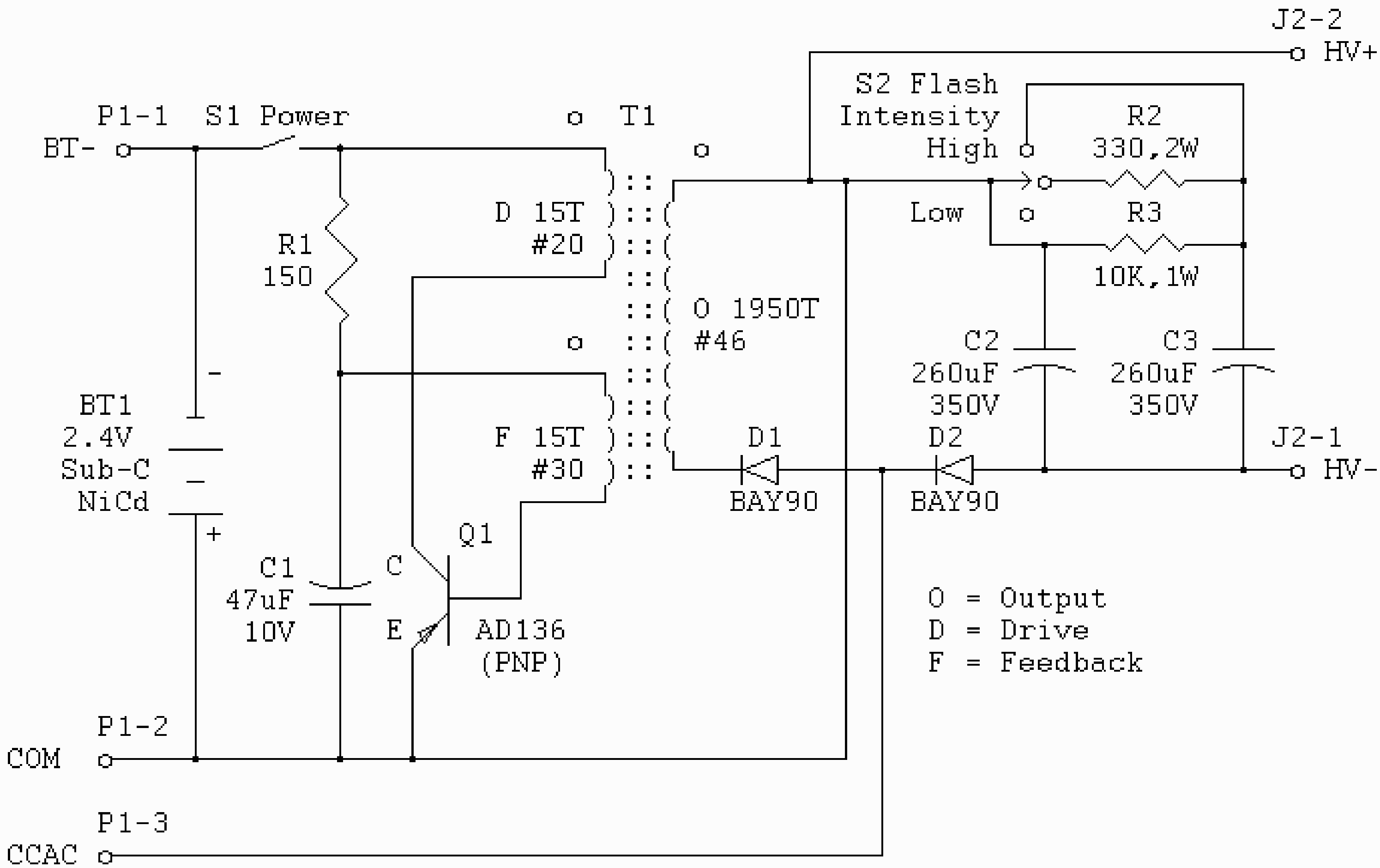
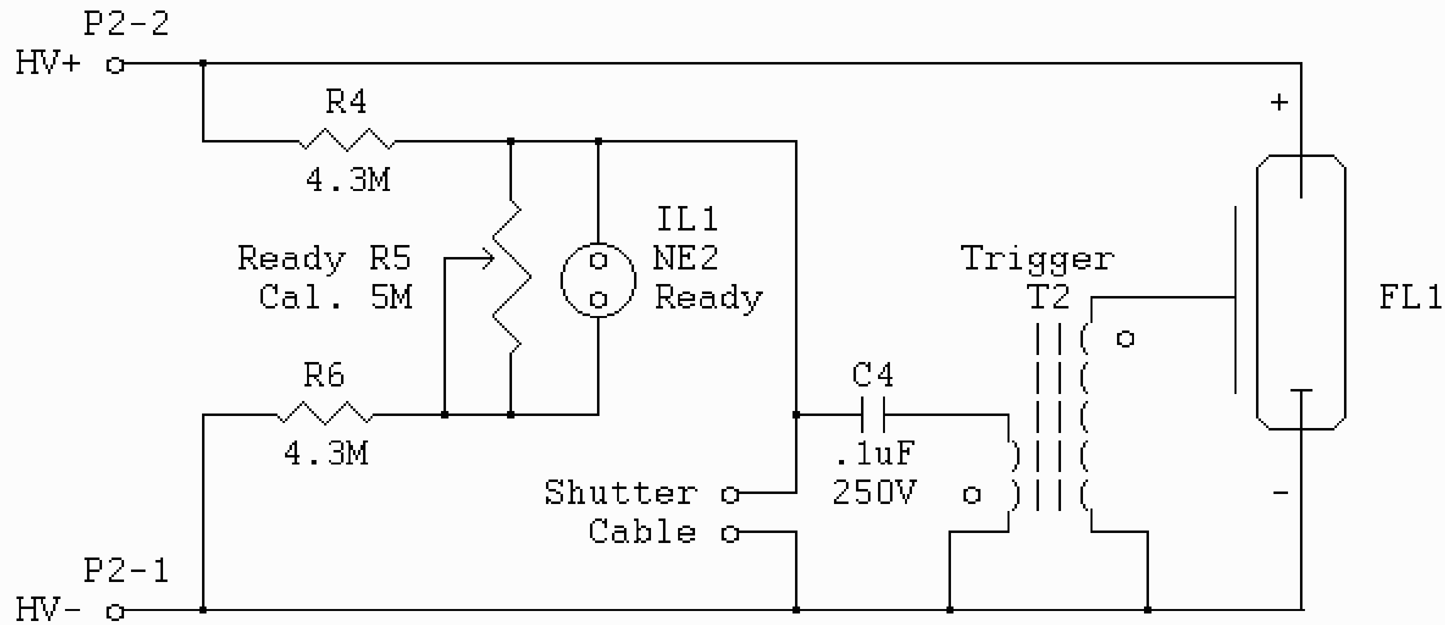
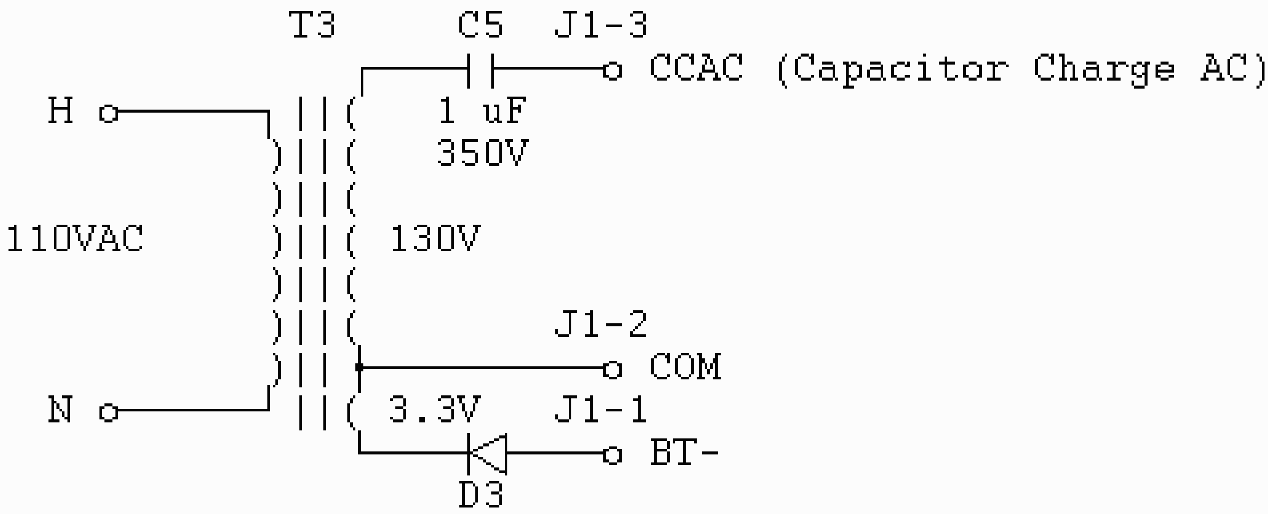


Minox ME1 Inverter and Energy Storage Capacitors



Minox ME1 Ready and Trigger Circuits



Minox ME1 AC Line Circuitry

Capacitor Testing, Safe Discharging and Other Related Information

Version 2.40

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

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Introduction

Scope of Thie Document

Capacitors may not be considered the superstars of electronic equipment (except perhaps in devices like xenon flash units and pulsed lasers), but more like the helpers and extras. However, they play a vital role in virtually everything that uses electrons in some way. A defective 2 cent capacitor in a TV or monitor can render it useless.

This document describes techniques for the testing of capacitors using a multimeter without a capacitance test mode. Information on safe discharging of high value or high voltage capacitors and a discharge circuit with visual indication of charge and polarity is also included.

There is also general information on capacitors, capacitance and ESR meters, and other related topics.

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Safety Considerations

Basic Capacitor Safety

While accidental contact with capacitors on a 3.3 V logic board isn't going to result in a shocking experience, this is not true of many common types of equipment including TVs, computer and other monitors, microwave ovens; the switchmode power supplies in some VCRs, laptop computers, camcorder battery chargers; electronic flash and other xenon strobes; laser power supplies, and many other consumer and industrial devices.

Where equipment is AC line connected or uses high voltages, special precautions are required both for personal safety and to prevent damage to circuitry from careless actions. In addition to the specific safety issues with respect to capacitors discussed below, read, understand, and follow the recommendations provided in the document: Safety Guidelines for High Voltage and/or Line Powered Equipment before attempting any testing or repairs to equipment for which this applies.

Capacitor Testing Precautions

WARNING: make sure the capacitor is discharged! This is both for your safety and the continued health of your multimeter.

A pair of 1N400x diodes in parallel with opposite polarities may help protect the circuitry of a DMM. Since a DMM doesn't supply more than 0.6 V generally on ohms ranges, the diodes will not affect the readings but will conduct should you accidentally put the meter across a charged cap or power supply output. They won't do much with a charged 10 F capacitor or high current supply where you forgot to pull the plug but may save your DMM's LSI chip with more modest goof-ups.

This approach cannot be used with a typical analog VOM because they usually supply too much voltage on the ohms ranges. However, my 20 year old analog VOM has something like this across the meter movement itself which has saved it more than once.

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Basic Capacitor Testing

Testing Capacitors with a Multimeter

Some DMMs have modes for capacitor testing. These work fairly well to determine approximate uF rating. However, for most applications, they do not test at anywhere near the normal working voltage or test for leakage. However, a VOM or DMM without capacitance ranges can make certain types of tests.

For small caps (like 0.01 uf or less), about all you can really test is for shorts or leakage. (However, on an analog multimeter on the high ohms scale you may see a momentary deflection when you touch the probes to the capacitor or reverse them. A DMM may not provide any indication at all.) Any capacitor that measures a few ohms or less is bad. Most should test infinite even on the highest resistance range.

For electrolytics in the uF range or above, you should be able to see the cap charge when you use a high ohms scale with the proper polarity - the resistance will increase until it goes to (nearly) infinity. If the capacitor is shorted, then it will never charge. If it is open, the resistance will be infinite immediately and won't change. If the polarity of the probes is reversed, it will not charge properly either - determine the polarity of your meter and mark it - they are not all the same. Red is usually **negative** with VOMs, for example. Confirm with a marked diode - a low reading across a good diode (VOM on ohms or DMM on diode test) indicates that the positive lead is on the anode (triangle) and negative lead is on the cathode (bar).

If the resistance never goes very high, the capacitor is leaky.

The best way to really test a capacitor is to substitute a known good one. A VOM or DMM will not test the cap under normal operating conditions or at its full rated voltage. However, it is a quick way of finding major faults.

A simple way of determining the capacitance fairly accurately is to build an oscillator using a 555 timer. Substitute the cap in the circuit and then calculate the C value from the frequency. With a few resistor values, this will work over quite a wide range.

Alternatively, using a DC power supply and series resistor, capacitance can be calculated by measuring the rise time to 63% of the power supply voltage from T=RC or C=T/R.

Ray's Notes on Capacitor Testing

(This section from: Raymond Carlsen (rrcc@u.washington.edu)

The best technique depends on what the cap is used for. A lot of electrolytics are said to be "leaky" when they are really partially open and just not doing their job. Electrolytics that are actually electrically leaky are not as common. You can take each capacitor out of circuit and test it with a cap checker or even a VOM, but in-circuit testing is faster. I don't like to grab for a soldering iron unless I'm pretty sure the part is bad. Time is money.

I first do a visual inspection and see if any electrolytics are bulging (they -are- leaky and usually get hot), or physically leaking (corrosion around terminals). Bulging caps in a switching power supply are a dead giveaway, but can point to leaky diodes as well. Next, if the unit will power up, I look for signs of filter caps open... hum bars in picture, hum in audio, flickering displays, low B+ but nothing gets hot, etc. You can tell quite a lot by just being observent and a makling a few simple checks. Try all controls and switches... you may get other clues. What works and what doesn't?

If you have an obvious fault... like a reduced vertical scan on a TV set or monitor for example, to find the cap that is starting to open up, you can bridge each of them with another cap, one at a time and see if it corrects the problem. (Experience has taught me that bad electrolytics will not -usually- kill vertical sweep completely.) In a TV set that is several years old or more, there could be more than one cap dried out (open). Check them all.

"Popping" filters (as it used to be called) by bridging the original with a like value is not good practice with solid state electronics. The shock to a live circuit is likely to damage other components, or it could shock the circuit into working again... for awhile. Then you get to sit there like a fool and wait for it to act up again... minutes or weeks later. For small electrolytics, I use a trick of bypassing each one with a small 0.1 to 0.47uF capacitor while the set is running. If I see -any- change in the performance, I KNOW the original is not doing its job (greatly reduced in value or open). Of course if you hit the timing caps, it will upset the vertical oscillator a bit... that's normal. For bigger electrolytics like the one used to feed the yoke or power supply main filters, the only effective way to check them is by substitution with the same or larger capacitance. Turn the set off, connect the new cap into the circuit and power it up again.

As I stated before, leaky caps are actually quite rare... but it does happen. They usually upset a circuit a lot more than open ones. Things tend to get hot quickly if the cap is a filter in a power supply. Shorted tantalums and electrolytics in power supplies can literally explode. Obviously, leaky caps must be removed from the circuit to substitute them for test purposes.

Most of the other types of small capacitors: mylar, disc ceramic, etc. are pretty rugged. It is rare indeed to find them bad. It happens just often enough to keep a tech humble.

Gary's Comments on Capacitor Testing

(From: Gary Collins (collgra@preferred.com).)

All an ohm-meter tells you is if the cap is shorted or not if it is an electrolytic of fairly large value it can tell you if a cap is open. I am a tech in a large industrial controls company in the factory service center. We consider any electrolytic cap to be suspect if it's code date is over five years old. We have a Fluke 97 and it is useless for in circuit tests. All a meter like a Fluke 97 can tell you is if the Cap is on the way to being open from electrolyte loss or if it is shorted. Actually not all you need to know. Several other facts you need to know are what is the conductance (internal leakage resistance), it sometimes varies with voltage. You also need to know what a caps power factor is in some cases. That is its ability to pass A.C. This is especially important in computer equipment that has to pass harmonics and noise to ground. Switching power supplies like are found in almost all PC's these days use high frequency voltage converters to regulate voltage. The harmonics and noise produced by this rapid switching heats DC filter caps and causes them to loose moisture from their imperfect seals. This effect causes the capacitor to gradually open or drop in capacitive value.

If you are talking about other types of capacitors you can test their value with a meter but I have seen caps that look good with a meter but break down under voltage. Special cap meters exist that test all these parameters and let you judge whether the cap is good or not but the best test short of that is to replace the cap and see if it works or not. Feel free to ask if that isn't what you wanted to know.

Actually sometimes the best test is to use a oscilloscope to look at what the cap is doing in the circuit.

What About Capacitance Meters?

Simple capacitance scales on DMMs just measure the capacitance in uF and do not test for leakage, ESR (Equivalent Series Resistance), or breakdown voltage. If the measurement comes up within a reasonable percentage of the marked value (some capacitors have tolerances that may be as much as +100%/-20% or more), then in many cases, this is all you need to know. However, leakage and ESR frequently change on electrolytics as they age and dry out.

Many capacitance meters don't test anything else but are probably more accurate than a cheap DMM for this purpose. A meter of this type will not guarantee that your capacitor meets all specifications but if it tests bad - very low - the capacitor is bad. This assumes that the test was made with the capacitor removed (at least one lead from the circuit - otherwise other components in parallel can affect the readings.

To more completely characterize a capacitor, you need to test capacitance, leakage, ESR, and breakdown voltage. Other parameters like inductance aren't likely to change on you.

ESR testers, which are for good for quick troubleshooting, are designed to just measure the Equivalent Series Resistance since this is an excellent indicator of the health of an electrolytic capacitor. Some provide only a go/no go indication which other actually display a reading (usually between 0.01 and 100 ohms so they can also be used as low-ohms meters for resistors in non-inductive circuits). See the section: What is ESR and How Can It be Tested?.

Note: always place the test probes on the capacitor terminals themselves if possible. Any wiring between your meter and the capacitor may affect the readings. Although your user manual may state that you can test capacitors in-circuit, other components in parallel with the capacitor can screw up the readings - usually resulting in an indication of a shorted capacitor or excessively large uF value. Removal is best. Unsoldering only one of the pins is adequate if you can isolate it from the circuit.

Substitution is really the best approach for repair unless you have a very sophisticated capacitance meterd.

The March 1998 issue of Popular Electronics has plans for a digital capacitance tester with a range from 1 pF to 99 uF.

The May 1999 issue of Popular Electronics has plans for an "Electrolytic Meter" which will accurately measure the capacitance and allow the determination of some of the other characteristic of large value capacitors - up to several hundred thousand uF. This is basically a time constant based tester using a constant current source.

More About Capacitor Testing than You Probably Wanted to Know

(From: John Whitmore (whit@hipress.phys.washington.edu).)

First, you need an AC ripple current source. Then, you tune to the frequency of interest (120 Hz for rectifier power supply filter capacitors is usual) and apply both the AC current and a DC voltage bias. Measure the phase shift between the current and the voltage (for a perfect capacitor, this is 90 degrees) and measure the induced voltage (for a perfect capacitor, this is I*2*pi*f*C).

Take the tangent of the difference of the phase shift and 90 degrees. (This is 'tan(delta)' and appears on the spec sheet for the capacitor...)

Then remove the AC, and crank the DC bias up to the voltage surge rating; measure leakage current. Ramp the DC bias down to the working voltage rating; measure leakage current.

Raise temperature and repeat the capacitance, phase shift, and working-voltage measurements at the max temperature the capacitor is rated for.

Yes, it DOES sound rather elaborate, but that's the test that the manufacturers use.

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Safe Discharging of Capacitors in TVs, Video Monitors, and Microwave Ovens

Why This Matters

It is essential - for your safety and to prevent damage to the device under test as well as your test equipment - that large or high voltage capacitors be fully discharged before measurements are made, soldering is attempted, or the circuitry is touched in any way. Some of the large filter capacitors commonly found in line operated equipment store a potentially lethal charge.

This doesn't mean that every one of the 250 capacitors in your TV needs to be discharged every time you power off and want to make a measurement. However, the large main filter capacitors and other capacitors in the power supplies should be checked and discharged if any significant voltage is found before touching anything - some capacitors (like the high voltage of the CRT in a TV or video monitor) will retain a dangerous or at least painful charge for days or longer!

A working TV or monitor may discharge its caps fairly completely when it is shut off as there is a significant load on both the low and high voltage power supplies. However, a TV or monitor that appears dead may hold a charge on both the LV and HV supplies for quite a while - hours in the case of the LV, days or more in the case of the HV as there may be no load on these supplies.

The main filter capacitors in the low voltage power supply should have bleeder resistors to drain their charge relatively quickly - but resistors can fail. Don't depend on them. There is no discharge path for the high voltage stored on the capacitance of the CRT other than the CRT beam current and reverse leakage through the high voltage rectifiers - which is quite small. In the case of old TV sets using vacuum tube HV rectifiers, the leakage was essentially zero. They would hold their charge almost indefinitely.

(From: Edwin Winet (ewinet@softwareresearch.org).)

Some of us work in areas where capacitors are huge, unusual or sometimes both. Many people believe that only "big" capacitors can kill you, knock you across the room, blow a hole in you, or get your attention. Here are a couple of comments:

When a capacitor is safely discharged, do not stop there. Some capacitors, due to their ability to leak---are "dead" after being safely discharged with a "bleeder resistor" of the right value for the job. Using a resistor that is under-rated - wattage-wise - can result in the bleeder going open circuit DURING a discharge sequence LEAVING some energy! High voltage capacitors, or worse yet, high energy-high voltage capacitors require correct wattage AND correct resistance to be bled safely. Also, high microfarad low voltage capacitors can vaporize a screwdriver and spray metal in your eyes. (Adequate voltage margin is also essential for resistors used in high voltage circuits. --- Sam.)

Certain types of capacitors are made of VERY good materials, which can hold a charge for YEARS! Putting away charged capacitors of this type is an invitation to disaster!

Low inductance capacitors that are used in energy pulse circuitry, many times are of the oil-filled high energy/high voltage type. This type can give a MOST un-pleasant surprise AFTER it has been completely drained by a safe bleeding technique. After the capacitor has been bled, IMMEDIATELY short it, from terminal to terminal AND to the external metal can (if applicable)!!! These capacitors RE-charge from their internal fluid and can STILL deliver a lethal, as they "recover" a certain amount of energy! this type of capacitor, or any capacitor of any high (enough) energy value MUST be LEFT shorted.

Be particularly leery of any capacitor with a broken off lead that is sitting in a drawer! Sometimes, these units break off during testing and don't get thrown out - but remain charged - to kill or shock years later.

Lastly, the word "electrocution" is used in many high voltage device writings. That's bad, because it was only intended for the "electric chair", short for electro + execution.

Capacitor Discharge Technique

The technique I recommend is to use a high wattage resistor of about 5 to 50 ohms/V of the working voltage of the capacitor. This isn't critical - a bit more or less will be fine but will affect the time it takes to fully discharge the capacitor. The use of a current limiting resistor will prevent the arc-welding associated with screwdriver discharge but will have a short enough time constant so that the capacitor will drop to a low voltage in at most a few seconds (dependent of course on the RC time constant and its original voltage).

Then check with a voltmeter to be double sure. Better yet, monitor while discharging (monitoring is not needed for the CRT - discharge is nearly instantaneous even with multi-M ohm resistor).

Obviously, make sure that you are well insulated!

- For the main capacitors in a switching power supply, TV, or monitor, which might be 400 uF at 350 V, a 2 K ohm 25 W resistor would be suitable. RC=.8 second. 5RC=4 seconds. A lower wattage resistor (compared to that calculated from V^^2 / R) can be used since the total energy stored in the capacitor is not that great.

- For the CRT, use a high wattage (not for power but to hold off the high voltage which could jump across a tiny 1/4 watt job) resistor of a 1 to 10 M ohms discharged to the chassis ground connected to the outside of the CRT - NOT SIGNAL GROUND ON THE MAIN BOARD as you may damage sensitive circuitry. The time constant is very short - a ms or so. However, repeat a few times to be sure. (Using a shorting clip lead may not be a bad idea as well while working on the equipment - there have been too many stories of painful experiences from charge developing for whatever reasons ready to bite when the HV lead is reconnected.) Note that if you are touching the little board on the neck of the CRT, you may want to discharge the HV even if you are not disconnecting the fat red wire - the focus and screen (G2) voltages on that board are derived from the CRT HV.

- For the high voltage capacitor in a microwave oven, use a 100 K ohm 25 W (or larger resistor with a clip lead to the metal chassis. The reason to use a large (high wattage) resistor is again not so much power dissipation as voltage holdoff. You don't want the HV zapping across the terminals of the resistor.

Clip the ground wire to an unpainted spot on the chassis. Use the discharge probe on each side of the capacitor in turn for a second or two. Since the time constant RC is about 0.1 second, this should drain the charge quickly and safely.

Then, confirm with a WELL INSULATED screwdriver across the capacitor terminals. If there is a big spark, you will know that somehow, your original attempt was less than entirely successful. At least there will be no danger.

DO NOT use a DMM for this unless you have a proper high voltage probe. If your discharging did not work, you may blow everything - including yourself.

The discharge tool and circuit described in the next two sections can be used to provide a visual indication of polarity and charge for TV, monitor, SMPS, power supply filter capacitors and small electronic flash energy storage capacitors, and microwave oven high voltage capacitors.

Reasons to use a resistor and not a screwdriver to discharge capacitors:

1. It will not destroy screwdrivers and capacitor terminals.

2. It will not damage the capacitor (due to the current pulse).

3. It will reduce your spouse's stress level in not having to hear those scary snaps and crackles.

Capacitor Discharge Tool

A suitable discharge tool for each of these applications can be made as quite easily. The capacitor discharge indicator circuit described below can be built into this tool to provide a visual display of polarity and charge (not really needed for CRTs as the discharge time constant is virtually instantaneous even with a muli-M ohm resistor).

- Solder one end of the appropriate size resistor (for your application) along with the indicator circuit (if desired) to a well insulated clip lead about 2-3 feet long. For safety reasons, these connections must be properly soldered - not just wrapped.

- Solder the other end of the resistor (and discharge circuit) to a well insulated contact point such as a 2 inch length of bare #14 copper wire mounted on the end of a 2 foot piece of PVC or Plexiglas rod which will act as an extension handle.

- Secure everything to the insulating rod with some plastic electrical tape.

  This discharge tool will keep you safely clear of the danger area.

Again, always double check with a reliable voltmeter or by shorting with an insulated screwdriver!

Capacitor Discharge Indicator Circuit

Here is a suggested circuit which will discharge the high value main filter capacitors in TVs, video monitors, switchmode power supplies, microwave oven capacitors, and other similar devices quickly and safely. This circuit can be built into the discharge tool described above (Note: different value resistors are needed for LV, HV, and EHV applications.)

A visual indication of charge and polarity is provided from maximum input down to a few volts.

The total discharge time is approximately:

- LV (TV and monitor power supplies, SMPSs, electronic flash units) - up to 1000 uF, 400 V. Discharge time of 1 second per 100 uF of capacitance (5RC with R = 2 K ohms).

- HV (microwave oven HV capacitors) - up to 5,000 V, 2 uF. Discharge time of 0.5 second per 1 uF of capacitance (5RC with R = 100 K ohms)

- EHV (CRT second anodes) - up to 50,000 V, 2 nF. Discharge time of 0.01 second per 1 nF of capacitance (5RC with R = 1 M ohm). Note: discharge time is so short that flash of LED may not be noticed.

Adjust the component values for your particular application.

```
(Probe)
<-------+
 In 1   |
        /
        \    2 K 25 W (LV)    Unmarked diodes are 1N400X (where X is 1-7)
        /  100 K 25 W (HV)     or other general purpose silicon rectifiers.
        \    1 M 10 W (EHV)   Resistors must be rated for maximum expected
        |                      voltage.
        +-------+--------+
      __|__   __|__      |
      _\_/_   _/_\_      /
        |       |        \ 100 ohms
      __|__   __|__      /
      _\_/_   _/_\_      |
        |       |        +----------+
      __|__   __|__    __|__      __|__      Any general purpose LED type
      _\_/_   _/_\_    _\_/_ LED  _/_\_ LED   without an internal resistor.
        |       |        |    +     |    -   Use different colors to indicate
      __|__   __|__      +----------+         polarity if desired.
      _\_/_   _/_\_      |
 In 2   |       |        |
>-------+-------+--------+
(GND Clip)
```

The two sets of 4 diodes will maintain a nearly constant voltage drop of about 2.8-3 V across the LED+resistor as long as the input is greater than around 20 V. Note: this means that the brightness of the LED is NOT an indication of the value of the voltage on the capacitor until it drops below about 20 volts. The brightness will then decrease until it cuts off totally at around 3 volts.

WARNING: Always confirm discharge with a voltmeter before touching any high voltage capacitors!

For the specific case of the main filter caps of switchmode power supplies, TVs, and monitors, the following is quick and effective.

(From: Paul Grohe (grohe@galaxy.nsc.com).)

I've found that a 4 watt 'night light' bulb is better than a simple resistor as it gives an immediate visual indication of remaining charge - well down to below 10 V.

Once it stops glowing, the voltage is down to non-deadly levels. Then leave it connected for a little while longer, and finish it off with the `ole screwdriver.

They're cheap and readily available. You can make dozen 'test-lamps' out of an old 'C7' string of Christmas lights (`tis the season!).

Editor's note: where a voltage doubler (or 220 VAC input) is involved, use two such bulbs in series.

(From: Dave Talcott (75711.1537@compuserve.com).)

I built the capacitor discharge tool. I had all the parts to hand except for the series resistor, for which I used a 2 watt axial unit, since the power dissipation is not critical. I decided to package it in probe form for convenience. Except for the series resistor, which lives in a counterbore, everything is surface mounted and communicates through a LOT of cross-drilled holes. A piece of heat-shrink tubing holds everything in place. The only tricky part was making two small recesses to locate the LEDs. The probe tip is a short piece of solid copper wire salvaged from some Romex house wiring and ground to a point.

Voltage Checkers

Whereas a multimeter is intended to measure voltages (and other things), a checker is used mostly to just produce a quick indication of the presense of voltage, its polarity, and other basic parameters. One use is a quick, but reliable indication of the status of the charge on a BIG capacitor. An, example of a simple version of such a device is the "capacitor discharge indicator circuit" described above.

(From: Ian Field (ionfieldmonitors@ic24.net).)

The version of the checker that I have, also contains a miniature 12 V battery for continuity checking - any resistance less than about 22K will produce some glow. It's handy for quick checks of semiconductor junctions - in general if it produces a slight glow it's leaky, but transistor B/E junctions have an inherent zener voltage, so there is usually some glow. Also schottky-barrier diodes give a reverse leakage glow - this does not mean they're faulty, check the Vf with the diode-check on a DMM before binning! Any zener diode above 10-11 V can be given a quick test for S/C, lower Vz will produce some glow - again check Vf before binning.

These checkers are getting hard to obtain, most of the component stockists here only carry vastly over complicated (and expensive) versions with built-in measurement computer and LCD - these wouldn't last 5 min's around flyback circuitry! Some Automotive accessory shops have a simpler version with no battery - always check that it's stated to be capable of measuring AC or DC at 4 to 380 V before parting with money! The internal circuit should contain the LED's, a 15 ohm resistor to limit the maximum surge current when the PTC is cold and the special PTC film-thermistor. The battery can be added with a button from a VCR front panel - but don't blame me if you kill yourself because you didn't insulate the added components properly! There is a more complicated non-battery version with 2 LED's close to the front of the handle to indicate polarity and a row of LED's along the length of the handle to indicate the voltage-range. This version contains 2 special PTC's and a discrete-transistor bargraph circuit - there might be room to add a battery inside the case. As for the special PTC this is the only place I've seen them - one possibility that might be worthy of looking into is the Siemens PTC SMPSU startup thermistor for TDA4600 control chips, this usually has a series resistor of at least 270 ohms and is more likely to turn-up in European TV set's, but I have seen it in early Matsushita IBM displays and a few others (possibly Tandon) the PTC thermistor is always blue and looks like a very-miniature copy of the Philips white-plastic PTC degauss thermistor.

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Equivalent Series Resistance (ESR) and Related Parameters

What is ESR and How Can It be Tested?

ESR (Equivalent Series Resistance) is an important parameter of any capacitor. It represents the effective resistance resulting from the combination of wiring, internal connections, plates, and electrolyte (in an electrolytic capacitor). The ESR affects the performance of tuned circuits (high ESR reduces the Q factor) and may result in totally incorrect or unstable operation of devices like switchmode power supplies and deflection circuits in TVs and monitors. As would be expected, electrolytic capacitors tend to have a high ESR compared to other types - even when new. However, due to the electrochemical nature of an electrolytic capacitor, the ESR may indeed change - and not for the better - with time.

Here is a Web site that discusses ESR testing in some detail:

- Stephen M. Powell's ESR Page

When troubleshooting electronic equipment, electrolytic capacitors, in particular, may degrade resulting in a significant and unacceptable increase in ESR without a similar reduction in uF capacity when measured on a typical DMM's capacitance scale or even a cheap LCR meter.

There commercial ESR meters and kits available ranging from $50 to $200 or more. Here are a couple of sites to check out:

- Bob Parker's ESR Meter Site (both low cost kit and assembled versions are available).

- Capacitor Wizard Site

There devices can generally be used to measure really low resistances of non-inductive devices or circuits as well (they use AC so inductance would result in inaccurate readings). Since their lowest range is at least 10 times better than a typical DMM (1 ohm full scale - 0.01 ohm resolution), they can even be used to located shorted components on on printed circuit boards.

Note: always place the test probes on the capacitor terminals themselves if possible. Any wiring between your meter and the capacitor may affect the readings. While usually not a problem, very low resistance components in parallel with the capacitor may result in a false negative indication - a capacitor that tests good when in fact its ESR is excessive.

(From: Larry Sabo (ac274@FreeNet.Carleton.CA).)

I find my ESR meter invaluable for finding high ESR caps, and have never seen a shorted cap that hadn't exploded. It's such a pleasure to zip through the caps in a power supply that's duff and find the ones that have had it, all without touching the soldering iron.

There have been days I wish I had the LC102 for it's leakage measuring capability, but in my limited experience the 10% figure seems high. The LC102 commends itself for the inductance ringer, too, but you sure pay a premium. I'll build Sam's gizmo first.

BTW, I built my ESR meter from a kit purchased from Dick Smith Electronics in Australia, for $A 52.74 + $A 25.00 for delivery. It took about 8 hours to assemble, but I'm a fuss-ass.

More on ESR, DF, and Q

(From: Michael Caplan (cy173@FreeNet.Carleton.CA).)

Before I bought my ESR meter I too wondered--what exactly did it measure? Nevertheless, having heard so much about the meter, I went ahead and bought one. It works, and that's the real bottom line.

A recent question about what exactly in being measured (DF or Q) piqued my interest again. I think I have the answer -- 'think' being the operative word. Here's my interpretation.

In summary, the ESR is indeed related to Dissipation Factor (DF), but it is not the same. A DF measuring device might not as readily identify a bad capacitor as does the ESR meter because the reading varies and is not direct, as described below.

Capacitors may be thought of as having pure capacitance (C) and some pure resistance (R), the two being in series. An ideal capacitor would have only C, and no R. However, there are the leads and plates that have some resistance and constitute real R. Any R in series with C will reduce the capacitor's ability to pass current in response to a varying applied voltage, as in filtering or DC isolation applications, and it will dissipate heat which is wasteful and could lead to failure of the component. As with ESR, a lower DF (or higher Q, it's inverse) may be equated with better performance, all other things being equal.

Now I get a bit more mathematical, but only using basic electronic theory and formulas so I hope most will be able to follow this.

DF is defined as Rc/Xc, the ratio of the R in the capacitor (Rc) to the reactance of the capacitor (Xc). The higher the Rc, the higher the DF and the "poorer" the capacitor. So far so good.

The reactance (Xc) is a function of frequency. Xc=1/(2*pi*f*C). So, as the frequency goes up, Xc goes down. Now look back at the formula for DF. DF is an inverse function of Xc. As Xc goes down, DF goes up, and vice-versa. So DF varies proportionately with frequency.

Here's an example using the ubiquitous 22 uF, 16 V electrolytic that seems to be at fault too often in many switched mode power supplies.

At 1000 Hz, this capacitor has an Xc of 7.2 ohms. If the series Rc is only 0.05 ohms (pretty good), then the DF is 0.0069.

At 50,000 Hz, this same capacitor would have an Xc of only 0.14 ohms. At this frequency, the DF is 0.36, again good.

Now, change the Rc from 0.05 to 25 ohms. At 1000 Hz, DF = 3.4. At 50,000 Hz, DF = 178.

So we see that DF is a function of the test frequency. The higher the frequency, the higher the DF. DF is a measure of the capacitor "quality", but the figure is valid only at the frequency of the test. (A good capacitor, with an ideal Rc of zero, will have a DF of zero regardless of frequency.)

DF can indeed be used to identify a bad capacitor, but the user must interpret the level of measured DF that would indicate a bad component. Any 'go/no go' tables of DF values would be valid only at the specified frequency. As an alternative, the user can calculate the Rc by first measuring both DF and C, and then, knowing the test frequency, determine if the Rc is excessive. (Rc=DP*Xc).

The ESR meter measurement system, however, does not appear to be a function of Xc. It measures the voltage across the capacitor resulting from the application of a very short pulse of current. This short pulse is not enough to charge the capacitor so the voltage being measured across the capacitor's leads is primarily a function of Rx, which is not frequency sensitive. And, with the 'tables' of typical ESR (=Rc) that is provided with the ESR meters I have seen, there is no need to do any further calculations.

The ESR meter is not going to be reliable with very small capacitors. In this case, they will become more fully charged by the applied current at the time the meter samples the voltage. Even if the Rc is an ideal zero ohms, the meter will now read the voltage built up on the capacitor and interpret it as a very high (possibly off-scale) ESR. Thus its advantage, and main purpose, is in testing electrolytics which tend to be larger value capacitors.

(Note: The inability of the ESR meter to test low value capacitors is true only if the meter does not distinguish between in-phase and quadrature voltages, and it does not. If it did sense only the in-phase voltage that is produced across Rx (i.e. in-phase with the applied current), then it would not be sensitive at all to the delayed (minus 90 degrees) voltage built up on the capacitor's plates.)

All testing I have done with small capacitors (less than 0.001 uF) seems to suggest that the (Bob Parker) ESR meter is not phase discriminating and Bob Parker has confirmed this. This is not a great disadvantage. The objective of the ESR meter is to identify capacitors that have gone bad. This is more the case with electrolytics where the dielectric compound tends to dry up. Smaller capacitors usually are not electrolytic and therefore tend to be relatively stable. Faults in the latter (e.g. ceramic, mica, polystyrene) are more likely to be open, shorted, or leaky, all of which will be detectable by capacitance or resistance measuring devices.)

(From: Roy McCammon (rbmccammon@ieee.org).)

Note that "equivalent series resistance" is not necessarily the same as "series resistance".

"Series resistance" is just the resistance in series with the capacitance. This is what most of the descriptions have delt with, and with high currents and frequencies as you tend to see in a switchmode supply, the "true series resistance" is just what you want to know.

"Equivalent series resistance" is the resistance that you would have to place in series with a pure capacitance to produce the same loss. It may be frequency dependent. A cap with a resister in parallel has an esr. At a single frequency, you cannot tell the difference between a cap with a parallel resister and a cap with a series resister. For example, at 100 Hz, a 1 uF and 10 ohm in series has a reactance of 10 + J1591, as does a 1 uf in parallel with 253K, hence both have an ESR of 10 ohms.

You need to know just what your meter is doing. Its best that the measurement relate to your use.

Simple ESR meter schematics and plans

Electronics magazines have published various ESR meter schematics over the years. Here is one that is unique is being able to test caps on live equipment though I'm not sure what great advantage this is:

(From: Pete Culf (pete@topden.com).)

> "The January 2003 issue of Television magazine has an article about a *live* - in circuit electrolytic ESR

> tester. The battery operated project by Ian field is based on a TL431 high gain comparator with the input isolated via an optocoupler. It is designed for live testing. I haven't built the thing yet as it's my habit to wait awhile and read about any problems the other guys find before I try it, but in subsequent issues I havn't read of any problems."

Here are a couple of basic analog ESR meter schematics:

Mark Zenier (mzenier@eskimo.com) has an ESR Meter Schematic which is about as simple as it gets.

(From: Gary Woods (gwoods@albany.net).)

Thanks to a friend with a scanner, ESR meter schematics, theory of operation, and sales literature (From a company that, alas, no longer exists) are on my ESR Meter Page.

Boat-anchor relevance - although the device is sand-state, it's just the ticket for checking out those old 'lytics!

ESR testing without an ESR meter

While, the techniques described below can in principle be applied to any capacitor, they will be most useful for electrolytic types. Of course, make sure to observe the polarity and voltage rating of the capacitor during testing! In addition, take care with the maximum voltage applied to other components if you attempt to test caps in-circuit. It should be small enough that semiconductor junctions do not get forward biased (a few tenths of a volt max) and the impedance should be such that low value resistors don't smoke!

The ultimate in cheap if you have an oscilloscope would be: 99 Cent ESR Test Adapter.

(From: Ron Black (ron.black@pstbbs.com).)

An inexpensive way (for the cost of a resistor) to measure the ESR of a capacitor is to apply a squarewave signal through a resistor in series with the capacitor under test. Monitor the waveform on the capacitor using an oscilloscope. When using a sensible squarewave frequency (a few kHz - not one where the inductance of the circuit becomes an issue) there will be a triangle waveform with a step at the squarewave transition times. The amplitude of the step will proportional to the ESR of the capacitor. Calibrate things by adding a known small value ESR simulating resistor in series with the capacitor. This doesn't have to cost anything if you have a squarewave generator, or can build one cheaply.

(From: Gary C. Henrickson (gary@aloha.net).)

Motivated by the discussions on the virtues of ESR testing, I ordered a genuine ESR meter. While waiting for it's arrival, a large pile of dogs were accumulating in my shop.

To crank out these repairs quickly in the meantime, I constructed an 'ESR meter' by cabling a (50 ohm) function generator output to the scope input and, via a T-connector, on to a set of test leads.

With the test leads shorted, mere millivolts displayed on the scope. Across a good capacitor, mere millivolts. Across a sick capacitor, mucho volts. The defective caps stuck out like a sore thumb.

Wow, this is too easy. Instant in-circuit (power off) fool-proof testing of electrolytics. I wish I had thought of this 50 years ago.

I used 100 kHz and 5 V p-p. With scope set at 0.2 V/div you can also check diodes surrounded by low ohm transformer or inductor windings.

(Editor's note: to avoid the possibility of damage to semiconductors due to excessive voltage, use a lower amplitude signal - say 0.5 V p-p - for in-circuit testing. This will also prevent the most semiconductor junctions from conducting and confusing your readings.

(From: Bert Christensen (70461.2507@compuserve.com).)

I have been reading the various messages about ESR checkers and while I don't doubt their value in electronic servicing, I think that the use of these devices adds an extra and IMHO unneeded step. My method of diagnosing possible electrolytic fault is to use just a scope. Remembering that electrolytics pass AC or signals through them, a scope should show *the same* waveshape on both sides of the cap. If the cap is a bypass cap to ground, then the waveshape should just be a flat line on both sides; if it is a coupling cap, the waveshape should be the same on both sides.

There are some exceptions, one being a cap that is used for waveshaping in a vertical circuit but such applications are few. Most electrolytics are either coupling or bypass.

Using 'my' scope method has several advantages. The main one is that it tests caps dynamically in the circuit they are used in and using the actual signals applied to them in real life. The method is fast because you just have to go from one to another (if you are using the scatter-gun approach) using just the scope prod. But, best of all, it seamlessly integrates a total dynamic approach to servicing using the set's own signals or lack thereof. If you are tracing a video circuit, you can find an open cap, an open transistor, or a defective IC using the same piece of equipment.

I have been running a service business for over 40 years. Most of my business today is doing tough-dog service for other service companies.

But, I must admit that sometimes I fix sets just by changing the caps that are swollen. ;-}

(From: Clifton T. Sharp Jr. (clifto@megsinet.net).)

I still do just enough work that I'll one day break down and buy an ESR meter (I always give in and indulge myself with the toys of my "trade"). For now, though, the quickie method I use is the oscilloscope. It goes something like this:

1. Scope positive lead. Any significant AC? If not, go to next cap.

2. Is the AC more than about 5% of the DC? If not, note this location and go to next cap.

3. Scope negative lead. AC here roughly the same as on positive lead? If so, go to next cap. (If this lead is *obviously* grounded, skip this step.)

4. Set off; note value; jumper in roughly same value at safe voltage rating. (Note: make sure both caps are discharged! --- sam)

   Set on; scope positive lead. Significant difference? If not, note this location and go to next cap.

5. Replace cap. Test set. If not okay, go to next cap.

If that doesn't catch it, a quick review of the "noted locations" often does. This fixes 98% of cap problems. Not exhaustive or perfect, nor is it intended to be. Close cover before striking. Probably causes cancer in laboratory rats. Your mileage may vary.

(From: Tony Williams (tonyw@ledelec.demon.co.uk).)

It is always best when measuring a component parameter to lean the measurement method towards some sort of emulation of the application to which the parameter is important. This is particularly true of power components, because the parameter-value may vary with operating conditions. It is essential with magnetics, less so with electrolytics, but a good habit anyway.

Hold the cap charged up and find some way of applying repetitive square *current* pulses to it, an Amp or more each time, depending on the expected ESR.

If the cap has no ESR then a scope across its terminals will show that each current pulse results in a nice smooth ramping triangle. If the cap has an ESR then each triangle will be preceded by a small vertical step. If the current is known, measurement of that step gives you the ESR-value. You can cross-check the accuracy of the method by seeing the effect of increasing the "ESR" as low-value R's are put in series with the cap, 0.01 to 0.1 ohms.

Be careful about the placement of the scope leads, you don't want to measure the IR-drop in the wiring.

If the size of each step+triangle is small compared to the steady voltage on the cap then the known "constant-I" discharge pulse can be approximated with no more than a resistor and switching Fet.

(From: Oliver Betz (list_ob@gmx.de).)

If you want to the decoupling capability, you maybe want to know the ESR only at the series resonant frequency. It's quite simple:

Use a sine generator, connect some coax cable to its output, at the end of the cable put 47 ohms in series and connect the resistor to one end of the cap, connect a kind of detector in the same way (47R - cable - detector) to the same lead. Other end of the cap (and coax shields) to a small ground plane. Detector can be voltmeter, scope or spectrum analyzer, depends on your equipment and resonant frequency. Spectrum analyzer with tracking generator eliminates need for separate generator, makes measurement easy and enables you to measure even very small capacitor values.

Tune to minimum signal at the detector. With a scope you can check also phase shift (thanks for this hint, Winfield!), cap should be only resistive (no phase shift). ESR can be easily calculated now.

(From: George R. Gonzalez (grg@umn.edu).)

After seeing all the glowing recommendations for ESR meters on the sci.electronics.repair newsgroup, I decided to look into this. Being a cheap sort, I first tried setting up my own ESR meter using stuff lying around the shop: Function generator set to 2 volts p-p, 100 kHz sine wave, hooked up to a BNC tee, one side of the tee goes to some clip leads, other side to the scope, set for 0.1 volts/cm, 10 us/cm sweep.

With the clip leads dangling free, the scope trace is almost invisible, as it's zooming up and down 20 cm 10 times across the screen. With the clip leads shorted, I get about 0.3 cm of a sine wave. With a 1 ohm resistor across the clip leads, I get about 1 cm of sine wave.

I put a GOOD 2 uF capacitor across the clip leads, we see about 0.5 cm of sine wave. Tests with various good electrolytics all give less than 1 cm of sine wave.

Now we can just hop along a circuit board bridging the electrolytics as we go along. A good electrolytic is going to show 1 cm or less of deflection. Many old ones with 1970's date codes will show 2 or 3 cm. Probing around a suspect old pc board revealed that 80% of the caps gave more than 2 cm of deflection!

Now this isn't always a bad thing. You have to use a little judgement. If the electrolytic is in a high-impedance circuit, such as coupling two voltage amp stages, a few ohms isn't going to hurt too much. But if it's a bypass capacitor on a Vcc line, it could be significant. Just realize that a circuit may appear to work just fine even with caps with many ohms of ESR. I usually replace these caps anyway, as they're only going to go downhill from here.

I can't tell you how much time this little set-up has already saved me!. Before I had to unsolder one lead of the capacitor, hook it up to the cap bridge, twiddle the dials until I got a semblance of balance, or if it was a bad capacitor, I'd waste even more time trying to find the missing null. Now I can just probe the caps in-circuit, and mark the bad ones with a big red magic-marker for later replacement. It's quick and great for morale.

This method works well with caps in the range of 1 to 500uf, with medium or high ESR. But it doesn't have enough oomph to drive BIG caps. For this you'd need a generator with a lower output impedance.

Next experiment-- we'll hook up a tranny from an old dead SMPS to lower the generator's output impedance so we can test those big PS capacitors. Stay tuned....

BTW, this isn't meant to take away from built ESR meter sales! It may even increase them as once you see how wonderful this technique is, you may want to buy a dedicated ESR meter.

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Electrolytic Capacitors and Special Types

Cool Electrolytics - Temperature Rating Versus ESR

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

Electrolytic capacitors like to be kept cool! If there's anything that these capacitors can't stand, it's heat. It causes them to dry out.

Electrolytic capacitors exist in (at least) two different temperature ratings: 85 C and 105 C. The latter are obviously more temperature resistant. Unfortunately they also tend to have a higher ESR than their 85 C counterparts. So in an application where the heat is due to I^2 * ESR dissipation, the 105 C type may actually be a *worse* choice! If the heat is due to a nearby hot heatsink then 105 C is indeed a better choice.

From: Ralph W. M. (ralphwm@aol.com).)

While it seems true that 105 C electrolytics have about 50% greater ESR when new, compared to similar 85 C electrolytics, IMO, that is not significant in the circuit. If you would (could) perform a long term experiment and install a 85C and a 105 C in the same circuit, and measure the ESR after 1,000 hours, I would expect to see the ESR of the 105 C part after aging/usage, now to be less than the 85 C.

Care, Feeding, and Storage of Electrolytic Capacitors

> "I seem to recollect reading (or is it an old wives' tale?) that electrolytics last longer if you apply a voltage

across them every so often. This to me implies that seldom used devices should be turned on every now and again to make them last longer, not left sitting on the shelf. True or false?"

(From: Ralph W. M. (ralphwm@aol.com).)

Electrolytics have a shelf life. Electrolytics can go bad (i.e., dry out) on the shelf even though they were never used/turned on even once.

Technically, a "stale" electrolytic (more than one year after it was manufactured) would have excessive DC leakage, and should be properly re-formed before using it. In practice, I have never found this to be a problem 99% of the time (only exception is critical timing/direct coupled circuits; very rare these days). The worst I have even noticed, when installing a stale electrolytic, was that the circuit was slightly unstable for 15 minutes, but cleared up and was fine thereafter and NEVER "bounced". (all bets are off if something so old it has "whiskers" is tried though).

How old is too old? I would offer that up to 5 years on the shelf, in practice, should not be a problem. But 10 years stale MIGHT upset things a bit.

Technically, if you read electrolytic specification sheets, you will find that the best (i.e., lowest) DC leakage is not until it has been ACTUALLY used for at least 10% of the total projected lifetime, (i.e., a 1,000 hour @105C electrolytic would not achieve the lowest DC leakage until it was used for 100 hours @ 105C (or used for 600 hours @ 65C; but that conversion is another story).

In practice, IMO, the vast amount of circuitry designs/type of circuits being currently designed, have built into it enough tolerance for above average DC leakage, that (these days), excessive/drifting DC leakage is rarely a problem.

As far as "exercising" seldom used equipment; couldn't hurt.

Some Qs & As about Capacitor Failure

Here is a three part question concerning electrolytic capacitors. This is an automotive computer application.

Problem: Electrolytic capacitors are leaking after a period of time causing computer failure.

Questions:

1. What is/are the physical mechanism which causes the dielectric to leak?
2. Is there advantage to upping the voltage rating for a replacement cap?
3. What are the pros and cons of Tantalum replacements?

(From: Asimov (mike.ross@juxta.mnet.pubnix.ten).)

1. Heat is the enemy of the dielectric, it may be passing a lot of high frequency current for which it was not designed. Leakage current increases exponentially with temperature.

2. This reduces the possibility of rupture of the dielectric junction which, though usually self-healing, can become permanent after repeated episodes.

3. Tantalums will work well into the sub megahertz range. The main problem with them is when their dielectric ruptures and it is connected across a supply with ample current, it can draw some fantastic amount of energy. This usually results in an explosion of the capacitor which sprays hot molten material all around. It goes off like a

gunshot and the tantalum pellet is the bullet.

Comments on ESR and uF Ratings

(From: Asimov (mike.ross@m-net.axess.com).)

I saw a very revealing graph in the Sprague catalog concerning life tests at +130'C plotting ESR versus time. It turns out that for a 10 uF cap, the ESR actually drops during the first 1,500 hours or so. The interesting part is that from 1,500 hours out to 5,000 hours the value then about doubles.

On the other graph the results of a 47 uF cap shows no change in ESR over the whole life time test. However, it's uF value drops by about 2.5%. The 10 uF electro on the other hand shows little capacitance change (less than 1%).

If we extrapolate these results we can see a general trend of the larger value caps losing capacitance over time but their ESR remaining pretty constant and the smaller caps keeping their value but their ESR increases over time. Thus this sort of makes some sense to me as to why those little 1 uF caps are so notorious. Comments welcome...

Voltage Rating of Electrolyitc Capacitors Versus Reliability

Some of the questions go like:

> "I am wondering if there is any problem with replacing a cap of lower voltage rating with one of higher rating. For example, would a 2.2uf 50v cap generally work OK as a replacement for a 2.2uf 16v cap which is used as a filter in a 6 volt or 12 volt circuit? I never used to think twice about doing this, but have seen some discussion recently leading me to question whether an electrolytic will function properly if it is only operated at a small fraction of its rated voltage."

(From: Ralph W. M. (ralphwm@aol.com).)

I know a lot of people try to improve reliability by increasing the volt of the replacement electrolytic. And some companies like Sony issue modification upgrades increasing volt rating. And yes, SOME, (but NOT all) electrolytic manufacturers recommend increasing volt rating to improve reliability of ORGANIC electrolytics. But in my opinion, I would not, and do not.

To improve reliability, I first upgrade the temp. Or I might chose to upgrade to a Low ESR electrolytic. Sometimes, circumstances or logistics prevents the proceeding, and I will increase the uF up to 200% of original IF it is filtering or decoupling application.

Basically, any improvement in lifetime from increasing volt rating would simply come from the larger case size allowing the electrolytic core temp to be perhaps 5C cooler, i.e., the temp reduction comes from the larger case size being a better "radiator". I estimate that increasing the volt rating of the replacement part would not achieve greater than 50% lifetime improvement; BUT at the expense of greater/worse DC leakage, (the greater DC leakage might not be a problem).

On the other hand, I have read some component manufacturers who recommend increasing the uF to improve reliability, and I estimate that 2X the original uF will result in at least 200% improvement (maybe 400%), in component operating lifetime.

And, to anticipate a possible question, i.e., "what if you tried to restore the "1.5X" cap that was operated at a lower voltage to it's original volt rating by trying to carefully, and slowly increasing the applied voltage in order to restore the dielectric". Maybe, I don't know, never performed such an experiment. At a minimum it would require a lot of labor on something that cost relative pennies.

(From: Steve Bell (service@bell-electronics.freeserve.co.uk).)

From experience I see no problem fitting capacitors of slightly higher voltage ratings. I keep a full range of high frequency low ESR 105 deg caps. I find, as an example, when I replace a 47uf 35V cap, it is with a 47uf 50v device. Due to improvements in capacitor manufacturing, the replacement fitted is usually the same size, possibly smaller, and usually has a lower ESR than the original did before failing..

Where problems might occur is if someone fits a much higher voltage cap in a critical area, such as a monitor switchmode power supply or video circuit. Higher voltage capacitors have higher ESR that may be unsuitable for the circuitry.

(From: Robert Macy (macy@california.com).)

The higher voltage electrolytic has a higher esr value.

The ripple current will be the same for both caps and the higher esr means more power dissipated into the cap, drying out the electrolyte and shortening the capacitor's life a lot.

Comments on Old Electrolytics and Failure Mechanisms

A question that often (well, at least sometimes) comes up is what to do with respect to electrolytics capacitors in really old equipment. Replace all?

Without going into an extended discussion (see below):

1. There is no general rule.

2. Equipment that has been heavily used and/or in a hot environment will likely have more problems with dried up capacitors.

3. I would generally just check them and replace any that are much reduced in uF value, have higher ESR, or higher leakage after giving them time to reform. I just was working on a 30 year old Minox strobe. Its electrolytics seem to be as good as the day they were manufactured.

   (From: David Sherman (davids@virtual-cafe.com).)

   I have been "into" electronics for at least 20 years and learned electronics originally on old WWII military surplus gear which was cheap at the time. Since then I have been a degreed EE and professional engineer and an avid junk collector. To really old military gear designers often went to a lot of expense to avoid electrolytics. They' use a big 2-section choke and a couple 4uF oil-filled paper capacitors in a power supply rather than just one big electrolytic because the electrolytics in those days tended to "dry out" and fail with age.

   In early consumer electronics I have often found bad electrolytics. The first thing to do on that old stuff is look and see if anything has leaked out of the capacitors. Next, power it up. It's not unusually at that point for something that has been idle to blow a capacitor with a puff of steam! Then you know which one's bad. Signal capacitors (coupling, emitter/cathode bypass, etc) are not usually a problem because they don't have so much voltage on them as power supply capacitors. After replacing any blown capacitors (and maybe other that look just like it) fire the thing up again. If it doesn't work, check DC voltages across all electrolytics. Even if you don't know what they're for, they should all have DC of the proper polarity and usually within a fair fraction of the working voltage printed on them. Also feel to see if any is hot. I think you're getting the idea.

Now, about salvaging old capacitors. Ones made since, maybe, 1970 are FAR better than ones from the '40s and '50s and are all worth saving unless they have goo leaking from them or the rubber plug is bulging out (kind of like evaluating an old can of beans!). I have never found one in post-1970 gear to go bad from storage. If you want to be sure before installing it in a circuit, simply apply the rated working voltage from a variable power supply (right polarity, of course) and let it sit with it for a few minutes. If you can set the current limit on the supply to a low value, it will prevent a potentially gooey explosion. Applying the DC voltage is actually a good thing. It's called "forming" the capacitor and it builds the insulating oxide film on the aluminum foil.

(From: John Popelish (jpopelish@rica.net).)

There are at least two distinct wear-out mechanisms at work in electrolytics. One is electrolyte loss by leakage from the container. This is made worse by poor seals and heat, so varies a lot depending on the quality of the original package and things like ambient temperature and internal heating by ripple current. If they are stored in cool conditions, they can stay wet for a lot longer than 10 years. The second is oxide deterioration, and this has a thermal and a bias component. Heat speeds up the deterioration during storage, and lack of bias voltage also speeds up the loss. I always plug very old equipment into a variac the first time I bring it up, and apply no more than about 70% line voltage for a while, and check for caps heating up. If everything looks good, I will slowly raise the line to full voltage over about an hour. This allows some oxide recovery to occur without catastrophic thermal rise. I have not had to replace caps wholesale unless reliability was very important (where a later malfunction would be a lot more costly than all the capacitors).

Electrolytic caps have one metal plate and one liquid plate. The dielectric between them is a very thin layer of oxide that is formed on the metal plate after it has been etched to make its surface very spongy and porous. This etching process multiplies the surface area of the metal by many times (increasing the capacitance which is proportional to surface area), but means that the oxide is formed over a very rough surface. So some of the oxide is wrapped around very sharp edges and over points. This is a chemically less stable situation compared to oxide formed over a smooth surface or inside a hollow. Same for oxide formed over metal grain boundaries. Over time, some of this oxide either breaks off, cracks, or reverts to metal and oxygen atoms, resulting in thin spots in the insulating layer.

If the cap is stored with a DC bias, these thin spots draw current which liberates atomic oxygen from the electrolytic which reoxidizes those weak spots as they form. If it is stored without applied voltage, all these spots need reforming at once when the cap is put in service. This makes them leak excessive current, produce lots of gas, and give off heat. If the leakage is bad enough, the cap may self destruct. If large and expensive caps, especially high voltage types, are going to be put in service after extended storage, they can be more gracefully reformed by applying a voltage in series with a current limiting resistance. And they should be checked for acceptable leakage current at rated voltage before being used. I think modern electrolytic caps are expected to last about 10 years in cool storage. Higher temperatures shorten their life.

If you were going to be reforming lots of similar caps, you could build an adjustable DC supply that had both voltage regulation and a current limit that could be set to values appropriate for various sized caps. For one or two, I have used a Variac upstream of a simple unregulated supply. The point is to allow some forming current to flow, but limit it to less than what would cause a noticeable temperature rise in the cap. For a small tubular cap, this on the order of a tenth of a watt. Divide that by the applied voltage, and you have some idea of the current limit needed. For large (fist sized) caps, you might allow the internal dissipation to approach a watt. These power levels would not raise the cap's temperature so that you would notice it with your fingers (though they might cause some quite measurable hot spots at small areas within the cap).

(From: Dbowey)

My recollection of forming electrolytics is that a time-stepped voltage was applied. The timer was me, and I increased the Variac output to a power supply over the span of a day or two, starting with 10% of the rated voltage and ending up with 100%.

(From: Jack Schidt (jack@wintel.net).)

This works well. NOS electrolytic caps should always have this done prior to using. Often, for old gear, NOS or used caps must be used for economics or availability.

Since I do a lot of tube equip repair, I built a small isolated tripler- to easily deliver 450V for the supply electrolytics. I used all new mylar caps.

I modified your procedure slightly by setting the tripler to the working voltage of the cap unloaded, putting a 2 M or so resistor in series with the cap, and connect it to the supply.

For really large (1000 uF+) caps, I use a few hundred K; you want the applied current to be more than the average leakage current of a good cap.

Check the cap voltage periodically with a DVM or VTVM, disconnecting the meter probes immediately after measurement. If you use a high voltage, low leakage transistor as an emitter follower, you can leave the meter connected at all times. I recommend this.

Often you see an older cap get to a particular voltage, then drop dramatically, as its dielectric breaks down, then the process repeats. These should be tossed, as the dielectric clearly has thin spots, and will fail in service.

Some will charge up completely in a few hours [t=RC], some a few days, and some never get off the ground. Toss those that do not charge.

What are These Scored Lines on the Ends of Electrolytic Capacitors?

They are there to channel the debris in a known direction should the capacitor turn into a bomb. Really :-).

However, exploding capacitors aren't all THAT common in properly designed equipment.... (Well, except for that EPROM programmer that had a tantalum electrolytic installed backwards at the factory. Six months later - K-Blam!)

(From: Gary Woods (gwoods@wrgb.com).)

If you look in a DigiKey catalog, they detail the 'Vent Test' in which an electrolytic cap is overloaded in a specified way and the can fails expelling the material *only* through that scored portion. Sounds like material for another urban legend; like the supplier who carefully tested each incoming fuse for blowing in a specified time at a specified overload. Of course, the people trying to *use* those fuses didn't appreciate how nicely they passed these tests!

You can do a vent test by hooking up an electrolytic to your 'suicide cord' and plugging it into 110 VAC. Entertaining. (I did NOT recommend you do this, and am NOT liable!)

Making Non-Polarized Capacitors from Normal Electrolytics

You may find non-polarized electrolytic capacitors in some equipment - usually TVs or monitors though some turn up in VCRs and other devices as well. Large ones may be found in motor starting applications as well. These usually do need to be replaced with non-polarized capacitors. Since polarized types are generally much cheaper, the manufacturer would have used them if it were possible.

For small capacitors - say, 1 uF or less - a non-electrolytic type will very likely be satisfactory if its size - these are usually much larger - is not a problem.

There are several approaches to using normal polarized electrolytic capacitors to construct a non-polarized type.

None of these is really great and obtaining a proper replacement would be best. In the discussion below, it is assumed that a 1000 uF, 25 V non-polarized capacitor is needed.

Here are three simple approaches:

1. Connect two electrolytic capacitors of twice the uF rating and at least equal voltage rating back-back in series:

```
          -  +         +  -
o----------)|-----------|(-----------o
        2,000 uF     2,000 uF
          25 V         25 V
```

   It doesn't matter which sign (+ or -) is together as long as they match.

   The increased leakage in the reverse direction will tend to charge up the center node so that the caps will be biased with the proper polarity. However, some reverse voltage will still be unavoidable at times. For signal circuits, this is probably acceptable but use with caution in power supply and high power applications.

2. Connect two electrolytic capacitors of twice the uF rating and at least equal voltage rating back-back in series. To minimize any significant reverse voltage on the capacitors, add a pair of diodes:

```
      +---|>|----+----|<|----+
      |   -  +   |    +  -   |
o-----+----)|----+-----|(----+------o
        2,000 uF     2,000 uF
          25 V         25 V
```

   Note that initially, the source will see a capacitance equal to the full capacitance (not half). But very quickly, the two caps will charge to the positive and negative peak values of the input across the combination via the diodes. In the steady state, the diodes will not conduct at all and therefore it will be as though they were not in the circuit.

   However, there will be some non-linearity into the circuit under transient conditions (and due to leakage which will tend to discharge the capacitors) so use with care. The diodes must be capable of passing the peak current without damage.

3. Connect two capacitors of twice the uF rating in series and bias the center point from a positive or negative DC source greater than the maximum signal expected for the circuit:

```
                +12 V
                  o
                  |
                  /
                  \ 1K
                  /
         -  +     |     +  -
o----------)|-----+-----|(-----------o
        2,000 uF     2,000 uF
          35 V          35 V
```

The resistor value should be high compared to the impedance of the driving circuit but low compared to the leakage of the capacitors. Of course, the voltage ratings of the capacitors need to be greater than the bias plus the peak value of the signal in the opposite direction.

About Tantalum Capacitors

(From: Ralph W. M. (ralphwm@aol.com).)

First off, you need to identify/specifiy the particular Tantalum you're speaking of. There are both SOLID, and ORGANIC tantalum's. If it is the familar epoxy teardop case style, it is the solid variety; any other package could be either solid or organic, (and they are NOT the same).

Yes, Solid tantalums can explode. But this is either rare in the case of manufactured equipment in original condition, OR someone modified, the circuit and selected/sized it improperly. Solid Tantalums are VERY intolerant of spikes/surges; BUT organic electrolytics are tolerant of spikes/surges; (BUT organic electrolytics are NOT a direct subsitute for solid tantalums!!!).

Solid tantalums are VERY stable in regards to:

1. The uF value.

2. Extreemly stable DC leakage. Notice, I did NOT say low leakage; they have average DC leakages compared to modern electrolytics.

Solid tantalums also have VERY low impedance, at low frequencies; (organic tantalums do not).

The statement that solid tantalums have lower DC leakages when compared to organic electrolytics has become a misnomer, i.e., 20 years ago that would basically be true, but not today. Currently the DC leakages of Solid tantalum's is similar to the average organic electrolytic; there are some organic electrolytics that have approx 50% LESS DC leakage, (after allowing from 2 to 5 minute "warm up"), (BUT solid tantalums have both VERY stable DC leakage, and NO "warm up").

Supercaps and Ultracaps

(From: Nicholas Bodley (nbodley@tiac.net).)

Within the past 2 weeks or so (current date: 11-August-1997), probably prompted by an article in EE Times, I set Excite to dig for 'supercapacitors' and 'ultracapacitors'. I did find that when you use the 'More Like This option' enough, it gives you the same hits.

Anyhow:

What I found was fascinating to an old-timer. Capacitor technology is now at the point where it can do load-leveling to extend the life of electric vehicle (EV) batteries. The high power needed for EV acceleration can be provided by an ultracapacitor. The ultracap. can also absorb energy for regenerative braking, to limit the otherwise very high charging current for the battery.

Noted in passing was a Mazda experimental EV that uses ultracaps. this way; it is called, believe it or not, the Bongo Friendee. No kidding. (I have a collection of 7 or 8 other such names...)

Mentioned were capacitors of 1,800 **farads** at 2.3V. Yup, we're now in the kilofarad era, folks! The capacitor bank comprised a total of 80, in groups of two in parallel, 40 groups in series. Total voltage was 92.

Other specifications noted in passing:

Ultracaps. are now in the 0.1 to 8 kWh (kilowatt-hour) range.

Some are made of carbon aerogels (that must not be news...)

Maxwell has an 8-cell assembly rated at 24V, bipolar, 4.5 Wh/kg. The same company also has a monopolar cell (monopolar?) rated at 2,300 F, 3V; 5 Wh/kg. This one can provide over 100 A !

Some ultracapacitors apparently (pretty sure) do not use electric double layer technology. They use oodles of alternating layers of conductor and dielectric, stacked 'to the thickness of a credit card'. Some keen mind(s) have found out how to make a dielectric layer that is 'intrinsically free of defects'. These caps, fairly sure, use metal conductors; they have quite-low inductance.

Multilayer thin-film caps can be made up to 25 cm^2, to 1,200 V (!), and store 10 joules / cm^2 with applied voltage just below breakdown.

Also noted, but considering the topic, maybe a repeat: Carbon aerogel caps can go to 40 F /cm^3; work excellently as cold as -30 C, and can manage power over 7kW/kg. Self-discharge is in weeks.

I found this info. utterly fascinating. When I get a decent job, I'm getting myself a 100F Elna.

BTW, did you hear that a DMM uses a supercap. for power? I think the figures are that a 3 minute charge will run it for 3 hours.

What are those X and Y Capacitors in the AC Line Input?

> "I have noticed recently that so-called "X" and "Y" capacitors are used at the input power section of power supplies. When I have looked into this further, I find that there are various grades of X and Y - X1, X2, Y1, Y2, etc. Apparently this is code or regulatory agency related.
>
> 1. What is the definition or use of the various classes are (X1, X2, etc.)

2. Where do the regulator agencies say we must use the various types.
3. What is good design practice for noise filtering of a SMPS using these devices et al."

(From: Paul Kasley (kasley@fnal.gov).)

Class X caps are for across-the-line use. Class Y caps are for line-to-safety ground. These caps are constructed to be "self-clearing". That is, if the device develops a short, the energy dissipated in the short will "blow" the short away. A typical line input filter will have a single Class X cap from line to neutral or from line to line and a Class Y cap from each line to ground or from line to ground and neutral to ground. No regulatory agencies require their use. However, you may find you need them to meet EMI/EMC regulations and to meet your own EMI/EMC susceptibility requirements. UL, CSA, VDE, and other safety agencies will require that you use proper components to meet safety standards (which is always good practice) and to receive permission to use their safety markings. As for the precise differences between the types (X1, X2, Y1, Y2), I suggest you contact cap manufacturers such as Vishay-Roederstein for their catalogs and applications books.

Photoflash Capacitors

These are found not only in electronic flash units and strobes, but pulsed laser power supplies and other fast discharge applications. They are designed for rapid discharge with minimum losses and without self destructing. Thus, the ESR and inductance are very low and the internal structure is set up to survive very high peak currents (hundreds or thousands of amps).

The common ones from photographic flash units are electrolytic capacitors but those in more specialized applications may be other types which can have much shorter pulse durations.

Note that photoflash capacitors may have mediocre temperature ratings like 55 °C instead of the 70 to 105 °C normally found in consumer electronic equipment. Thus, they may not be appropriate for use as service parts replacements for general electronics even though the uF and voltage ratings match.

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On-Line Tech-Tips Databases

Version 1.15 (10-Aug-03)

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Every attempt has been made to assure that the information in this document is up to date and accurate. However, these Web sites come and go without prior notice and may change their access policies including charges or restrictions. In addition, their recommendations may not be correct resulting in added time, expense, and possible damage to equipment. They also assume that the user is aware of required electrical and fire safety guidelines and precautions.

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

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Introduction

Scope of This Document

Note: This document replaces the individual sections in each of major repair guides.

A number of organizations have compiled databases covering thousands of common problems with VCRs, TVs, computer monitors, and other electronic equipment. Most charge for their information but a few, accessible via the Internet, are either free or have a very minimal monthly or per-case fee. In other cases, a limited but still useful subset of the for-fee database is freely available.

A tech-tips database is a collection of problems and solutions accumulated by the organization providing the information or other sources based on actual repair experiences and case histories. Since the identical failures often occur at some point in a large percentage of a given model or product line, checking out a tech-tips database may quickly identify your problem and solution.

In that case, you can greatly simplify your troubleshooting or at least confirm a diagnosis before ordering parts. My only reservation with respect to tech-tips databases in general - this has nothing to do with any one in particular - is that symptoms can sometimes be deceiving and a solution that works in one instance may not apply to your specific problem. Therefore, an understanding of the hows and whys of the equipment along with some good old fashioned testing is highly desirable to minimize the risk of replacing parts that turn out not to be bad.

The other disadvantage - at least from one point of view - is that you do not learn much by just following a procedure developed by others. There is no explanation of how the original diagnosis was determined or what may have caused the failure in the first place. Nor is there likely to be any list of other components that may have been affected by overstress and may fail in the future. Replacing Q701 and C725 may get your equipment going again but this will not help you to repair a different model in the future.

One alternative to tech-tips databases is to search via Google Groups (formerly Deja.com/Dejanews) for postings with keywords matching your model and problem and the USENET newsgroup sci.electronics.repair. See the document: Troubleshooting of Consumer Electronic Equipment for more information.

Safety

The people who compile tech-tips databases assume you know what you are doing, at least to the extent of taking appropriate precautions to minimize the possibility of bodily harm and equipment damage. Before going inside any piece of electronic equipment, make sure you understand and follow the guidelines in the document: Notes on Safety. If you are at all unsure of your understanding of this safety info, take the equipment to a professional for repair or buy a new one. Your life is more valuable than the few dollars you might save by doing it yourself!

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List of On-Line Tech-Tips Databases

This list is a lot shorter than it was the last time I went through and checked the tech-tips sites to be sure they still existed. :(

- Here are some tech-tips sites for computer monitors, TVs, and VCRs:

  - Anatekcorp Tech Forum (Free)
  - Repair World (about $8/month)
  - Electronic Repair Tips Home Page (Free, somewhat limited)

- Here is a site from which you should be able to download a fully operational version of a database with over 115,000 tips for TVs, VCRs, camcorders monitors, microwave ovens, audio equipment, and more. It will work for 14 days and can be purchased and registered during this time. There are versions for both Windows (WinSTIPS) and DOS (SVCTIPS). This from KDTV - Indiana Wholesale Electronics:

  - WinSTIPS and SVCTIPS Page

  They also offer ServiceTalk, an on-line discussion group for electronics repair professionals. This members-only forum has access to a subset of WinSTIPS (about 17,000 tips).

- Here are a couple of comprehensive tech-tips databases just for VCRs that are currently free:

  - Fixer - VCR Repair Instruction (Quite extensive)
  - Vidcam (Australia, but has USA models as well)

- (From: Sidney (sidneybek@yahoo.com).)

  Here is a list of my 390 sites containing free repair tips, forums, free schematics/service manuals & EEPROM access, I have organized them in accordance to subject so you would have to go through them and find which sets have what you need:

  - 390 Web Sites Containing Repair Tips, Forums, Schematics and EEPROM Access

- This has quite a bit of info for TVs. Some may be free but others require a relatively small charge (up to $25) or a monthly or other membership fee. However, this may include a personal reply from a technician experienced with your monitor so it could be well worth it:

  - Shop Helper

- Here is free site just for TVs with some tips mainly for RCA and Sony with a some for "miscellaneous". They also have EEPROM setup parameters for some samples of the RCA/GE/Proscan CTC175 and CTC177 chassis.

- Videotech

- This one is really an amateur radio site but has tech-tips for a variety of (mostly) European TVs:

  - B.A.D.A.R.C. Homepage.

- The following are just for monitors:

  - KMR Technical Services Tech Support ($19.95 charge)
  - ADCC (Tech-tips of the month and 'ask a wizard' options)
  - AMR Monitor Repair Tips
  - Noahtech (Some tips, other repair info)

- This one has monitor schematics and some tech-tips and allows upload of your schematics or tech-tips:

  - Monitory upload page

  - Monitors starting with "s". (I can't find an index to all the monitors, just replace the "s" in "s.htm" with the first letter of your monitor.)

- The following is specifically for microwave ovens. In addition to a large database of specific repairs, there is a great deal of useful information and links to other sites:

  - MicroTech Home Page (Everything you always wanted to know about microwave ovens)

  The next one is provided at the Bucks County Tech School Audio/Video Technology Web site.

  - Tech-Tips for Technicians (Tech-Tips for all sorts of equipment but not very extensive)

These types of sites seem to come and go so it is worth checking them out from time-to-time even if you don't have a pressing need. If possible, download and archive any useful information for use on a rainy day in the future. Some also include many useful links in addition to the tech-tips info so are worth investigating even if you don't have a specific symptom to deal with! The sites in this list were active as of the version date - that's all I'll guarantee! :)

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Notes on the Troubleshooting and Repair of Compact Disc Players and CDROM Drives

Version 3.47

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Working on optical storage equipment entails a number of personal risks: electrical, laser, mechanical, as well as the possibility of irreversible damage to the equipment and loss or corruption of data due to improper repair or adjustment.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Introduction

Compact discs and the digital audio revolution

The transformation of CD players and CDROMs from laboratory curiosities to the economical household appliances that have revolutionized the musical recording industry and have made possible multimedia computing depend on the availability of two technologies: low power low cost solid state laser diodes and mass produced large scale integrated circuits. Without these, a CD player using 1960's technology would be the size of dishwasher!

Most of us take all of this for granted rarely giving any thought to the amazing interplay of precision optics and complex electronics - at least until something goes wrong. The purpose of this document is to provide enough background on CD technology and troubleshooting guidance so that anyone who is reasonably handy whether a homeowner, experimenter, hobbiest, tinkerer, or engineer, can identify and repair many problems with CD players and possibly laserdisc players, CDROM drives, and optical storage drives as well.

Even if you have trouble changing a light bulb and do not know which end of a soldering iron is the one to avoid, reading through this document will enable you to be more knowledgeable about your CD player. Then, if you decide to have it professionally repaired, you will have a better chance of recognizing incompetence or down right dishonesty when dealing with the service technician. For example, a bad laser is not the most likely cause of a player that fails to play discs - it is actually fairly far down on the list of typical faults. A dirty lens is most likely. There - you learned something already!

Scope of this document

This document was developed specifically for the troubleshooting and repair of the CD players in component stereo systems, compact stereos, boomboxes, car units and portables, as well as CDROM drives (including the Sony Playstation).

The primary differences between these types will relate to how the disc is loaded - portables usually are top loaders without a loading drawer or tray:

However, as a result of the level of miniaturization required for portables and to a lesser extent, CDROM drives, everything is tiny and most or all of the electrical components are surface mounted on both sides of an often inaccessible printed circuit board with the entire unit assembled using screws with a mind of their own and a desire to be lost.

For other types:

- Laserdisc players and optical disk storage units have much in common with CD players with respect to the mechanical components and front-end electronics. Therefore, the information contained in this document can represent a starting point for their troubleshooting as well. However, they may include additional servo systems (optical pickup tilt, for example), as well as additional and/or different signal processing subsystems.

- DVD (Digital Versatile - or Video - Disc) players (which are now widely available and will completely replace CD players in a few years), suffer from many of the same problems as CDs and Laser Discs. Thus, a familiarity with the operating and repair of current technology will give you a head start on the amazing wonders (and similarly amazing problems) to come. There is a great deal of information on DVD technology in the DVD FAQ. Electronics Now, December, 1997, has a nice article by Steven J. Bigelow covering everything from the DVD format to installing and using a DVDROM drive in your PC.

- BD (Blu-Ray) players and recorders. Stay tuned for future developments. However, much of the information on CD and DVD technology applies to these next generation high capacity video and computer storage devices as well.

Note that throughout this document, the term 'CD player' is used most often. However, it should be understood that in most cases, the information applies to CDROM drives, game machines using CDs like the Sony Playstation, laserdisc players, MiniDisk players/recorders, DVD players, and other types of optical disk systems. Also see the document specifically devoted to these other technologies: "Notes on the Troubleshooting and Repair of Optical Disc Players and Optical Data Storage Drives". Also, where I remember, the term 'disc' is used to denote a read-only medium (e.g. a regular audio CD or LD) while 'disk' is used for one that is recordable (e.g., CD-R or MiniDisk).

Note: Links to all the diagrams and photographs referenced from this document can be found in Sam's CD FAQ Files.

Types of problems found in CD players

Many common problems with CD players can be corrected without the need for the service manual or the use of sophisticated test equipment (though a reliable multimeter will be needed for any electrical tests and an oscilloacope of at least 5 MHz bandwidth is highly desireable for servo alignment and more advanced troubleshooting). The types of problems found in a CD player can be classified into several categories:

1. Mechanical - dirt, lubrication, wear, deteriorated rubber parts, dirty/bad limit switches, physical damage. A dirty lens (coated with dust, tobacco smoke residue, or condensed cooking grease) - easily remedied - is probably the number one cause of many common problems: discs not being recognized, seek failure, audible noise, and erratic tracking, sticking, or skipping.

   Even many professionals may mistake (either accidentally or on purpose) these symptoms being due to much more serious (and expensive) faults. Don't be fooled!

   Cleaning of the lens and any other accessible optical components (usually only the turning mirror, if that) and a mechanical inspection should be the first things done for any of these problems (and as periodic preventive maintenance especially if the equipment is used in a less than ideal environment). See the section: General inspection, cleaning, and lubrication.

2. Electrical Adjustments - coarse tracking, fine tracking, focus, laser power. However, some CD players no longer have some of these adjustments. The servo systems are totally digital - they either work or they don't.

3. Power problems (mostly portables) - weak batteries, inadequate, defective, or improper AC wall adapter.

4. Bad connections - broken solder on the pins of components that are stressed like limit or interlock switches, or audio or power jacks, internal connectors that need to be cleaned and reseated, broken traces on flexible cables, or circuit board damage due to a fall.

5. Electrical Component Failure. These are rare except for power surge (storm and lightning strike) related damage which if you are lucky will only blow out components in the power supply. (Or, plugging a 3 V portable into the 12 V of your automobile. You can probably forget about this even being a CD player again.)

6. Incompatible geographic location. :-) This doesn't really apply to CD players but may be a factor with equipment like Sony PlayStations and very likely with DVD players. In their infinite wisdom (or greed), manufacturers are including 'country codes' on the discs so that a game or movie sold in one place cannot be used in another. So, if you bought a disc on the other side of the world and it doesn't work at home, thank the lawyers.....

You can often repair a CD player which is faulty due to (1) or (2) except for laser power which I would not attempt except as a last resort without a service manual and/or proper instrumentation if needed - improper adjustment can ruin the laser. If discs are recognized at all or even if the unit only focuses correctly, then laser power is probably ok. While the laser diodes can and do fail, don't assume that every CD player problem is laser related. In fact, only a small percentage (probably under 10%) are due to a failure of the laser diode or its supporting circuitry. Mechanical problems such as dirt and lubrication are most common followed by the need for electrical (servo) adjustments.

The solutions to category (3) and (4) problems are obvious - but it may take a conscious effort to remember to check these out before assuming that the fault is due to something much more serious.

Category (5) failures in the power supply of component (AC line powered) CD players can also be repaired fairly easily.

Most other electrical failures will be difficult to locate without the service manual, test equipment, and a detailed understanding and familiarity with audio CD technology. However, you might get lucky. I have successfully repaired problems like a seek failure (replaced a driver chip because it was running excessively hot) and a door sensor failure (traced circuitry to locate a bad logic chip). Since so much of the intelligence of a CD player is in the firmware - the program code inside the microcontroller, even the schematic may be of only marginal value since I can pretty much guarantee that the firmware will not be documented. The service manuals rarely explain *how* the equipment is supposed to work - and then perhaps only in poorly translated Japanese!

You can pretty much forget about repairing electrical problems in portable equipment other than perhaps bad connections (usually around the audio or power jacks, internal connectors, interlock switch (since it is stressed), or elsewhere due to the unit being dropped). Nearly everything in a portable (and most CDROM drives for that matter though this is not quite as bad) is itty-bitty surface mount components. There is generally only minimal useful information printed on the circuit board. Tracing the wiring is a nightmare. Even the test points and adjustments may be unmarked!

Repair or replace?

While CD players with new convenience features are constantly introduced, the basic function of playing a CD has not changed significantly in 15 years. None of the much hyped 'advancements' such as digital filters, oversampling, one bit D/As, and such are likely to make any difference whatsoever in the listening pleasure of most mortals. The people who care, do so only because they are more concerned with the technology than the musical experience. Most of these so called advances were done at least in part to reduce costs - not necessarily to improve performance.

Therefore, unless you really do need a 250 disc CD changer with a remote control that has more buttons than a B777 cockpit and 2000 track programmability, a 10 year old CD player will sound just as good and repair may not be a bad idea. Many older CD players are built more solidly than those of today. Even some new high-end CD players may be built around a mostly plastic optical deck and flimsy chassis.

If you need to send or take the CD player or CDROM drive to a service center, the repair could easily exceed the cost of a new unit. Service centers may charge up to $50 or more for providing an initial estimate of repair costs but this will usually be credited toward the total cost of the repair (of course, they may just jack this up to compensate for their bench time). Parts costs are often grossly inflated as well - possibly due to a deliberate effort on the part of manufacturers to discourage repair of older equipment. However, these expensive parts do not really fail nearly as often as is commonly believed - the laser is not the most likely component to be bad! Despite this, you may find that even an 'authorized' repair center will want to replace the expensive optical pickup even when this is not needed. I do not know how much of this is due to dishonesty and how much to incompetence.

If you can do the repairs yourself, the equation changes dramatically as your parts costs will be 1/2 to 1/4 of what a professional will charge and of course your time is free. The educational aspects may also be appealing. You will learn a lot in the process. Thus, it may make sense to repair that bedraggled old boombox after all.

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CD Digital Audio Technology

General Introduction to CD Technology

Information on a compact disc is encoded in minute 'pits' just under the label side of the CD. The CD itself is stamped in much the same way as an old style LP but under much more stringent conditions - similar to the conditions maintained in the clean room of a semiconductor wafer fab. The CD pressing is then aluminum coated in a vacuum chamber and the label side is spin-coated with a protective plastic resin and printed with the label.

CD-Rs - recordable CDs use a slightly different construction. CD-R blanks are prestamped with a spiral guide groove and then coated with an organic dye layer followed by a gold film, resin, and label. The dye layer appears greenish and deforms upon exposure to the focused writing laser beam to form pits and lands.

The newest variation - DVDs or Digital Versatile Disks (or Digital Video Disks depending on who you listen to) - implement a number of incremental but very significant improvements in technology which in total add up to a spectacular increase in information density - almost 10:1 for the same size disc. These include higher frequency laser (670 or shorter visible wavelength), closer track spacing, better encoding, and a double sided disc. According to early reports on the final specifications, DVDs will be able to store 8 times the audio of current CDs at a higher sampling rate and bit resolution, 2 hours of MPEG encoded high quality movies, and all kinds of other information. Raw data capacity is somewhere between 5 and 10 GBytes. See the section: Comparison of CD and DVD Specifications for additional information.

On the near horizon is the "Blu-Ray" standard using a blue-violet laser to achieve even higher capacity for multimedia and computer storage applications. See the section: Comparison of CD, DVD, BD Specifications

CD information storage and playback

The actual information to be recorded on a CD undergoes a rather remarkable transformation as it goes from raw audio (or digital data) to microscopic pits on the disc's surface. For commercial or professional audio recording, the process starts with pre-filtering to remove frequencies above about 20 kHz followed by analog-to-digital conversion, usually at a sampling rate of 48 K samples/second for each stereo channel. The resulting data stream is then recorded on multi-track digital magnetic tape. All mixing and pre-mastering operations are done at the same sampling rate. The final step is conversion through re-sampling (sample-rate conversion including some sophisticated interpolation) to the 44.1 K samples/second rate actually used on the CD (88.2 K total for both channels). (In some cases, all steps may be performed at the 44.1 K rate.)

That is followed by extremely sophisticated coding of the resulting 16-bit two's-complement samples (alternating between L and R channels) for the purpose of error detection and correction. Finally, the data is converted to a form suitable for the recording medium by Eight-to-Fourteen modulation (EFM) and then written on a master disk using a precision laser cutting lathe. A series of electroplating, stripping, and reproduction steps then produce multiple 'stampers', which are used to actually create the discs you put in your player (more below).

Of course, it is possible to create your own CDs with a modestly priced CD-R recorder (which does not allow erasing or re-recording). Now, re-writable CD technology with fully reusable discs enables recording and editing to be done more like that on a cassette tape

Like a phonograph record, the information is recorded in a continuous spiral. However, with a CD, this track (groove or row of pits - not to be confused with the selections on a music CD) starts near the center of the CD and spirals (counterclockwise when viewed from the label side) toward the outer edge. The readout is through the 1.2 mm polycarbonate disc substrate to he aluminized information layer just beneath the label. The total length of the spiral track for a 74 minute disc is over 5,000 meters - which is more than 3 miles in something like 20,000 revolutions of the disc!

The digital encoding for error detection and correction is called the Cross Interleave Reed-Solomon Code or CIRC. To describe this as simply as possible, the CIRC code consists of two parts: interleaving of data so that a dropout or damage will be spread over enough physical area (hopefully) to be reconstructed and a CRC (Cyclic Redundancy Check) like error correcting code. Taken together, these two techniques are capable of some remarkable error correction. The assumption here is that most errors will occur in bursts as a result of dust specs, scratches, imperfections such as pinholes in the aluminum coating, etc. For example, the codes are powerful enough to totally recover a burst error of greater than 4,000 consecutive bits - about 2.5 mm on the disc. With full error correction implemented (this is not always the case with every CD player), it is possible to put a piece of 2 mm tape radially on the disc or drill a 2 mm hole in the disc and have no audio degradation. Some test CDs have just this type of defect introduced deliberately.

Two approaches are taken with uncorrectable errors: interpolation and muting. If good samples surround bad ones, then linear or higher order interpolation may be used to reconstruct them. If too much data has been lost, the audio is smoothly muted for a fraction of a second. Depending on where these errors occur in relation to the musical context, even these drastic measures may be undetectable to the human ear.

Note that the error correction for CDROM formats is even more involved than for CD audio as any bit error is unacceptable. This is one of many reasons why it is generally impossible to convert an audio CD player into a CDROM drive. However, since nearly all CDROM drives are capable of playing music CDs, much can be determined about the nature of a problem by first testing a CDROM drive with a music CD.

CD (disc) construction

The information layer as mentioned above utilizes 'pits' as the storage mechanism. (Everything that is not a pit is called a 'land'.) Pits are depressions less than .2 um in depth (1/4 wavelength of the 780 nm laser light taking into consideration the actual wavelength inside the polycarbonate plastic based on its index of refraction). Thus, the reflected beam is 180 degrees out of phase with incident beam. Where there is a pit, the reflected beam from the pit and adjacent land will tend to cancel. This results in high contrast between pits and lands and good signal to noise ratio. Pits are about .5 um wide and they come in increments of .278 um as the basic length of a bit (encoded, see below) on the information layer of the disc.

Each byte of the processed information is converted into a 14 bit run length limited code taken from a codebook (lookup table) such that there are no fewer than 2 or more than 10 consecutive 0s between 1s. By then making the 1s transitions from pit to land or land to pit, the minimum length of any feature on the disc is no less than 3*p and no more than 11*p where p is 0.278 um. This is called Eight-to-Fourteen Modulation - EFM. Thus the length of a pit ranges from 0.833 to 3.054 um.

Each 14 bit code word has 3 additional sync and low frequency suppression bits added for a total of 17 bits representing each 8 bit byte. Since a single bit is .278 um, a byte is then represented in a linear space of 4.72 um. EFM in conjunction with the sync bits assure that the average signal has no DC component and that there are enough edges to reliably reconstruct the clock for data readout. These words are combined into 588 bit frames. Each frame contains 24 bytes of audio data (6 samples of L+R at 16 bits) and 8 bits of information used to encode (across multiple frames) information like the time, track, index, etc:

```
Sync                     (24 + 3).
Control and display      (14 + 3).
Data                     (12 * 2 * (14 + 3).)
Error correction         ( 4 * 2 * (14 + 3).)
                         --------------------
                         588 total bits/frame
```

A block, which is made up of 98 consecutive frames, is the smallest unit which may be addressed on an audio CD and corresponds to a time of 1/75 of a second. Two bits in the information byte are currently defined. These are called P and Q. P serves a kind of global sync function indicating (among other things) start and end of selections and time in between selections. Q bits accumulated into one word made of a portion of the 98 possible bits in a block encodes the time, track and index number, as well as many other possible functions depending where on the disc it is located, what kind of disc this is, and so forth.

Information on a CD is recorded at a Constant Linear Velocity - CLV. This is both good and bad. For CD audio - 1X speed - this CLV is about 1.2 meters per second. (It really isn't quite constant due to non constant coding packing density and data buffering but varies between about 1.2 and 1.4 meters per second). CLV permits packing the maximum possible information on a disc since it is recorded at the highest density regardless of location. However, for high speed access, particularly for CDROM drives, it means there is a need to rapidly change the speed of rotation of the disc when seeking between inner and outer tracks. Of course, there is no inherent reason why for CDROMs, the speed could not be kept constant meaning that data transfer rate would be higher for the outer tracks than the inner ones. Modern CDROM drives with specs that sound too good to be true (and are) may run at constant angular speed achieving their claimed transfer rate only for data near the outer edge of the disc.

Note that unlike a turntable, the instantaneous speed of the spindle is not what determines the pitch of the audio signal. There is extensive buffering in RAM inside the player used both as a FIFO to smooth out data read off of the disc to ease the burden on the spindle servo as well as to provide temporary storage for intermediate results during decoding and error correction. Pitch (in the music sense) is determined by the data readout clock - a crystal oscillator usually which controls the D/A and LSI chipset timing. The only way to adjust pitch is to vary this clock. Some high-end players include a pitch adjustment. Since the precision of the playback of the any CD player is determined by a high quality quartz oscillator, wow and flutter - key measures of the quality of phonograph turntables - are so small as to be undetectable. Ultimately, the sampling frequency of 44.1 K samples per second determines the audio output. For this, the average bit rate from the disc is 4.321 M bits per second.

Tracks are spaced 1.6 micrometers apart - a track pitch of 1.6 um. (This is the nominal specification but may vary somewhat and will be less on those CDs that contain more than 74 minutes of music or 650 MB of data. However, unlike LPs, the pitch is not affected in the slightest by the content.) Thus a 12 cm disc has over 20,000 tracks for its 74 minutes of music. Of course, unlike a hard disk and like a phonograph record, it is really one spiral track over 3 miles long! However, as noted above, the starting point is near the center of the disc. The width of the pits on a track is actually about 0.5 um. The focused laser beam is less than 2 um at the pits. Compare this to an LP: A long long playing LP might have a bit over 72 minutes of music on two sides or 36 minutes per side. (Most do not achieve anywhere near this much music since the groove spacing needs to vary depending on how much bass content the music has and wide grooves occupy more space.) At 33-1/3 rpm, this is just over 1,200 grooves in about 4 inches compared to 20,000 tracks on a CD in a space of just over 1.25 inches! The readout stylus for an LP has a tip radius of perhaps 2 to 3 mils (50 to 75 um).

CD (disc) manufacturing

(From: Reinhart (Lasernut23@aol.com).)

An LP is pressure pressed using a solid vinyl biscuit. A CD, on the other hand, is not manufactured in this manner. CDs are replicated through injection molding, where molten polycarbonate is injected into a mold under high pressure. CDs *must* be manufactured in strict clean room environments. On a side note, when LaserDiscs were released to market by MCA DiscoVision in 1978, this requirement wasn't recognized, or ignored by MCA Corporate in an attempt to keep manufacturing costs of these silver platters down. The first discs were manufactured in an environment similar to an LP plant. As a result, the finished product, while looking visibly okay when observed casually, had major problems playing reliably on many LaserDisc players. Now, of course, we know better, although Pioneer recognized these requirements far more quickly than MCA. Even RCA's Videodisc plant for their needle-in-grove CED (SelectaVision Videodisc) format recognized these requirements better than MCA! CED's market introduction in 1981 did not start as catastrophically like LaserDisc did as a result.

And you thought driving on a narrow winding country road was tough!

To put the required CD player servo system performance into perspective, here is an analogy:

At a constant linear velocity of about 1.2 meters per second, the required tracking precision is astounding: Proper tracking of a CD is equivalent to driving down a 10 foot wide highway (assuming an acceptable tracking error of less than +/- .35 um) more than 3,200 miles for one second of play or over 14,400,000 miles for the entire disc without accidentally crossing lanes! Actually, it is worse than this: focus must be maintained all this time to better than 1 um as well (say, +/- .5 um). So, it is more like piloting a aircraft down a 10 foot wide flight path at an altitude of about 12 miles (4 mm typical focal length objective lens) with an altitude error of less than +/- 7 feet! All this while the target track below you is moving both horizontally (CD and spindle runout of .35 mm) 1 mile and vertically (disc warp and spindle wobble of up to 1 mm) 3 miles per revolution! In addition, you are trying to ignore various types of garbage (smudges, fingerprints, fibers, dust, etc.) below you which on this scale have mountain sized dimensions. Sorry for the mixed units. My apologies to the rest of the world where the proper units are used for everything).

The required precision is unbelievable but true using mass produced technology that dates to the late 1970s. And, consider that a properly functioning CD player is remarkably immune to small bumps and vibration - more so than an old style turntable. All based on the reflection of a fraction of a mW of invisible laser light!

Of course, this is just another day in the entertainment center for the CD player's servo systems. Better hope that our technological skills are never lost - a phonograph record can be played using the thorn from a rosebush using a potter's wheel for a turntable. Just a bit more technology is needed to read and interpret the contents of a CD!

Why does focus need to be so precise?

Since a laser printer doesn't need to have so precise a focus (afterall, paper isn't that smooth), what's all this fuss about focusing with respect to CD, DVD, and other optical disc/k systems? Laser beams remain fairly parallel, no?

Wrong.

First, laser light that remains precisely parallel - doesn't diverge - only can be found in bad Sci-Fi. Laser light still obeys the laws of physics and in order to get the required spot size on the disc - about 1 micrometer (um), 1,000th of a mm, 1,000,000th of a meter, it needs to be focused precisely at the disc surface. Due to manufacturing tolerances for disc flatness (warp), the surface may move up-and-down as much as 100 times this amount. And disc height from player to player isn't that precise either. Large diameter laser beams can be kept quite parallel but a beam 1 um in diameter would diverge at about a 60 degree angle. The lens in the CD player has a focal length of about 4 mm and focuses the light from a beam a couple millimeters in diameter to a 1 um spot on the disc surface and because of the small depth of focus, the distance needs to be kept constant to 1 or 2 um. For DVD systems, the required precision is even greater.

Laser printers DO have focusing optics with correction for the flat paper surface. They don't need to be quite as precise because the spot size is much larger than for a CD or DVD player - a 1,200 dpi printer would have a spot on the order of 50 um. Therefore, the lens can be quite far away from the paper and the depth of focus is much larger. Thus, no active focusing mechanism is needed.

CD optical pickup operating principles

A diagram showing the major functional components of the three-beam optical pickup described below is available in PDF format: CDT3BP.

This design is typical of older optical pickups (though you may come across some of these). Newer types have far fewer individual parts combining and eliminating certain components without sacrificing performance (which may even be better). Additional benefits result is lower cost, improved robustness, and increased reliability. However, operating principles are similar.

The purpose of the optical pickup in a CD player, CDROM drive, or optical disk drive, is to recover digital data from the encoded pits at the information layer of the optical medium. (With recordable optical disks, it is also used to write to the disk medium.) For CD players, the resulting datastream is converted into high fidelity sound. For CDROMs or other optical storage devices, it may be interpreted as program code, text, audio or video multimedia, color photographs, or other types of digital data.

Most of the basic operating principles are similar for single-beam CD pickups and for pickups used in other digital optical drives.

It is often stated that the laser beam in a CD player is like the stylus of a phonograph turntable. While this is a true statement, the actual magnitude of this achievement is usually overlooked. Consider that the phonograph stylus is electromechanical. Stylus positioning - analogous to tracking and focus in an optical pickup - is based on the stylus riding in the record's grooves controlled by the suspension of the pickup cartridge and tone arm. The analog audio is sensed most often by electromagnetic induction produced by the stylus's minute movements wiggling a magnet within a pair of sense coils.

The optical pickup must perform all of these functions without any mechanical assistance from the CD. It is guided only be a fraction of a mW of laser light and a few milligrams of silicon based electronic circuitry.

Furthermore, the precision involved is easily more than 2 orders of magnitude finer compared to a phonograph. Sophisticated servo systems maintain focus and tracking to within a fraction of a micrometer of optimal. (1 um is equal to 1/25,400 of an inch). Data is read out by detecting the difference in depth of pits and lands of 1/4 wavelength of laser light (about .15 um in the CD)!

- The laser beam is generated by a solid state laser diode emitting at 780 nm (near IR). Optical power from the laser diode is no more than a couple of mW and exits in a wedge shaped beam with a typical divergence of 10x30 degrees in the X and Y directions respectively.

Note that despite what some people believe, the laser diode in a CD or DVD player is a true laser and not just a glorified LED. It has a gain medium (the semiconductor), mirrors (on the cleaved parallel ends of the crystal), and an means of excitation (electric current). Its nearly monochromatic single spatial mode (TEM00) beam can be focused to a spot less than 2 um in diameter. No LED or other non-laser light source is capable of this kind of performance.

- A diffraction grating splits the beam into a main beam and two (first order) side beams. (The higher order beams are not used). Note that the diffraction grating is used to generate multiple beams, not for its more common function of splitting up light into its constituent colors. The side beams are used for tracking and straddle the track which is being read. The tracking servo maintains this centering by keeping the amplitude of the two return beams equalized.)

- Next, the laser beam passes through a polarizing beam splitter (a type of prism or mirror which redirects the return beam to the photodiode array), a collimating lens, a quarter wave plate, a turning mirror, and the objective lens before finally reaching the disc.

- The collimating lens converts the diverging beam from the laser into a parallel beam.

- A turning mirror (optional depending on the specific optical path used) then reflects the laser light up to the objective lens and focus/tracking actuators.

- The objective lens is similar in many ways to a high quality microscope objective lens. It is mounted on a platform which provides for movement in two directions. The actuators operate similarly to the voice coils in loudspeakers. Fixed permanent magnets provide the magnetic fields which the coils act upon. The focus actuator moves the lens up and down. The tracking actuator moves the coil in and out with respect to the disc center.

- The collimated laser beams (including the 2 side beams) pass through the objective lens and are focused to diffraction limited spots on the information - pits - layer of the disc (after passing through the 1.2 millimeters of clear polycarbonate plastic which forms the bulk of the disc).

- The reflected beams retrace the original path up until they pass through the polarizing beam splitter at which point they are diverted to the photodiode array. The polarizing beam splitter passes the (horizontally polarized) laser beams stright through. However, two passes (out and back) through the quarter wave plate rotates the polarization of the return beam to be vertical instead and it is reflected by the polarizing beam splitter toward the photodiode array.

The return beams from the disc's information layer are used for servo control of focus and tracking and for data recovery.

- A cylindrical lens slightly alters the horizontal and vertical focal distances of the resulting spot on the photodiode array. The spot will then be perfectly circular only when the lens is positioned correctly. To close or to far and it will be elliptical (e.g., elongated on the 45 degree axis if too close but on the 135 degree axis if too far).

  The central part of the photodiode array is divided into 4 equal quadrants labeled A,B,C,D. Focus is perfect when the signal = (A+C)-(B+D) = 0.

  The actual implementation may use a thick beam splitter mirror (which adds astigmatism) or an astigmatic objective lens rather than a separate cylindrical lens to reduce cost but the effect is the same. Since the objective lens is molded plastic, it costs no more to mold an astigmat (though grinding the original molds may have been a treat!). It is even possible that in some cases, the natural astigmatism of the laser diode itself plays a part in this process.

- The side beams created by the diffraction grating are positioned forward and back of the main beam straddling the track of pits being followed (not directly on either side as shown in the diagram - but that was easier to draw!).

Segments on either side of the photodiode array designated E and F monitor the side beams. Tracking is perfect when the E and F signals are equal.

- The data signal is the sum of A+B+C+D.

In essence, the optical pickup is an electronically steered and stabilized microscope which is extracting information from tracks 1/20 the width of a human red blood cell while flying along at a linear velocity of 1.2 meters per second!

See the sections: "Parts of a CD Player or CDROM Drive" and "Startup Problems" for more information on the components and operation of the optical pickup and descriptions and photos of some typical laser diodes, optical pickups, and optical decks.

The Laser Fundamentals Page has an interactive tutorial (requires JAVA) illustrating the operation of an optical pickup in very simplified form. It doesn't really have much detail but if the explanation above makes no sense, it may be worth viewing.

Optical pickup complexity

The opto-mechanical design of optical pickups varies widely. Originally, they were quite complex, bulky, heavy, and finicky with respect to optical alignment. However, in their continuing effort to improve the design, reduce the size and mass, and cut costs, the manufacturers have produced modern pickups with remarkably few distinct parts. This should also result in better performance since each optical surface adds reflections and degrades the the beam quality. Therefore, the required laser power should be reduced and the signal quality should improve.

- Generally, the most complex types are also the oldest. With these, there were individual optical elements for each stage in the beam path and completely separate laser diode and photodiode array packages. In short, while details varied, the overall construction was very similar to the diagram and description given in the section: CD optical pickup operating principles. These also had several optical adjustments - which in some cases needed frequent attention.

  An example of this type is the Sony KSS110C Optical Pickup. Most components perform individual functions and it is larger and heavier than more modern designs.

- The most common types still have a separate laser diode and photodiode array but may have eliminated the cylindrical and collimating lenses and perhaps the polarizer and quarter wave plate. There are few if any adjustments.

  The Sony KSS361A Optical Pickup is typical of these mainstream designs. With very minor variations (mostly in mounting), various models may be found in all types of CD players and CDROM drives manufactured by Sony, Aiwa, and others.

  Another similar design is used in the Sanyo K38N Optical Pickup which is somewhat newer and more compact.

  For a diagram and detailed description of these mainstream pickups, see the section: Sony KSS series optical pickups.

- Some manufacturers have gone to a combined laser diode/photodiode (LD/PD) array package which looks like a large LD but with 8 to 10 pins. Aside from the objective lens assembly, the only other part may be the turning mirror, and even this is really not needed. Such a pickup can be very light in weight (which is good for fast-access drives) and extremely compact.

Eliminating the components needed to separate the outgoing and return beams should result in substantial improvement in optical performance. The only disadvantage would be that the beams are no longer perfectly perpendicular to the disc 'pits' surface and this may result in a very slight, probably negligible reduction in detected signal quality - more than made up for by the increased signal level.

The CMKS-81X Optical Pickup and Optical Pickup from Philips PCA80SC CDROM are typical of these modern designs.

The smallest ones such as the Optical Pickup from the Philips CR-206 CDROM are only about 1/2" x 5/8" x 3/4" overall - just about the size of the lens cover! For this single-beam pickup, there are absolutely NO additional optical elements inside. A three-beam pickup would have a diffraction grating in front of the laser diode.

Some of these use what are known as "hologram lasers" (a designation perhaps coined by Sharp Corporation). With these, the functions previously performed by multiple optical components. can be done by a "Holographic Optical Element" or HOE. The HOE can simply be a diffraction grating replacement or can be designed to perform some more complex beam forming. A variety of hologram lasers (as well as conventional laser diodes and photodiode arrays) are listed under Sharp Laser Diode Products. The typical Sharp hologram laser (versions for CD, DVD, and other types of optical storage devices) eliminate the normal diffraction grating in the three-beam pickup as well as the polarizing beam splitter and associated components making for a very simple, compact, low cost unit. DVD Laser Holographic Optical Element shows the HOE glued to the front of a DVD laser diode assembly.

For a diagram and detailed description of this type of pickup, see the section: Super simple optical pickups.

For more information on CD technology

The books listed in the section: Suggested references include additional information on the theory and implementation of digital audio, laserdisc, and optical drive technology.

Philips/Magnavox used to have a very nice on-line introduction to a variety of consumer electronics technologies. Although their site has disappeared - and even people who work for them have no clue - I have now recovered several of the articles including those on TVs, VCRs, camcorders, satellite reception, and connections. See the Introductory Consumer Electronics Technology Series.

Also check out:

- A Fundamental Introduction to the Compact Disc Player is a somewhat more theoretical discussion of compact disc audio technology with diagrams and even some equations. If it doesn't put you to sleep, you will find quite a bit of interesting information in this article. In either case, it may prove of value.
- The University of Washington has at least one course in consumer electronics which varies from year to year. Last year (2000) it was on CD technology but most of that info has disappeared. However, there is an on-line tutorials which appears to be an excellent resource providing easy to understand discussions with many diagrams:
    - Audio Compact Disc - An Introduction.
- The How Stuff Works Web site has some really nice introductory material (with graphics) on a variety of topics relating to technology in the modern world. Of relevance to this document are articles on CD technology, motors, remote controls, power adapters, etc.
- The Cimram International, Inc Web site has some information on CD and DVD technology, formats, mastering, and

manufacturing.

The following sites have a variety of information on CD and DVD technology:

- CD Page
- MediaWorld

A site with CD-R specific information including some repair tips is:

- Andy McFadden's CD-R FAQ.

An extensive amount of information on other optical disc/k technologies with many useful links can be found at:

- Leopold's Audio/Video Page
- MiniDisc, DAT, CD-R, DVD-RAM, etc..
- The DVD Page.
- DVD Central at E/Town.
- DVD Demystified (Includes the DVD FAQ).

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CD Player Placement, Preventive Maintenance, and CD Care

General CD player placement considerations

Proper care of a CD player does not require much. Following the recommendations below will assure peak performance and long life, and minimize repairs.

- Locate the CD player in a cool location. While the CD player is not a significant heat producer, keeping it cool will reduce wear and tear on the internal components and assure a long trouble free life.

- Don't locate CD players in dusty locations or areas of high (tobacco) smoke or cooking grease vapors. I cannot force you to quit smoking, but it is amazing how much disgusting difficult to remove brown grime is deposited on sensitive electronic equipment in short order from this habit.

- Make sure all audio connections are tight and secure to minimize intermittent or noisy sound.

- Finally, store CDs away from heat. The polycarbonate plastic used to mold CDs is quite sturdy but high temperatures will eventually take their toll. Return them to their jewel cases or other protective container when not being played.

Preventive maintenance

You no doubt have heard that a CD should be cleaned and checked periodically. "Purchase our extended warranty" says the salesperson "because CD players are very delicate and require periodic alignment". For the most part, this is nonsense. CD players, despite the astonishing precision of the optical pickup are remarkably robust. Optical alignment is virtually never needed for a component CD player and is rarely required even for portable or automotive units. In fact, modern CD players often don't even have any of these adjustments - the components of the optical pickup are aligned at the factory and then fixed in place with hardening sealer.

An occasional internal inspection and cleaning is not a bad idea but not nearly as important as for a VCR. Realistically, you are not going to do any of this anyway. So, sit back and enjoy the music but be aware of the types of symptoms that would be indications of the need for cleaning or other preventive or corrective maintenance - erratic loading, need to convince the CD player to cooperate and play a disc, audio noise, skipping, sticking, and taking longer than usual to recognize a disc or complete a search.

If you follow the instructions in the section: A HREF="#cdgicl">General inspection, cleaning, and lubrication, there is minimal risk to the CD player. However, don't go overboard. If any belts are in good condition (by appearance and stretch test), just clean them or leave them alone. Except for the Sony drawer loading mechanism, belts are rarely as much of a problem in CD players as in VCRs.

Of course, acute symptoms like refusal to play or open the door is a sign of the need for emergency treatment. This still may mean that a thorough cleaning is all that is needed.

CD lens cleaning discs

Every CD, stereo equipment, department, discount, store - and even sidewalk venders - carries CD lens cleaning discs. Are they of any value? Can they cause damage?

I generally don't consider CD lens cleaning discs to be of much value for preventive maintenance since they may just move the crud around. However, for pure non-greasy dust (no tobacco smoke and no cooking grease), they probably do not hurt and may do a good enough job to put off a proper cleaning for a while longer. However, since there are absolutely no sorts of standards for these things, it is possible for a really poorly designed cleaning disc to damage the lens. In addition, if it doesn't look like a CD to the optical pickup or disc-in sensor, the lens cleaning disc may not even spin. So, the drawer closes, the drawer opens, and NOTHING has been accomplished!

As if this isn't enough, NEVER put one into a high-X CDROM (DVD player or DVDROM drive). The high speed rotation may cause the cleaning disc and/or player/drive to self destruct. And, don't try a cleaning disc on an automotive CD player that sucks in the disk - it will get stuck.

CD protection and handling

Although CDs are considerably more tolerant of abuse than LPs, some precautions are still needed to assure long life. Also, despite the fact that only one side is played, serious damage to either side can cause problems during play or render the CD totally useless.

It is important that the label side be protected from major scratches which could penetrate to the information layer. Even with the sophisticated error correction used on the CD, damage to this layer, especially if it runs parallel to the tracks, can make the CD unusable.

The CD is read by focusing a laser beam through the bottom 1.2 mm of polycarbonate. As a result of the design of the optical system used in the pickup, at the bottom surface, the beam diameter is about 1 mm and thus small scratches appear out of focus and in many cases are ignored and do not cause problems.

At the information layer with the pits, the beam diameter has been reduced to under 2 um. Still, scratches running parallel to the tracks are more problematic and can cause the optical pickup to get stuck repeating a track, jumping forward or back a few seconds, or creating noise or other problems on readout. In severe cases, the CD may be unusable especially if the damage is in the directory area.

This is why the recommended procedure for cleaning a CD is to use soap and water (no harsh solvents which may damage the polycarbonate or resin overcoat) and clean in a radial direction (center to edge, NOT in the direction of the tracks as you would with an LP). While on the subject of CD care, CDs should always be returned to their original container for storage and not left out on the counter where they may be scratched. However, if there is a need to put one down for a moment, here are some considerations:

- The label side is probably to be preferred since minor scratches have no effect on performance as long as they do not penetrate to the storage layer below (in which case the CD is probably history). Protectors are available to prevent damage to the label side of the disc. Personally, I think this is taking care to an excessive level but, hey, if you use your CDs as frisbies, go for it!

- However, the opposite argument may apply as well: Slight damage to the readout-side will be ignored by the optical system or corrected for by the decoding process And, there are ways of dealing with scratches should they occur.

Thus, I won't offer a hard and fast rule other than to avoid leaving CDs out where the dog can get to them. :)

Never apply sticky labels to the readout-side of a CD or to the label-side unless they are specifically designed for this application. And, if a label was stuck on despite the warnings, don't attempt to remove it (or at least exercise the utmost care) as the lacquer layer and some of your valuable bits may come away with it. This is especially critical for CD-Rs (and maybe CD-RWs) which seem to be more fragile than normal CDs. I've seen samples of CD-Rs literally self destruct due to slight stress on the label side.

CD cleaning

You do not need a fancy CD cleaning machine.

Use a soft cloth, tissue, or paper towel moistened with water and mild detergent if needed. Wipe from center to edge - NOT in a circular motion as recommended for an LP. NEVER use any strong solvents. Even stubborn spots will eventually yield to your persistence. Washing under running water is fine as well.

Gently dry with a lint free cloth. Do not rub or use a dry cloth to clean as any dirt particles will result in scratches. Polycarbonate is tough but don't expect it to survive everything. Very fine scratches are not usually a problem, but why press your luck?

Should I really worry about cleaning my CDs?

Something that not everyone is aware of is the multilevel error handling technology in a CD player. Therefore, a dirty CD may not produce instantly obvious audio problems but can nonetheless result in less than optimal audio performance.

Very severe errors - long bursts - will result in audible degradation including noise and/or muting of the sound. Even this may not always be detectable depending on musical context.

Shorter runs of errors will result in the player interpolating between what it thinks are good samples. This isn't perfect but will probably not be detected upon casual listening.

Errors within the correcting capability of the CIRC code will result in perfect reconstruction.

Not all players implement all possible error handling strategies.

Therefore, it is quite possible for CD cleaning to result in better sound. However, a CD that is obviously clean will not benefit and excessive cleaning or improper cleaning will introduce fine (or not so fine) scratches which can eventually cause problems.

Can a dirty CD or dirty lens damage my player?

So the droid in the CD store warned you that dirty CDs could do irepairable harm to your CD player, your stereo, your disposition, etc. "Buy our $19.95 Super-Laseriffic CD cleaning kit".

The claim made at one major chain was that dirt or dust on the laser eye would cause heat build-up that would burn out the mechanism. This is different from a dirty disc. The cleaner he was pushing was a little brush attached to a CD that brushed off the lens as it played.

This is total rubbish. The power of a CD laser is less than 1 mW and is not concentrated at the lens. And, as noted elsewhere, those cleaning CDs with the little brush are next to useless on anything but the smallest amount of dry dust.

There are a lot of suckers out there. Save your money.

The worst that can happen is the CD will not play properly. There may be audible noise, it may fail to track properly, abort at random times, or not even be recognized. The electronics will not melt down.

It is just about impossible for a dirty CD to do any damage to the player. A dirty lens will only result in disc recognition or play problems similar to those caused by a dirty CD. The laser will not catch fire.

The only way damage could occur is if you loaded a cracked CD and the crack caught on the lens.

You do not need any fancy CD cleaners in any case - soap or mild detergent and water and a soft cloth are all that are required. If the CD looks clean, it probably will be fine. If there are serious smudges or fingerprints, then cleaning could make a significant difference in performance.

For further information, see the sections "CD cleaning" and "General inspection, cleaning, and lubrication".

Rental or library CD considerations

Unlike old or worn video tapes, it is unlikely that a 'bad' CD could damage your player. If the borrowed CD is dirty, clean it as described in the section: CD cleaning. If it is badly scratched, the worst that will happen is that it will sound bad - skipping and audible noise. No damage to your player will result. However, if the CD is cracked or broken (this is really difficult to do but I have gotten cracked CDs from public libraries), don't even attempt to load it - a broken edge could catch on the lens and ruin the optical pickup entirely. An improperly made or defective CD could result in seek/search problems which could eventually overheat and/or damage components but you'd probably notice the lack of music before anything irreversible happened.

(From: Bart Wessel (wessel@home.nl).)

There seems to be a new risk in playing CDs or CD-ROMs borrowed from a public library.

New, because of the fact that (at least at our library) they have a small metallic strip attached to the top of the CD, apparently as a measure against theft. The strip can be activated/deactivated at the counter, just like the system in use in most department stores.

The risk comes from the fact that these strips can come off if you happen to have a CD-ROM player that plays at speeds higher than 40X. There is a warning on the box not to use plates over 40X but who reads the warnings!

Can a CD player damage CDs?

The perhaps unexpected answer is a definite *yes* even though everyone has heard about the virtues of non-contact laser playback. There are several ways that a broken or poorly designed or manufactured player can result in scratched discs:

- If the lens moves too high while attempting to focus and the mechanical stop does not prevent it from hitting the disc, scratches can occur. On some players, the objective lens can easily go this high if focus is not found on the first pass. Note that in most cases, the lens will not suffer since it is protected by a raised ridge which is what actually scratches the disc.

- Mechanical misalignment of the spindle motor or plastic cabinet parts can result in the disc touching the bottom or top of the disc compartment and this can leave scratches. This could be the result of poor or cheap design, shoddy manufacturing, or damage from a fall or other abuse.

- If the control logic gets confused, it may allow you to eject a disc while it is still spinning and not fully supported by the spindle platter. A dirty disc that resulted in failure of the CLV servo to lock can result in a disc speed runaway condition with some players. If the drawer is then opened too soon, the disc will still be spinning because the controller has no way of knowing its present status and will not have provided enough reverse torque to stop the spindle motor - or too much and it will be spinning in reverse.

The likelihood of any of these is increased with dirty, smudged, warped, or previously damaged discs.

Minor scratches may not result in a serious problem and there are products to polish them - don't know how well they work. However, if these scratches can be proven to be a direct consequence of a defective player still under warranty, you should try to get some compensation from the manufacturer for any seriously damaged and now unplayable CDs.

The one thing that is extremely unlikely is that the laser beam itself is damaging the disc. Although this IS in principle possible IF the disc is stationary AND the laser is on and focussed properly, AND laser power were high enough, at most what would happen is that the information layer would have a microscopic hole blown in it (and this would be taken care of by the error correction processing). However, this really is extremely improbable in a normal CD player or CDROM drive with normal CDs, especially if the unit is working otherwise since the disc starts spinning as soon as focus is established. Forget it. Mechanical causes of damaged discs are about a zillion times more likely! :-)

Thus, there is absolutely no way for a software command to the CDROM drive to affect the contents of the disc in any way. The laser power is simply too low to affect the CD and there is no way to boost it, even for an instant. Anything you've heard to the contrary it total rubbish. However, a faulty CD-R or CD-R/W writer could indeed result in damage to CD-R and CD-R/W media from its higher power laser but that's another story.

Repairing a scratched CD

So your five year old decided that your favorite CD would make nice frisbee - didn't really know much about aerodynamics, did he?

Now it sounds like a poor excuse for a 78 rpm record. What to do?

There seem to be about as many ways of fixing scratches on CDs as producing them in the first place. However, they fall into 3 classes of techniques:

1. Mild abrasives: plastic or furniture polish, silver polish, toothpaste. These will totally remove minor scratches. DO NOT use anything that contains solvents including petrolium distillates - if it smells like kerosene, it will likely attack the polycarbonate plastic of the CD rendering it useless. Brasso(tm), a popular product may fall into this

category but I've also heard that it works fine without damaging the CD.

2. Fillers: turtle wax, car wax, furniture wax. Apply over the whole disc and buff out with a lint free cloth. Filling larger scratches should be fairly effective but the disc will be more prone to damage in the future due to the soft wax.

3. Motorized buffing wheel. Sort of a miniature version of what is used for polishing your car. :) See the details below.

4. Blowtorch. At least one person who claims to have worked for several years in used CD store swears by this technique. Supposedly, he uses a pencil-type pocket butane torch and with great dexterity fuses the surface layer of the readout side of the disc so that all of those scratches and unsightly blemishes-well-melt away. Obviously, there are dangers in using fire on plastic and this is likely a last resort. I would assume that you are rolling with hysterical laughter at this point. In any case, I would not take this approach too seriously :-).

For (1) and (2), as with cleaning a CD, when applying or rubbing any of these materials, wipe from the center to the outside edge. A CD player can generally track across scratches that are perpendicular to its path reasonable well, but not those that run the parallel to the tracks.

A mild abrasive will actually remove the scratch entirely if it is minor enough. This is probably more effective where the surface has been scuffed or abraded rather than deeply scratched.

Wax-like materials will fill in the space where the scratch is if the abrasive was not successful. Even deep scratches may succumb to this approach.

A combination of (1) and (2) may be most effective.

Exorbitantly priced versions of these materials are available specifically marketed for repair of CDs. However, the common abrasives and waxes should work about as well.

I cannot comment on the use of the blowtorch or how many years of practice is required to get you CD repair license with this technique. However, I am highly skeptical that this works at all and suspect that destruction of the CD is the most likely outcome - totally melting, warping, or cracking or shattering from the thermal stress. In other words, I don't recommend trying the Blowtorch approach unless you have a stack of AOL or MSN CDs to sacrifice and you have sufficient accident insurance!

Even some of other solutions may make the problem worse or destroy the CD entirely if not done correctly or if the wrong materials or technique is used. So, test any method on a CD you don't care about first.

An alternative to CD home repair are companies specializing in this service. A couple of these are: Aural Tech CD and CD Repairman. I do not have information as to their effectiveness or cost. However, if you have a very special irreplaceable CD that someone used as a skateboard, one of these may be worth considering.

(From: Shawn Stopper (shstop@prodigy.net).)

In the CD repair process, I use a 1/4 horse electric motor, cotton buff, 2 hose clamps, 2 washers, a screw, and brown tripoli rouge. The motor should be mounted to a surface for permanent use. The first hose clamp should be mounted about halfway back on the motor shaft. A shaft about 4 inches in length will be necessary for this application. after mounting the first hose clamp, apply a washer, the buff, another washer, and the final hose clamp. Mount a screw about 1/2 inch above the motor shaft where the outer clamp can be twisted around the screw to keep the buff spinning. When buffing cds, start out using brown tripoli rouge and slowly move the cd from inside to out. Do not apply too much pressure on the CD because this will cause the CD to "splinter", and it will be ruined. Patience is the key to CD buffing. The first few you do may take longer than you expect, but the more you do the better you get at it. At this time, I can buff about 3 to 4 CDs in five minutes. Once again, practice is the key!

Repairing top-side problems on CDs

If scratches penetrate to the information layer, all bets may be off. Much of the optical system compliance with respect to damage depends on the short depth of focus assuring that surface scratches *on the bottom* will be out of focus and ignored. This is not possible with damage to the pits. Even though the CIRC code should be able to deal with thousands of bad bits, such damage can confuse the tracking servos to the point where the disc will be unusable.

What if the aluminum (or gold) reflective layer has come off with no damage to the plastic underneath? First of all, I don't know how this could occur unless you were attempting to clean them with a strong solvent. Any physical damage which removed the mirror coating will also damage the pits and recoating will be useless.

(Note that I have unintentionally removed the gold coating on a CD-R using a solvent similar to what is in Liquid Wrench(tm). I was actually trying to remove the label but went a little too far! The solvent apparently dissolved the greenish coating or binding underneath allowing the gold film and label to just flake off - very strange behavior. Most of the green layer was still intact. I now have a nice greenish somewhat transparent plastic coaster.)

Some discs may still work on some players or drives without the aluminum coating. However, this isn't that likely. How to replace it? Ideally, vacuum deposition is needed. The problem isn't only the reflectance but the micro structure - the original coating was vacuum deposited to conform to the pits and lands of the information layer. It is perfectly uniform below the resolution of the laser beam. Modeling (silver or gold colored) paint is amorphous and rough at these feature sizes and floppy disk write protect stickers or other adhesive backed reflective films don't even come close to contacting the information layer consistently. Mirror paint may work but is a long-shot.

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CD Player and CDROM Drive Troubleshooting

SAFETY

While there are far fewer potential dangers involved in servicing a CD or DVD player compared to a TV, monitor, or microwave oven, some minimal precautions are still required when working with the cover removed. These relate to electrical connections to the AC line and exposure to the laser beam:

- Electrical: There may be a few exposed electrically live parts from the power line, usually around the power cord entrance, power transformer, and on/off switch. If there are, tape them over or cover them somehow so you need not be concerned with a low tech shock! Unless you are troubleshooting a primary side power supply problem, there will be no need to go near the AC line.

- Laser (CD): The laser in a CD player is infra red, near IR - 780 nm - border of visible range but for all intents and purposes invisible. However, it is very low power (generally under 1 mW at the lens) and due to the optics, extremely unlikely that you could be in any danger. Nonetheless, don't go out of your way to look closely into the lens while the unit is on!

  As long as the lens is intact, the beam is highly divergent and at anything beyond a few inches, especially at an oblique angle, is quite safe. The only possibility of risk would be if the lens fell out and you were looking directly into a collimated beam from above. While the power is less than that of most laser pointers, there would be no aversion reflex to the nearly invisible IR. And, yes, some models of CD players are known to drop their lenses!

CAUTION: There is usually a very low intensity (in appearance) emission from an IR laser which appears deep red. It will be visible as a spot the size of the period at the end of this sentence when the lens is viewed from an oblique angle. This is just your eye's response to the near IR energy of the main beam. (Some people apparently cannot see this at all.) Do not be mislead into thinking that the laser is weak as a result of how dim this is. The main beam is up to 10,000 times more intense than it appears! It's power output is generally around 1 mW - comparable to a laser pointer. Take care. However, the red dot is an indication that the laser is being powered and probably functional, though it is no guarantee of the latter. You really need a laser power meter or at least an IR detector to confirm the existence of an IR laser beam.

Whenever a full size (5-1/4") CD is in place, there is absolutely no danger of exposure to the laser beam. Reflections of laser light at these power levels are harmless. However, if you are testing with a 3-1/2" 'single' or homemade cut-down test CD (see the section: Useful ways to mangle CDs, avoid staring into the lens if there is any chance the laser is powered.

If you don't want to take even the minimal risk of looking into the lens at all, project the beam onto a piece of paper held close to the lens. In a dark room, it should be possible to detect a red spot on the paper when the laser is powered.

- Laser (CD-R, CD-RW, and other writeable optical drives): These may use IR laser diodes producing 10s of mW. A typical CD-R drive sets the laser power at 3 to 5 mW for read and 25 to 30 mW for write. While the basic precautions are the same, much greater care must be taken due to the much higher power when writing.

- Laser (DVD): The DVD laser pickup is very similar to that of the CD player except that the wavelength is in the 635 to 650 nm range which is a very visible red - about the same as the color of newer laser pointers or a helium-neon laser (632.6 nm). The power is still under 1 mW and everything else above is still applicable.

  One note: If the DVD player is of the dual pickup variety with a separate laser for CDs, that one is IR like a normal CD player and the precautions listed above will apply. Take care because it may not be obvious ahead of time which one (or if both) will be powered!

Troubleshooting tips

Many problems have simple solutions. Don't immediately assume that your problem is some combination of esoteric complex convoluted failures. For a CD player, it may just be a bad belt or dirty lens. Try to remember that the problems with the most catastrophic impact on operation (a CD player that will not play past track 6) usually have the simplest solutions (the gears that move the optical pickup need lubrication). The kinds of problems that we would like to avoid at all costs are the ones that are intermittent or difficult to reproduce: the occasional audio noise or skipping or a CD player that refuses to play classical CDs (depending on your tastes!) of music composed between the years 1840 and 1910.

When attempting to diagnose problems with a CDROM drive, start by trying to get it to play an audio CD. Data readback is more critical since the error correction needs to be perfect. However, with audio playback functional, all of the optical pickup and most of the servo systems and front-end electronics must be working. A CDROM drive which cannot even play a music CD will have no chance of loading Windows 95.

If you get stuck, sleep on it. Sometimes, just letting the problem bounce around in your head will lead to a different more successful approach or solution. Don't work when you are really tired - it is both dangerous and mostly non-productive (or possibly destructive).

Whenever working on precision equipment, make copious notes and diagrams. You will be eternally grateful when the time comes to reassemble the unit. Most connectors are keyed against incorrect insertion or interchange of cables, but not always. Apparently identical screws may be of differing lengths or have slightly different thread types. Little parts may fit in more than one place or orientation. Etc. Etc.

Pill bottles, film canisters, and plastic ice cube trays come in handy for sorting and storing screws and other small parts after disassembly.

Select a work area which is well lighted and where dropped parts can be located - not on a deep pile shag rug. Something like a large plastic tray with a slight lip may come in handy as it prevents small parts from rolling off of the work table. The best location will also be relatively dust free and allow you to suspend your troubleshooting to eat or sleep or think without having to pile everything into a cardboard box for storage.

Another consideration is ESD - Electro-Static Discharge. The electronic components - especially the laser diode - in CD players, CDROM drives, and similar devices, are vulnerable to ESD. There is no need to go overboard but do take reasonable precautions like not wearing clothing made of wool that tends to generate static. When working on component CD and laserdisc players, get into the habit of touching a ground like the metal chassis before touching any circuit components. The use of an antistatic wrist strap would be further insurance especially if the optical pickup assembly needs to be unplugged for any reason.

A basic set of precision hand tools will be all you need to disassemble a CD player and perform most adjustments. However, these do not need to be expensive. Needed tools include a selection of Philips and straight blade screwdrivers, needlenose pliers, wire cutters, tweezers, and dental picks. A jeweler's screwdriver set is a must particularly if you are working on a portable CD player or CDROM drive.

For making servo adjustments, non-metallic fine tip jeweler's screwdrivers or alignment tools will be essential as some of the front-end circuitry may be sensitive to body capacitance - contact with the slot may alter the behavior of the player (for better or for worse). In a pinch, wrapping electrical tape around the part of a normal jeweler's that you grasp will probably provide enough isolation. However, with a tool with a blade made out of an insulator, you will be less likely to accidentally short things out as well

Note that low level signals from the optical pickup like the data (RF) and other photodiode outputs are extremely sensitive to interference picked up from a finger on or near the flex cable, a disconnected ground strap, or possibly even a nearby broadcast antenna. Thus, when the optical deck isn't fully mounted and connected, there may be unusual behavior - this is probably normal. Just be aware of this and don't panic, and adjustments should be made with the unit as close to fully assembled as possible.

You should not need any CD specific tools except in the unlikely event you get into optical alignment in which case the service manual will detail what tools and special rigs are needed.

A low power fine tip soldering iron and fine rosin core solder will be needed if you should need to disconnect any soldered wires (on purpose or by accident) or replace soldered components.

CAUTION: You can easily turn a simple repair (e.g., bad solder connections) into an expensive mess if you use inappropriate soldering equipment and/or lack the soldering skills to go along with it. If in doubt, find someone else to do the soldering or at least practice, practice, practice, soldering and desoldering on a junk circuit board first! See the document: Troubleshooting and Repair of Consumer Electronic Equipment for additional info on soldering and rework techniques.

For thermal or warmup problems, a can of 'cold spray' or 'circuit chiller' (they are the same) and a heat gun or blow dryer come in handy to identify components whose characteristics may be drifting with temperature. Using the extension tube of the spray can or making a cardboard nozzle for the heat gun can provide very precise control of which components you are affecting.

Basic cleaning supplies include Q-tips (you may know them as cotton buds), lint free cloths or paper towels, water, and isopropyl alcohol (preferably 91 percent medicinal grade or better).

For info on useful chemicals, adhesives, and lubricants, see Troubleshooting and Repair of Consumer Electronic Equipment as well as other documents available at this site.

Test equipment

Don't start with the electronic test equipment, start with some analytical thinking. Many problems associated with consumer electronic equipment do not require a schematic (though one may be useful). The majority of problems with CD are mechanical and can be dealt with using nothing more than a good set of precision hand tools; some alcohol, degreaser, contact cleaner, light oil and grease; and your powers of observation (and a little experience). Your built in senses and that stuff between your ears represents the most important test equipment you have.

A DMM or VOM is necessary for checking of power supply voltages and testing of sensors, LEDs, switches, and other small components. This does not need to be expensive but since you will be depending on its readings, reliability is important. Even a relatively inexpensive DMM from Radio Shack will be fine for most repair work.

For servo and other electronic problems, an oscilloscope will be useful. However, it does not need to be fancy. A 10 to 20 MHz dual trace scope with a set of 10X probes will be more than adequate for all but the most esoteric troubleshooting of CD players and CDROM drives.

To determine if the laser diode is working properly, a laser power meter is very useful. Such a device is expensive but is often essential to properly and safely adjust laser power on many CD players and CDROM drives. However, for many problems, simply knowing that an IR laser beam is being emitted is enough. For this, the simple device described in the section: IR detector circuit is more than adequate. Alternatively, an inexpensive IR detector card or even some camcorders can perform the same function.

A stereo amplifier and loudspeakers is essential to allow your most important piece of audio test equipment to function effectively - your ears. A lot can be determined by listening to the audio output to distinguish among dirt, lubrication, servo, control, and other mechanical or electronic problems. I would caution against the use of headphones as a sudden burst of noise could blow your eardrums and spoil your entire day.

For testing of optical pickups, some additional equipment will be needed. However, this will be detailed in the section: Testing of Optical Pickup Assemblies.

Test CDs

An inexpensive test CD is nice to have just to be able to play known frequencies and volume levels. However, it is not essential - any half decent CD will work just fine for most tests. For many players, even an old CDROM disc will be adequate to diagnose startup problems. However, to fully exercise the limits of the player, a disc with a full 74 minutes of music will be needed - Beethoven's Ninth Symphony is a good choice (even if you are not into classical music) since it is usually very close (or sometimes slightly over) this length of time.

Keep those old demo CDs or even obsolete CDROM discs - they can be used for testing purposes. Where an optical deck has a servo problem, the disc will end up spinning out of control. Stopping this suddenly may result is the CD scraping itself against the drawer or or base of the deck and getting scratched. Therefore, some 'garbage' discs are always handy for testing purposes.

To evaluate tracking and error correction performance, any CD can be turned into a test CD with multiple width strips of black tape, a felt tip marker, or even a hand drill! In fact, some professional test discs are made in exactly this manner.

Also see the sections: "Comments on test discs" and "Custom test CDs using CD-Rs".

Useful ways to mangle CDs

These suggestions will allow you to put some of those AOL CDs to good use (well, besides making high tech coasters)!

- For portable CD players where the designers in their infinite wisdom put some of the servo adjustments *under* the spinning disc, a 3-1/2" CD 'single' is extremely handy. A normal CD can be cut down as well - to whatever size you need as long as enough actual tracks are left so that the directory and a few minutes of music/data remain - this could be as little as about 2-1/2" to gain access to the adjustments on some models. This surgery is best done on a band saw with a narrow fine tooth blade. However, tiny cracks may grow in from the edge (overnight, even) if the disc is subjected to any heating or stress from cutting or smoothing. Perhaps some annealing is needed to prevent these from getting started.

  Note that the lower mass (actually the lower moment of inertia for you purists) of the small CDs may alter the servo response somewhat. Putting a heavy metal ring or washer on top should help. However, this is still much much better than continually having to remove a normal CD to get at the adjustments, incrementally moving them one way or another, and then replacing the CD to see how you made out. One can grow old doing this! The little CDs will enable you to monitor the test points as the adjustments are made which is also a definite advantage :-).

  The RCA RP-7903A Portable CD Player is an example of a design where this type of modified CD is invaluable for testing.

- A handy special miniature CD can be made to permit viewing of the focusing action on any CD player or CDROM drive as long as you can get to the top of the deck while testing. Using a band saw, cut a garbage disc down so as to leave only a 1-1/2" diameter center hub with a 1/2" by 1/2" tab sticking out from it. This can then be positioned by hand to just cover the lens while it is supposed to be doing its focus search.

- An alternative that will permit you to view both the laser output (from a safe distance) and the focusing action is to create a window in a garbage CD by removing the label and aluminum layers from an area of the CD at the inner tracks - at least a square inch worth. Lacquer thinner (nail polish remover, with adequate ventilation) will probably work to remove the label. Fine sand paper or steel wool will remove the aluminum and information pits/lands (grooves). Then polish with a buffing wheel or old rag.

CAUTION: when using any of these cut-down or windowed test CDs, or 3-1/2" 'singles', avoid staring into the lens when the laser is powered. See the section: SAFETY.

Getting inside a CD player or CDROM drive

WARNING: you will void the warranty, if any. You may make the problem worse, possibly much worse. If the player partially worked, it may no longer even recognize the disc directory. You may accidentally damage parts that were perfectly fine. If you should decide to then have the unit professionally serviced, you may find that the shop simply refuses to touch it if they suspect your tampering. There is nothing worse than having to undo 'fixes' introduced by a well intentioned do-it-yourselfer where the state of the player is now a total unknown. At best you will be charged for this effort on a time and materials basis. It may be very costly. It may not be worth the expense.

A CD player still under warranty should probably be returned for service for any covered problems except those with the most obvious and easy solutions.

On the other hand, it is possible that you will do a better job than some repair shops. You will probably have a better understanding of the basic theory and will certainly be able to spend much more time on the problem. And, of course, hobbiest/handyman's time is cheap - as in free.

- Component CD players. It is generally very easy to remove the top cover on most CD players. There are usually some very obvious screws on the sides and possibly back as well. These are nearly always Philips head type - use the proper screwdriver. Once all the screws are out, the top cover will lift up or slide back and then come off easily. If it still does not want to budge, recheck for screws you may have missed.

  Once the top cover is removed, the optical deck and electronics board will usually be readily accessible.

  In rare cases, removing the bottom cover will provide access to the solder side of the electronics board. However, with most CD players, the bottom is solid sheet metal and the entire board would need to be unmounted. On some, the electronics board is mounted upside-down so there is full access to the wiring side once the cover is removed.

- With most single play designs, the entire optical deck can be lifted out after removing 3 or 4 screws. One screw may have a grounding contact under it. Replace this in exactly the same position. There may be fragile flexible cables. Be careful so as not to damage any. Usually, these cables plug in to connectors on the electronics board and permit the entire optical deck to be easily replaced if needed (not very common, however, despite what you may have heard).

- For changers, details will depend on the particular model but in general, it is more likely that removal of the entire changer mechanism will be more involved. However, this is usually not needed unless there is an actual mechanical problem with it. With Pioneer cartridge changers, for example, the optical deck is easily removed with just 4 screws.

- For portables, the bottom plate or top cover usually comes off after removing several very tiny screws - use the proper size Philips blade jeweler's screwdriver and don't lose them. Then, you either have access to the bottom of the mainboard or the top of the mainboard blocked mostly by the optical deck. With the RCA RP-7903A Portable CD Player, it is the latter and the pickup and/or normal size CD conveniently block all access to servo adjustments and test points (which as is often the case, are ummarked in this RCA unit). These types of CD players are usually quite a pain to troubleshoot! Of course, there are also many components including most of the large multilegged ICs surface mounted on the *bottom* side of the mainboard which makes for even more fun should probing be required! You can easily see all the 'stuff' packed into a box just slightly larger than a CD!

- For CDROM drives, both top and bottom covers may be removable depending on model. These are more wide open than portables, especially the newer models where everything has been shrunk to a tiny optical pickup and circuit board with a few large ICs. Unfortunately, adjustments (if any) and test points are even less likely to be labeled on CDROM drives. All testing will also require a working PC unless your model has built-in audio play capability.

Make notes of screw location and type and immediately store the screws away in a pill bottle, film canister, or ice cube tray.

When reassembling the equipment make sure to route cables and other wiring such that they will not get pinched or snagged and possibly broken, or have their insulation nicked or pierced, and that they will not get caught in moving parts. Replace any cable ties that were cut or removed during disassembly and add additional ones of your own if needed. Some electrical tape may sometimes come in handy to provide insulation insurance as well. (This applies mostly to portables and CDROM drives - component CD players are very wide open.

CD enhancers

The process of reading a CD is digital. I have seen and heard advertisements for sonic rings or special magic markers to improve the quality of the digital audio reproduction. This is total bunk. Don't waste your money. These products do nothing beyond depleting your pocketbook - and enhancing those of the vendors.

For more amusement, see the section: Totally worthless gadgets for CD enthusiasts.

Along the same lines, some apparently knowledgeable people (knowledgeable in what you might ask!) have asked if offers of software to turn a CDROM drive into a CD-R writer should be believed! This is just utter and total nonsense and what's more likely to happen if you fall for such a SCAM is to become the new owner of some nasty computer virus! Besides, this must be impossible since there is no place for a red "write" LED on a CDROM drive! :)

What about DVD player and DVDROM drive servicing?

DVD players and DVDROM drives have hit the market place in a big way and (if you believe the hype), DVDs are about to replace CDs totally. Realistically, this won't happen for some time. In any case, DVD players and DVDROM drives are *supposed* to accept CDs, CD-Rs, and CD-RWs, so no need to panic just yet. But availability of new CD based devices will disappear because the cost to manufacture a DVD player or drive isn't much more than that of a similar CD unit so manufacturers will want to close down their old production lines and concentrate on DVDs only.

In any case, eventually all things break, and DVD equipment will be no exception. Fortunately for us, the similarities between CD and DVD technology are much more significant than the differences. The inside of a DVD player looks pretty much the same as the inside of a CD player and, for the most part, the same problems are likely to occur. Here are some things to look out for:

- DVD discs look virtually identical to CDs. They are the same size and thickness with the same large center hole and will fit perfectly well into a CD player or CDROM drive - but of course won't do much there. Despite the tracks and pits being closer together, the rainbow/diffraction effects are about the same so a casual glance isn't enough to tell them apart but there is always that DVD logo! However, the information layer is precisely in the center of a sandwich of polycarbonate (each half .6 mm thick). (The DVD standard supports a double sided DVD. This, of course leaves virtually no room for the label!) More info on DVD media, storage capacity, and so forth can be found in the section: Comparison of CD and DVD Specifications.

- The laser in a DVD based device is a very visible red (a wavelength around 650 nm compared to the nearly invisible IR 780 nm laser used for CDs). This is about the same wavelength as used in newer red laser pointers. It is still low power (1 mW or less at the objective lens) but the laser will appear very bright when it is powered and working correctly. As far as hazards to vision, the same recommendations apply - don't look into the beam directly but viewing from an oblique angle at 12 inches or more from the objective lens should be safe. The eye's aversion reflex will prevent damage in any case - you will blink or turn away from a the bright light. CAUTION: Some (probably older) DVD equipment may also have a standard CD pickup to be able to read CDs. For these, obviously, all the IR laser precautions apply.

- It should be easier to determine if the laser is bad by brightness alone though a laser power meter and the manufacturer specifications will still be needed in marginal cases.

- As a result of the march of technology, the optical pickup is likely to of simpler design than that in older CD based devices with even fewer or no adjustments possible. However, there could be additional complexity due to the need to handle DVDs and CDs in the same equipment. The use of combined laser diodes and photodetector arrays is likely to be quite common if not pervasive. However, pickups may also use separate laser diodes and photodiode arrays possibly sharing some of the optics or at least part of the beam path in the optical block. In some pickups, objective lenses for the CD and DVD lasers can be rotated into position as required by applying enough current of the appropriate polarity to the fine tracking coils..

- The same basic functions need to be performed by the front-end electronics including amplification of the photodetector array output, and focus, tracking, and spindle servos. Much this is likely to be done inside large chips with no service adjustments.

- More functions will be incorporated into fewer surface mount chips. Fortunately, failures of the large scale integrated circuits themselves are not nearly as common as simple mechanical problems. Better hope so in any case as troubleshooting of things like an MPEG decoder is way beyond what could be done without a complete service manual, sophisticated test equipment, and probably a whole lot more!

- More plastic and less metal is likely to be used - lighter, flimsier, less likely to be serviceable at all.

So, the bad news is that if something breaks inside a large chip, accept defeat and send the unit in for service. The good news is that most problems will still be mechanical - dirt, dust, gummed up grease, bad motors, abuse. From our experience with CD repair, we should be well equipped to deal with these!

Hopefully, manufacturers have learned from their experience with CDs to make a more reliable robust product but that may be wishful thinking where the bottom line is involved. It's still too early to tell.

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CD Player and CDROM Drive Fundamentals

Parts of a CD player or CDROM drive

While CD players and CDROM drives started out and still have much in common, they are diverging. The optical pickups remain similar but the data processing and servo systems needed to support 16X speed CDROM technology are much more sophisticated than those needed for 1X speed CD audio. Therefore, should you peek inside your shiny new CDROM drive, you may see parts that differ considerably from those in a old Discman.

Power supply

In component stereos units, there are normally linear supplies and thus very reliable but easy to repair as well. In portables, they are likely to be switching supplies, possibly sealed in a shielded can (or at least all surface mount components), and difficult to troubleshoot and repair.

Usually, at least three voltages are needed: logic power (e.g. +5 Vcc) and a pair of voltages for the analog circuitry (e.g., +/-15V). However, some designs use a variety of voltages for various portions of the analog (mainly) circuitry.

Electronics board

This contains the microcomputer controller, servos, readback electronics, audio D/A(s) and filters. Most servo adjustment pots will be located here. In many cases they are clearly marked but not always. DO NOT turn anything unless you are sure of what you are doing - and then only after marking their original positions precisely.

The optical deck

This subsystem includes all of the components to load and spin the disc, the optical pickup, and its positioning mechanism. Refer to the section: Typical optical decks for photos of some common models.

- Loading drawer - Most portable and many lower cost CD players or CDROM drives lack this convenience. Most are motor driven. However, some must be pushed in or pulled out by hand.

Common problems: loose or oily belt causing drawer to not open or close, or to not complete its close cycle. There can be mechanical damage such as worn/fractured gears or broken parts. The drawer switch may be dirty causing the drawer to decide on its own to close. The motor may be shorted, have shorted or open windings, or have a dry or worn bearing.

- Spindle, spindle table, or spindle platter, (we will use these names more or less interchangeably) - When the disc is loaded, it rests on this platform which is machined to automatically center it and minimize runout and wobble.

  Common problems: Dirt on table surface, bent spindle, dry or worn bearings if spindle not part of motor but is belt driven, loose spindle.

- Spindle motor - The motor that spins the disc. Most often the spindle platform is a press fit onto the spindle motor. Two types are common: The first is a miniature DC motor (using brushes) very similar to the common motors in toys and other battery operated devices. The second type is a brushless DC motor using Hall effect devices for commutation. If there are more than 2 wires attached to the motor or if it uses exposed coils and control board, it is likely of the brushless type. In very rare cases, a belt is used to couple the motor to the spindle but most are direct drive - the spindle is the motor shaft.

  Common problems: partially shorted motor, shorted or open winding, dry/worn bearings, defective electronics. The brushless type are much less likely to have electrical problems.

- Clamper - Usually a magnet on the opposite side of the disc from the spindle motor which prevents slippage between the disc and the spindle platform. The clamper is lifted off of the disc when the lid or drawer is opened. Alternatively, the spindle may be lowered to free the disc.

  Common problems: doesn't engage fully permitting disc to slip on spindle due to mechanical problem in drawer closing mechanism.

- Sled - The mechanism on which the optical pickup is mounted. The sled provides the means by which the optical pickup can be moved across the disc during normal play or to locate a specific track or piece of data. The sled is supported on guide rails and is moved by either a worm or ball gear, a rack and pinion gear, linear motor, or rotary positioner similar to what is in a modern hard disk drive - in increasing order of performance.

  Note that a single-beam optical pickup can be used with either a linear or rotary mechanism. However, a three-beam pickup will not work with a rotary positioner because the angle of the pickup changes with radial position. Functionally, neither type is fundamentally superior but most manufacturers seem to use the three-beam type. Philips/Magnavox (and their other brand names) appear to be the principal exceptions.

  Common problems: dirt, gummed up or lack of lubrication, damaged gears.

- Pickup/sled motor - The entire pickup moves on the sled during normal play or for rapid access to musical selections or CDROM data. The motor is either a conventional miniature permanent magnet DC motor with belt or gear with worm, ball, or rack and pinion mechanism, or a direct drive linear motor or rotary positioner with no gears or belts.

  Common problems: partially shorted motor, shorted or open winding, dry or worn bearings.

- Optical pickup - This unit is the 'stylus' that reads the optical information encoded on the disc. It includes the laser diode, associated optics, focus and tracking actuators, and photodiode array. The optical pickup is mounted on the sled and connects to the servo and readback electronics using flexible printed wiring cables.

  Common problems: hairline cracks in conductors of flexible cable causing intermittent behavior.

Typical optical decks

Some examples of common optical decks are shown in the following sets of photos. Note: The disc loading components and clampers are not shown.

Note: The resolution of the optical deck photos is 37.5 dpi unless otherwise noted. All other photos include a scale indicator.

The first 4 are from consumer grade CD players:

- The Pioneer CD Player Optical Deck shows a typical sled-type using a PM motor driven screw. This uses a three beam pickup.

  This model (or one similar to it) can be found in both Pioneer single (e.g., PD5100) and changer (e.g., PDM500) type CD players. In the latter case, the assembly is mounted upside-down with the clamper on the bottom.

- The Sony D-2 CD Player Optical Deck shows another common sled-type with a gear driven rack. This model (and as far as I know, all others from Sony) use three-beam pickups.

  This deck (or one similar to it) can be found in the Sony Model D2 and other portable CD players. (The flex cable, a common failure item, has been removed to provide unobstructed views.)

  It uses the Sony KSS220A optical pickup which is virtually identical to the Sony KSS361A Optical Pickup.

- The Sony D-14 CD Player Optical Deck is also uses a gear driven rack. It has a three-beam pickup.

  This deck is from a very old D-14 portable CD player, possibly only the second portable model manufactured by Sony.

  The Sony KSS110C Optical Pickup it uses is distinctly different than other more modern Sony models. In addition to being larger, the optics include a beam splitter prism, a negative lens in the return path, and the objective lens is mounted on a shaft enabling it to slide up and down (for focus), and rotate (for tracking).

- The Philips CD Player Optical Deck provides an example of a unit using a rotary type voice coil tracking actuator and uses a single-beam pickup.

  This one came from a front loading (flip down see-through door) Magnavox Model AH197M37 Modular Stereo System (includes dual cassette, AM/FM radio, and turntable).

  CD players and some CDROM drives manufactured by Philips (this includes the Magnavox and Sylvania brand names) seem to be the only ones still using rotary actuator technology in consumer products. In older versions, parts of the optical pickup (like the laser diode) were pluggable and easily replaced.

The three below are from CDROM drives:

- The Sony CDU-31/33A CDROM Optical Deck is typical of the mechanism found in lower performance models that use a screw drive for sled positioning. The pickup used is a three-beam KSS360A which is very nearly identical to the Sony KSS361A Optical Pickup (only the shape of the mounting bracket differs). Like its consumer CD player counterpart, everything is glued in place at the time of manufacture - there are no adjustments.

The CDU-31A 1X, CDU-33A 2X, and other CDROM drives using this deck were probably the most popular models in the early 1990s. The CDU-31/33A used the Sony proprietary interface (also available on some sound cards) and were certainly nothing to write home about in the speed department. These drives used a high quality brushless DC motor for the spindle while other similar performance CDROM drives of the era had cheap permanent magnet DC motors that were prone to failure. However, they were the only popular front loading CDROM drives to NOT have the convenience of a motorized drawer mechanism - just a solenoid release. Of course, there was less to break down!

- The Sony CDU-8001 CDROM Optical Deck provides an example of a unit using a direct drive linear motor for the coarse tracking actuator. The pickup is a three-beam Sony KSS180A - quite similar to the Sony KSS361A Optical Pickup but appears to be more solidly constructed with at least one additional optical element that may be a collimating lens. Unlike most consumer grade pickups, the KSS180A is not totally glued together and some adjustment of optical alignment is possible.

  This deck came from a Sony CDU-8001 CDROM Drive Unit - a speedy 1X drive (aren't you impressed?) used with a SCSI interface for an Apple MacIntosh computer. The NEC Model CDR-82 CDROM Reader and others of the same vintage also use the same Sony KSS180A pickup.

  These were of the cartridge loading type (loading mechanism removed). The spindle motor is a high quality DC brushless type.

  Some component CD players by Technics (Matsushita) and others (in addition to Sony) also used linear motor technology as early as 1983 (possibly even before) to provide fast (under 1/2 second) music seek times which is better performance than some of the early CDROM drives using screw or gear type actuators.

- The Philips CR-206 CDROM Optical Deck views provide an example of a drive using a rotary actuator for both coarse and fine tracking. This uses a single-beam pickup where the laser diode and photodiode are apparently combined into one package which is mounted in a very simple compact optical assembly.

  This deck came from an inexpensive Philips CR-206 2X CDROM drive (vintage 1994). Note how much smaller this assembly is compared to the Philips CD player optical deck, above, which dates from around 1990.

Interestingly, most common popular higher performance CDROM drives (e.g., 4X, 12X, even 16X or more) do not use linear motors or rotary positioners to achieve rapid seek times. They use a screw or gear drive powered by a cheap permanent magnet DC motor! However, they do all use high quality brushless DC motors for the spindle since these high-X drives put a lot of stress on this component (especially those which are the true CLV type and vary speed based on track location). Although the optical pickups themselves have been simplified and have reduced mass, and the drive mechanism had been speeded up compared to the typical cheap portable CD player, this type of implementation is still far from optimal. Therefore, while the transfer rate may be pretty good (see the section: CDROM drive speed - where will it end? for why this really isn't assured even with a 32X unit), seek times may be mediocre - 250 ms full stroke being typical.

The next two are nearly complete CDROM drives of this type:

- The Philips PCA80SC CDROM Drive Optical Deck is a relatively modern design typical of low cost high spin-rate units. This one is an 8X model. The Optical Pickup from Philips PCA80SC CDROM appears to be a three-beam type.

  Apparently, many manufacturers used this basic mechanism. I have an Aztech CDA-268-01A CDROM drive (2X) which has the same pickup and a very similar optical deck.

- The Teac CD-532S CDROM Drive is another popular design used in late model (1998) low cost high spin-rate units. This one is a 32X (Max) model with a SCSI interface. The 32X (Max) rating really means that it spins at constant speed roughly equivalent to a 13X rate and the 32X spec is only achieved for data located near the outer edge of the disc.

The Sony KSS575B three-beam pickup used in this drive is quite compact but of the more complex design using a separate laser diode and photodiode array with beam splitter. The optical path is equivalent to that of that of the Sony KSS361A Optical Pickup. (See the section: Sony KSS series optical pickups.) The guts are located in a central box-like object about 1.5 cm on a side. However, the pickup is mostly made of plastic - gone are the days of the cast metal optical block! While this does make it weigh less, the difference would hardly seem to be significant for access speed given the primitive screw drive.

The Sanyo K38N Optical Pickup used in the earlier (like all of 3 months!) Teac model, the 16X CD516s, is substantially similar to this but of more solid construction. Teac CDROM drives from 6X (and possibly below) through this 32X unit appear virtually identical mechanically.

Also notice how little electronics there is in this unit - nearly all the circuitry is on the single small circuit board on the left side of the bottom view. On all the other CDROM drives, the logic board occupied all the space (and more in some models) above or below the optical deck!

Finally, here are photos of DVDROM drives:

- The Toshiba SD-M1212 DVDROM Drive is typical of the DVDROM drives shipped with bundled PCs (I believe this was from a Dell Dimension 450 MHz Pentium II system). The most notable feature of the optical deck used here is that it really is so similar in appearance to those used with late model CD players or CDROM drives. In fact, without the DVD logo or other distinguishing markings, it could just as well have been a CDROM drive. (Of course, we know that what's inside is quite different at least in the details.) I wasn't willing to go any deeper since this is still a working unit so there could be internal differences. An update will be forthcoming when I get my hands on a broken one!

  Note that it appears to have only a single objective lens. This would tend to imply that compromises have been made, most likely for CDs, and that performance with them may not be as good as with a dedicated CDROM drive.

  One thing that is obvious is the amount of circuitry compared to say, the Teac CD532s, above, whose PCB occupied less than 1/3rd of the available area. I don't know how much this is due to just being newer technology which hasn't been as highly integrated yet as opposed to the additional complexity required for DVD decoding and support for CD audio and data formats as well.

- The Optical Path of CD/DVDROM from Sony F390 Laptop shows the optics and laser diode assemblies from below. The objective lens would be where the turning mirror faces. This unit has separate DVD and CD lasers, each of the "hologram laser" type with a Holographic Optical Element (HOE) for generating the side beams and replacing the polarizing beam splitter and other components. One of the laser diodes is a Sharp HPD 24T3 according to the markings. The DVD laser diode assembly has a 3 way beam splitter crystal on the front, 'T' shaped, and the other has a two way splitter '-' on the crystal face. DVD Laser Holographic Optical Element shows the HOE on the DVD laser diode assembly. Thanks to John LeBourgeois (john@121email.com) for these photos.

Components of the optical pickup

All the parts described below are in the optical pickup. As noted, the optical pickup is usually a self contained and replaceable subassembly. The actual complement and arrangement of parts depends on the specific pickup design - a number of popular variations on the basic arrangement are used. Thus, should you actually end up dismantling a dead optical pickup, it will probably not match this description exactly. While the relatively old Sony KSS110C Optical Pickup has most of the same components as described below, the very common newer Sony and Sanyo optical pickups combine multiple functions into fewer elements. Typical examples are found in the Sony KSS361A Optical Pickup and Sanyo K38N Optical Pickup. The even simpler CMKS-81X Optical Pickup and Optical Pickup from Philips PCA80SC CDROM combine the laser diode and photodiode array into single package and eliminate all of the other optical components except for the diffraction grating and turning mirror (and the latter could be eliminated where space permits below the deck). The resulting designs are much cheaper to manufacture, more robust and reliable, and should have better performance as well since there are fewer intermediate optical components to degrade the beam.

Also see the section: CD optical pickup operating principles.

Despite its being a precision optomechanical device, optical pickups are remarkably robust in terms of susceptibility to mechanical damage.

- Laser Diode - This is Infra Red (IR) emitting usually at 780 nm - near IR, just outside the visible range of 400-700 nm. The power output is no more than a few milliwatts though this gets reduced to .25-1.2 mW at the output of the objective lens. A photodiode inside the laser diode case monitors optical power directly and is used in a feedback loop to maintain laser output at a constant and extremely stable value.

  The photos below show some of the types of laser diodes you may encounter in CD players, CDROM drives, laser printers, and bar code scanners:

  - A Variety of Small Laser Diodes (CD, laser printer, bar code scanner).
  - Closeup of Typical Laser Diode (from a laser printer).
  - Closeup of Laser Diode from the Sony KSS361A Optical Pickup (seen 'actual size' in the upper left corner of the group photo, above.)

  On an increasing number of pickups, the laser diode and photodiode array are combined into a single package. These are recognizable by their 8 or 10 lead package. See the section: Optical pickup complexity.

  Common problems: bad laser diode or sensing photodiode resulting in reduction or loss of laser output.

- Photodiode array - This is the sensor which is used to read back data and control beams. These are usually integrated into a single chip with a clear plastic cover. On an increasing number of pickups, the laser diode and photodiode array are combined into a single package. These are recognizable by their 8 or 10 lead package. See the section: Optical pickup complexity.

  The photodiode array for a three-beam pickup has 6 segments - 4 in the center (A,B,C,D) and 1 on either side (E,F). Only the center segments are used in a single-beam pickup.

  However, there are some CD players and CDROM drives are fitted with complete three-beam pickups, but don't take advantage of the side beams - the E and F segments of the photodiode array are simply grounded! So, the blurb for these models may say "Featuring three-beam pickup" when only a single-beam is used! Isn't marketing wonderful? :-).

  Common problems: bad photodiode(s) resulting in improper or absence of focus and weak or missing RF signal. A missing bias voltage to the photodiode array would also result in lack of output.

- Collimating lens - This converts the wedge shaped beam of the laser diode into nearly parallel rays. Not present in many (newer) designs.

- Diffraction grating - In a 'three-beam pickup', this generates two additional lower power (first order) beams, one on each side of the main beam which are used for tracking feedback. It is absent in a 'single-beam pickup'.

- Cylindrical lens - In conjunction with the collimating lens, this provides the mechanism for accurate dynamic focusing by changing the shape of the return beam based on focal distance. Modern pickups may actually use a thick beam splitter mirror or astigmatic objective lense to implement this function and/or take advantage of the natural astigmatism of the laser diode itself. The thick mirror approach is used in most common Sony KSS pickups, for example.

- Beam splitter - Passes the laser output to the objective lens and disc and directs the return beam to the photodiode array. There will be no beam splitter (and related optics) if the laser diode and photodiode are combined in a single package. Where this is a thick mirror, it also introduces the needed astigmatism for focusing (most Sony KSS pickups, for example).

- Turning mirror - Redirects the optical beams from the horizontal of the optical system to vertical to strike the disc. Where space permits under the pickup, there is no need for a turning mirror as everything can be vertically oriented.

  Common problems: dirty mirror. Unfortunately, this may be difficult to access for cleaning. Note: the turning mirror is probably not silvered but is coated to reflect IR so do not be surprised if you can see through it.

The previous five items are the major components of the fixed optics. Outside of damage caused by a serious fall, there is little to go bad. Better hope so in any case - it is usually very difficult to access the fixed optics components and there is no easy way to realign them anyhow. Fortunately, except for the turning mirror, it is unlikely that they would ever need cleaning. Usually, even the turning mirror is fairly well protected and remains clean.

Depending on the design of the pickup, many of the components of the optical system listed above may be missing or combined into a single unit. In fact, the most modern pickup designs combine the laser diode and photodiode into a single package with 8 to 10 leads. With this approach, there is no need for a beam splitter or related optical components as the outgoing and return beams take nearly the same path. The overall manufacturing process is simplified, performance is improved, the cost is reduced, and reliability and robustness are enhanced. See the section: Optical pickup complexity.

The following items are associated with focusing the laser beam down to a microscopic point and maintaining it precisely on the CD's tracks:

- Objective lens - High quality focusing lens, very similar to a good microscope objective with a numerical aperture (N.A.) of .45 and focal length of 4 mm. (Should you care, the N.A. is defined as the sine of the angle from the optical axis to the edge of the objective, as seen by the object. An N.A. of .45 implies a very fast high quality lens.)

  If you examine CD player objective lenses closely, you will also note that they are aspheric - the surface is not shaped like the surface of a sphere (as is the case with most of the small lenses you are likely to encounter) but its radius of curvature changes from center to edge (it is somewhat pointed). Because the light source (laser diode) is coherent and monochromatic, a low cost single element plastic molded lens with an antireflection coating (the blue tinge in the central area) can produce a diffraction limited spot (less than 2 um in diameter) at the disc information (pits) layer. An expensive multielement lens system would be required if the light source were not coherent and monochromatic. Of course, the entire technology would not be practical in this case!

  There is usually a ridge around its periphery to prevent the polished surface from being scratched should the assembly accidentally contact the spinning disc.

  Note: Some objective lenses (e.g., Philips/Magnavox) have a perfectly flat front surface. This would appear to be more susceptible to damage but perhaps a mechanical stop prevents contact even at the extreme upper limit.

The lens is suspended to permit movement in two directions: up and down (focus) and toward and away from the spindle (tracking). Common problems: dirty lens, dirt in lens mechanism, scratched lens, damage from improper cleaning or excessive mechanical shock.

- Focus actuator - Since focus must be accurate to 1 micron - 1 um, a focus servo is used. The actuator is actually a coil of wire in a permanent magnetic field like the voice coil in a loudspeaker. The focus actuator can move the objective lens up and down - closer or farther from the disc based on focus information taken from the photodiode array.

  Common problems: broken coil, damaged suspension (caused by mechanical shock or improper cleaning techniques).

- Tracking actuator - Like focus, tracking must be accurate to 1 um or better. A similar voice coil actuator moves the objective lens from side-to-side (relative to the tracks - toward or away from the spindle) based on tracking feedback information taken from the photodiode array.

  Note: On pickups with rotary positioners, there may be no separate tracking coil as its function is subsumed by the positioner servo. The frequency response of the overall tracking servo system is high enough that the separate fine tracking actuator is not needed. These are also always of the single-beam type since the angle of the pickup changes with radial position and three-beam tracking control cannot be used.

  Common problems: broken coil, damaged suspension (caused by mechanical shock or improper cleaning techniques).

Classification of CD player problems

While there are a semi-infinite number of distinct things that can go wrong with a CD player, any set of symptoms can be classified as a hard failure or a soft failure:

1. Hard failure - door opening/closing problems, disc is not recognized, no sound, unit totally dead.

2. Soft failure - skips, continuous or repetitive audio noise, search or track seek problems, random behavior.

Both of these types of problems are common with CD players and CDROM drives. The causes in both cases are often very simple, easy to locate, and quick and inexpensive to repair.

Most common CD player problems

While it is tempting to blame the most expensive component in a CD player or CDROM drive - the laser - for every problem, this is usually uncalled for.

Here is a short list of common causes for a variety of tracking and audio or data readout symtoms:

- Dirty optics - lens, prism, or turning mirror.
- Drawer loading belts - worn, oily, flabby, or tired.
- Sticky mechanism - dirt, dried up/lack of lubrication, dog hair, sand, etc.
- Broken (plastic) parts - gear teeth, brackets, or mountings.
- Need for electronic servo adjustments - focus, tracking, or PLL.
- Intermittent limit or interlock switches - worn or dirty.
- Bad connections - solder joints, connectors, or cracked flex cable traces.
- Motors - electrical (shorted, dead spot) or mechanical (dry/worn bearings).

- Laser - dead or weak laser diode or laser drive (power) problems.
- Photodiode array - bad, weak, or shorted segments or no power.
- Bad/heat sensistive electronic components.
- Bad or missing optical pickup shield ground.

The following two areas cover the most common types of problems you are likely to encounter. For any situation where operation is intermittent or audio output is noisy, skips, or gets stuck, or if some discs play and others have noise or are not even recognized consistently, consider these FIRST:

- Dirty lens - especially if your house is particularly dusty, the player is located in a greasy location like a kitchen, or there are heavy smokers around. Cleaning the lens is relatively easy and may have a dramatic effect on player performance.

- Mechanical problems - dirt, dried up lubrication, damaged parts. These may cause erratic problems or total failure. The first part of a CD may play but then get stuck at about the time location.

  If your CD player has a 'transport lock' screw, check that it is in the 'operate' position before breaking out the heavy test equipment!

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Troubleshooting Guide

Instant troubleshooting chart - most common problems and likely causes

The following chart lists a variety of common problems and nearly all possible causes. Diagnostic procedures will then be needed to determine which actually apply. The 'possible causes' are listed in *approximate* order of likelihood. Most of these problems are covered in more detail elsewhere in this document.

While this chart lists many problems, it is does not cover everything that can go wrong. However, it can be a starting point for guiding your thinking in the proper direction. Even if not listed here, your particular problem may still be dealt with elsewhere in this document.

- Problem: CD player is totally dead.
  Possible causes:

  1. Power outlet, wall adapter, or batteries are dead (as appropriate).
  2. Damage to line or wall adapter cord or plug.
  3. Bad connections or faulty component in power supply (including blown fuse).
  4. Defective microcontroller.

- Problem: CD player is operational but there is no display or partial display.
  Possible causes:

  1. Burned out back-light bulb(s).
  2. Bad connections to display panel (totally dead or erratic).
  3. Bad solder connections on display panel (some segment work).
  4. Bad power supply (EL panel filament, driver voltages).

- Problem: CD player ignores you.
  Possible causes:

  1. Bad connections to one or more buttons or sets of buttons.
  2. Microcontroller failed to reset properly.
  3. Missing/bad voltages from power supply.
  4. Defective microcontroller or other logic.

- Problem: Drawer does not open or close.
  Possible causes:

  1. Worn, stretched, oily, flabby, belt.
  2. Dirty mechanism or gummed up lubrication.
  3. Stripped gear or other mechanical damage.
  4. Defective motor or bad connections to motor.
  5. Bad drawer/eject button.
  6. Missing/bad voltages from power supply.
  7. Defective microcontroller or other logic.
  8. Dealer antitheft lock enabled.

- Problem: Drawer operation is erratic.
  Possible causes:

  1. Dirty sense switch contracts or bad connections.
  2. Worn, stretched, oily, flabby, belt.
  3. Dirty mechanism or gummed up lubrication.
  4. Defective motor or bad connections to motor.
  5. Stripped gear or other mechanical damage.
  6. Missing/bad voltages from power supply.
  7. Defective microcontroller or other logic.

- Problem: Drawer does not close (or open) completely.
  Possible causes:

  1. Worn, stretched, oily, flabby, belt.
  2. Dirty mechanism or gummed up lubrication.
  3. Foreign object like toy, rock, or runaway disc blocking drawer.
  4. Stripped gear or other mechanical damage.
  5. Gear timing is messed up.

- Problem: CD changer jams when selecting or ejecting CDs.
  Possible causes:

  1. Bad belts, dirt or need for lubrication.
  2. Foreign objects, chipped or broken gears, or other mechanical damage.
  3. Messed up gear timing.
  4. Defective sensor (microswitch or opto-interrupter.
  5. Defective motor, driver, or power supply.
  6. Logic or microcontroller problem.

- Problem: CD player or CDROM drive damages CDs.
  Possible causes:

1. Broken, bent, or missing part.
2. Messed up gear timing (mainly cartridge changers).
3. Other mechanical fault.
4. Lens hitting CD due to electronic fault or need to adjust focus servo.

- Problem: Spindle table loose or sticks to clamper upon eject.
  Possible causes:

  1. Set screw loosened or glue failed holding spindle to motor shaft.
  2. Parts of spindle table broke.

- Problem: Intermittent or erratic operation.
  Possible causes:

  1. Dirty, scratched, or defective disc.
  2. Dirty lens.
  3. Extended length discs too long for player.
  4. Loading (mechanical) not completed reliably.
  5. Bad connections including missing/erratic optical deck shield.
  6. Cracks in ribbon cable to optical pickup.
  7. Dirty drawer or limit switches.
  8. Power supply or logic problems.
  9. External interference.
  10. Internal damage (e.g., loose parts) in optical pickup.

- Problem: CD player or CDROM drive overheats.
  Possible causes:

  1. Excessive ambient temperature - sauna or hot stereo components.
  2. Failing/marginal part in power supply, logic, or optical pickup.

- Problem: Operation is poor or erratic when cold:
  Possible causes:

  1. Gummed up grease or dirt inhibiting movement until warm.
  2. Condensation on optical components due to temperature change.
  3. Bad connections or dirty contacts affected by temperature.

- Problem: Disc is not recognized displaying 'disc', 'error', etc.
  Possible causes:

  1. Disc loaded upside-down.
  2. Transportation lock engaged.
  3. Dirty, scratched, or defective disc.
  4. Dirty or damaged objective lens.
  5. Loading (mechanical) not completed reliably.
  6. Damaged lens suspension or damaged lens cover preventing free movement.
  7. Dirt, gummed up lubrication, or damage in sled drive mechanism.
  8. Dirty/defective limit switch or sensor.
  9. Defective spindle motor.
  10. Spindle table height incorrectly set.
  11. Bad component in optical pickup.

12. Cracks in ribbon cable to optical pickup.
13. Need to adjust servo (or less likely, optical) alignment.
14. Faulty power supply, electronics, or control logic.
15. Bad connections including missing/erratic optical deck shield.
16. External interference.

- Problem: Disc spins in wrong direction or overspeeds and is never recognized.
  Possible causes:

  1. Disc loaded upside-down.
  2. Dirty, scratched, or defective disc.
  3. Dirty or damaged objective lens.
  4. Tracking or CLV servo out of adjustment or faulty.
  5. Bad component in optical pickup.
  6. Microcontroller or control logic problems.
  7. Bad connections or defective ribbon cable to optical pickup.
  8. Defective spindle motor including worn bearings.

- Problem: Pickup attempts to reset past inner track.
  Possible causes:

  1. Dirty or defective limit switch, bad connections to it, or its electronics.
  2. Broken parts preventing limit switch from being activated.
  3. Tracking servo out of adjustment or faulty.
  4. Microcontroller or logic problems.

- Problem: Player won't let you go near it and/or use your favorite lamp.
  Possible causes:

  1. Missing optical deck shield, ground strap, or other connection.
  2. Outside interference.

- Problem: Seek operations take too long or fail to complete.
  Possible causes:

  1. Dirty, scratched, or defective disc.
  2. Transportation lock engaged.
  3. Dirty or damaged objective lens, suspension, obstruction, etc.
  4. Tracking or CLV servo out of adjustment or faulty.
  5. Mechanical problems with sled movement.
  6. Faulty sled motor or drive IC.
  7. Faulty control logic.
  8. Bad flex cable to optical pickup.

- Problem: Search, seek, or play starts correctly, then loses time or position.
  Possible causes:

  1. Dirty, scratched, or defective disc.
  2. Dirty or damaged objective lens, suspension, obstruction, etc.
  3. Tracking or PLL servo out of adjustment or faulty.
  4. Stuck button.
  5. Defective sled motor drive IC.

6. Faulty control logic.

- Problem: Short distance skipping.
  Possible causes:

  1. Dirty, scratched, or defective disc.
  2. Dirty or damaged objective lens, suspension, obstruction, etc.
  3. Fine tracking servo out of adjustment or faulty.
  4. Weak laser or other defective part in the optical pickup.

- Problem: Playback gets stuck (rapid repeat).
  Possible causes:

  1. Dirty, scratched, or defective disc.
  2. Dirty or damaged objective lens, suspension, obstruction, etc.
  3. Dirt, gummed up lubrication, or damage in sled drive mechanism.
  4. Transportation lock engaged.
  5. Need for servo alignment.

- Problem: Occasional long distance skipping or repeating.
  Possible causes:

  1. Dirty, scratched, or defective disc.
  2. Dirty or damaged objective lens, suspension, obstruction, etc.
  3. Dirt, gummed up lubrication, bad belt, or damage in sled drive mechanism.
  4. Transportation lock engaged.
  5. Need for servo alignment.

- Problem: Player gets stuck at approximately same time on multiple discs.
  Possible causes:

  1. Dirt, gummed up lubrication, or damage in sled drive mechanism.
  2. Sled reaching mechanical stop with extended length (>74 minute) disc.
  3. Transportation lock engaged.
  4. Need for servo alignment.
  5. Defective spindle motor.

- Problem: Various tracking problems on portions of discs:
  Possible causes:

  1. Dirty, scratched, or defective disc.
  2. Faulty spindle motor.
  3. Misalignment of spindle table and sled track.
  4. Need for CLV adjustment.

- Problem: Repetitive noise at disc rotation rate.
  Possible causes:

  1. Dirty, scratched, or defective (possibly warped) disc.
  2. Dirty or damaged objective lens, suspension, obstruction, etc.
  3. Loose spindle or foreign material on spindle table.
  4. Disc not firmly clamped.

5. Bent spindle.
6. Excessive spindle runout due to worn bearing.
7. Need for servo alignment.
8. Weak laser or other component in optical pickup.

- Problem: Audio muting, noise, or distortion.
  Possible causes:

  1. Dirty contacts on RCA jacks on CD player or amp.
  2. Bad connections to RCA jacks.
  3. Dirty/defective muting relay contacts.
  4. Defective components in the analog circuitry (final filter, muting, amp).
  5. Faulty power supply (for audio circuits if used).
  6. Dirty controls (probably on amp unless problem is with the headphones).

General inspection, cleaning, and lubrication

The following should be performed as general preventive maintenance or when erratic behavior is detected. The lens and its suspension, turning mirror, drawer mechanism, spindle, and sled drive should be checked, and cleaned and/or lubricated if necessary and appropriate.

You will have to get under the clamp to access the lens and spindle on drawer loading models but the lens and its suspension, at least, should be readily accessible on portable CD players with pop-up doors. These types can collect a lot of dust, dirt, and even fingerprints! Realistically, you probably won't do any of this for component CD players, CDROM drives, or other drawer loading models until something goes wrong! :-) (I don't blame you - getting one of those out from the tangle of entertainment center wiring, dusting it off, removing the cover, disassembling to whatever level is needed, and so forth can be a royal pain.)

Cleaning the objective lens and turning mirror (if accessible) are the most important general maintenance that can be done. Even minor contamination of their optical surfaces can easily result in 50 percent reduction in the returned signal - and all sorts of problems.

- Objective lens - Carefully clean the lens assembly. Be gentle! The lens is suspended by a voice coil actuated positioner which is relatively delicate. A CD lens cleaning disc is nearly worthless except for the most minor dust as it will not completely remove grease, grime, and condensed tobacco smoke products (yet another reason not to smoke!) and make matters worse by just moving the crud around.

  First, gently blow out any dust or dirt which may have collected inside the lens assembly. A photographic type of air bulb is fine but be extremely careful using any kind of compressed air source. Next, clean the lens itself. It is made of plastic, so don't use strong solvents. There are special cleaners, but isopropyl alcohol us usually all that is needed for CD players and VCRs. (91% medicinal is acceptable, pure isopropyl is better. Avoid rubbing alcohol especially if it contains any additives.) However, sometimes, a drop of water will be needed to dissolve sugar based crud. There should be no problems as long as you dry everything off (gently!) reasonably quickly. DO NOT LUBRICATE! You wouldn't oil a loudspeaker, would you?

  You cannot generally get to the bottom surface of the lens but this isn't nearly as exposed as the top surface so it usually isn't a problem. However, a few models do permit removal and replacement of the entire objective lens assembly without realignment. In such a case, you can get to the bottom of the lens as well as additional optics surfaces (see below) for cleaning.

  Do NOT use strong solvents or anything with abrasives - you will destroy the lens surface rendering the entire expensive pickup worthless.

- Now, inspect the lens. When clean, the lens should be perfectly shiny with a blue tinge uniform over the central surface. Minor (barely visible) scratches will probably cause no harm but any major scratches may result in erratic tracking or total inability to even read the disc directory. The pickup (or lens assembly) will need to be replaced in this case.

  It is easy to be misled into thinking that there are serious problems at the root cause of discs not being recognized, audible noise (CD players) or data errors (CDROM or optical drives), and tracking problems like skipping, sticking, or seek failures. However, in many cases, it is simply a dirty lens! Even people who repair CD players regularly may make an incorrect diagnosis since many of the symptoms **are** similar to those caused by a bad laser, spindle motor, or major logic failure.

- Turning mirror or prism. If you can get to it under the lens without disturbing anything, clean this as well using the same procedure. Cleaning this may be at least as important as the lens. Unfortunately, the turning mirror may not be accessible without major (and difficult) disassembly.

  Cleaning the turning mirror is nearly as important as cleaning the lens (especially for Sony pickups apparently since it is relatively exposed).

  However, for the typical Sony pickup (also used in Sony PlayStations and by AIWA and other manufacturers), it is really pretty easy. First, remove the black protective cover by prying the clips out on either side. Use a toothpick or Q-tip stick to GENTLY lift up on the lens assembly taking care not to damage any of the fine wires. Blow out any dust using an air bulb. There will be just enough room to get a Q-tip in between the lens and mirror.

  Note: The turning mirror is not silvered so don't expect a normal mirror appearance - it looks just like a piece of glass. However, it is coated to be an excellent reflector for the 780 nm IR laser light.

  Of course, this procedure doesn't get to the beam splitter, photodiode, or laser diode window - but you can't have everything! :-) Fortunately, these are usually better protected and less likely to collect dust and grime.

- Lens suspension for focus and tracking. Check this for free movement and damage:

  - Focus: The lens should move up and down without sticking (turn the player or pickup upside-down carefully to watch the lens move without power and/or move it gently with a dry Q-tip). It should remain parallel to the deck throughout its range and return to the center or just below center when released. However, it is hard to say just how far below the center is enough to consider it bad. Even a bottomed out lens might work - the focus servo can correct to a large extent - but could result in more susceptibility to skipping or other erratic operation particularly with less-then-perfect discs. Also, see the section: [Comments on Sony KSS pickup suspension problems]

  - Tracking: Use a Q-tip to gently move the lens toward and away from the spindle. It should move easily without sticking and remain parallel to the deck. When released, it should return to approximately the middle position.

  A suspension which fails any of these tests probably means replacement of the pickup - or CD player - is needed. However, the lens with its suspension is one of the few components of the optical pickup assembly that may be replaceable - at least in principle. See the section: [Interchangeability of components in the optical pickup].

- Spindle bearing - Check the spindle bearing (this is primarily likely to cause problems with repetitive noise). There should be no detectable side to side play. I.e., you should not be able to jiggle the platform that the CD sits on. If you find that the bearings are worn, it is possible to replace the motor (about $10 from various mail order houses), though removing and replacing the disc platform may prove challenging as a result of the usual press fit mounting.

The focus servo can compensate for a vertical movement of the disc surface of 1 mm or so. A small bearing side play can easily cause larger vertical errors - especially near the end (outer edge) of the disc. Even if you are not experiencing problems due to bearing wear, keep your findings in mind for the future.

Sometimes there is a bearing runout adjustment screw on the bottom of the spindle if the spindle is not driven by a standard permanent magnet motor. I have seen this in a Sony Discman which had a custom motor assembly. A small tweak to this may fix a marginal spindle problem.

To access the drawer mechanism and sled drive in component units, you will probably need to remove the optical deck from the chassis. It is usually mounted by 3 long screws (one of which may have a grounding doodad - don't lose it. In portables and CDROMs, the bottom panel of the unit will need to be removed. Try not to let any of the microscrews escape! A good set of jeweler's screwdrivers is a must for portables.

- Drawer mechanism (if present) - Check for free movement. Test the belt (if used) for life - it should be firm, reasonably tight, and should return to its original length instantly if stretched by 25% or so. If the belt fails any of these criteria, it will need to be replaced eventually, though a thorough cleaning of the belt and pulleys with isopropyl alcohol (dry quickly to avoid damaging the rubber) or soap and water may give it a temporary reprieve. Some models may use other types of drawer mechanisms but similar recommendations apply.

  Also, check the gears and motor for lubrication and damage and correct as necessary. Clean and lubricate (if necessary) with high quality light grease suitable for electronic mechanisms such as MolyLube or Silicone grease. A drop of light oil (electric motor oil, sewing machine oil) in the motor bearings may cure a noisy or dry bearing.

- Sled drive - check the components which move the pickup including (depending on what kind of sled drive your unit has) belt, worm gear, other gears, slide bearings. These should all move freely (exception: if there is a lock to prevent accidental damage while the unit is being transported the pickup may not move freely or very far). Inspect for damage to any of these components which might impede free movement. Repair or replace as appropriate.

  If the there is evidence of dirty or hardened grease, clean the gears and track thoroughly as this may interfere with free movement. Use a sharpened toothpick or (very carefully) a pin or other tool to get in between each of the gear teeth as well to be sure that it is not hard and caked there as this may result in erratic operation and skipping.

  Then lubricate (if necessary) with just a dab of high quality light grease suitable for electronic mechanisms such as MolyLube or Silicone grease). A drop of light oil (electric motor oil, sewing machine oil) in the motor bearings may cure a noisy or dry bearing. Also see the section: Testing the sled for mechanical problems.

Try to play a disc again before proceeding further. I guess you have already done this.

Cleaning the inside of the optical pickup

Except under extreme circumstances (like dropping the CD player in the bathtub), the interior of the optical pickup should remain relatively clean and dust-free. However, what happens if you DO drop the CD player in the bathtub? Well, there will no doubt be other problems to deal with but once those are taken care of (if ever), that leaves the optical pickup.

For many, the turning mirror is accessible by gently lifting up on the lens assembly after removing the protective shroud. But, even this may not be possible for some models. And, cleaning all of the other optics may be difficult or impossible.

For example, on many Sony models, there is a metal plate fastened with a single screw underneath the pickup. This plate can be removed without disturbing any adjustments revealing the angled beam splitter and diffraction grating (of the three beam pickup) in the barrel attached to the laser diode. These can be cleaned with a Q-tip and alcohol.

However, there is no way to get beyond this point. So, if any water got in there, the only chance of success would be via an alcohol? soak. Forget about further disassembly - realignment would be totally impossible without the factory jigs. A replacement pickup will probably be needed.

Each manufacturer has their own way of assembling a pickup. The only way to determine if access is possible will be by careful exploration!

Lubrication of CD players

The short recommendation is: DO NOT add any oil or grease unless you are positively sure it is needed. Most moving parts are lubricated at the factory and do not need any further lubrication over their lifetime. Too much lubrication is worse then too little. It is easy to add a drop of oil but difficult and time consuming to restore an optical pickup that has taken a bath.

NEVER, ever, use WD40! WD40 is not a good lubricant despite the claims on the label. Legend has it that the WD stands for Water Displacer - which is one of the functions of WD40 when used to coat tools for rust prevention. WD40 is much too thin to do any good as a general lubricant and will quickly collect dirt and dry up.

A light machine oil like electric motor or sewing machine oil should be used for gear or wheel shafts. A plastic safe grease like silicone grease or Molylube is suitable for gears, cams, or mechanical (piano key) type mode selectors. Never use oil or grease on electrical contacts.

Unless the unit was not properly lubricated at the factory (which is quite possible), don't add any unless your inspection reveals the specific need. In a CD player or CDROM drive, there are a very limited number of failures specifically due to lubrication.

Note that in most cases, oil is for plain bearings (not ball or roller) and pivots while grease is used on sliding parts and gear teeth. If the old lubricant is gummed up, remove it and clean the affected parts thoroughly before adding new oil or grease.

In general, do not lubricate anything unless you know there is a need. Never 'shotgun' a problem by lubricating everything in sight! You might as well literally use a shotgun on the equipment!

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General System Problems

CD player is totally dead

Check input power, power cord, fuse, power supply components. Locate the outputs of the power transformer and trace them to the rectifiers and associated filter capacitors and regulators. While the actual voltages will probably not be marked, most of the power in a CD player will be typically between +15 and -15 VDC. Sometimes, the voltage ratings of the filter capacitors and/or regulators will provide clues as to correct power supply outputs. Don't forget the obvious of the line cord, line fuse (if present), and power switch - or outlet. Most component CD players use linear power supplies so troubleshooting is straightforward.

Portables CD players and CDROM drives often use DC-DC converters to produce the various voltages required, and these are much more difficult to troubleshoot even with a complete service manual. Doing anything other than checking for shorted or open components is virtually impossible without an accurate schematic. If an incorrect power adapter was used (or this happened when you plugged or unplugged the power connector of a CDROM drive with power on - a no-no), then major damage can result despite the various types of protective measures taken in the design. However, check for the obvious - a blown fuse on the mainboard near the power connector. These may be picofuses(tm) which look like little green resistors, IC Protectors which look like tiny transistors with only 2 legs, or something else marked F, ICP, etc. You might get lucky.

I inherited a Sony Discman from a guy who thought he would save a few bucks and make an adapter cord to use it in his car. Not only was the 12-15 volts from the car battery too high but he got it backwards! Blew the DC-DC converter transistor in two despite the built in reverse voltage protection and fried the microcontroller. Needless to say, the player was a loss but the cigarette lighter fuse was happy as a clam!

Moral: those voltage, current, and polarity ratings marked on portable equipment are there for a reason. Voltage rating should not be exceeded, though using a slightly lower voltage adapter will probably cause no harm though performance may suffer. The current rating of the adapter should be at least equal to the printed rating. The polarity, of course, must be correct. If connected backwards with a current limited adapter, there may be no immediate damage depending on the design of the protective circuits. But don't take chances - double check that the polarities match - with a voltmeter if necessary - before you plug it in! Note that even some identically marked adapters put out widely different open circuit voltages. If the unloaded voltage reading is more than 25-30% higher than the marked value, I would be cautious about using the adapter without confirmation that it is acceptable for your player. Needless to say, if the player behaves in any strange or unexpected manner with a new adapter, if any part gets unusually warm, or if there is any unusual odor, unplug it immediately and attempt to identify the cause of the problem.

See the document: Audio Equipment and Other Miscellaneous Stuff for more info on linear power supplies. See the document Small Switchmode Power Supplies for more info on DC-DC convertors.

CD player is operational but there is no display or partial display

Where the display is very dim or totally out, suspect one or more burned out bulbs for the backlight. Sometimes the display uses miniature incandescent lamps and these burn out. Usually, alternatives to the high priced exact replacement bulbs can be located. Test the bulbs with an ohmmeter. Measure the voltage across the light bulb connections and then replace the bulb with one of about 25-50% higher voltage. These may not be quite as bright but should last forever.

If the light bulbs are not at fault or there are no light bulbs, then check for power to the display including bad connections or connectors that need to be reseated. There could also be a power supply (e.g., missing voltage to the filament or segments for a vacuum fluorescent display) or driver problem.

If only portions of the display are bad - some segments on multiple digits, for example, check for bad connections to the driver chip. The displays are usually multiplexed meaning that a single output of the driver chip actually is used for the same segment in multiple digits or even apparently unrelated words or icons. Thus, a single failure can result in strange display behavior. If no bad connections are found, the driver chip or actual display could be at fault. Since the player works otherwise, unless you are a purist, it make sense to just leave it alone.

In the case of a portable or car CD that uses a 'zebra stripe' type rubber compression connector, cleaning the rubber piece, display, and circuit board with alcohol and reinstalling may solve the problem. If it uses a glued on printed flex cable, DO NOT attempt to remove it. Take extreme care when working on such equipment as it is virtually impossible to repair a cable of this type should it tear or pull free.

CD player ignores you

Symptoms are that the display comes up normal when power is turned on but all (or certain) commands are ignored.

This could mean several things:

- Front panel problem - one or more buttons are not responding. Reseat internal cables, clean or replace offending push button switches. If your CD player has a remote control, see if it operates correctly.

- Reset failure - the player has failed to reset properly and is not ready for user input. Try pulling the plug for a couple of minutes to see if it will reset. Check power supply voltages, clean and reseat internal connectors.

- Controller and/or driver electronics for the affected functions are defective. Check power supply voltages, reseat internal connectors.

For all but the first one, a service manual will probably be needed to proceed further if the problem is not with a bad power supply or bad connections.

Drawer does not open or close

If the drawer doesn't open when the front panel button is pressed, listen for motor attempting to open the drawer. If you hear it whirring but nothing happens, check for an oily/loose belt or other mechanical fault like a gear loose on the motor shaft or a slipping rubber wheel. Such a gear is probably split and a replacement will be needed. Rubber parts may be cleaned for a temporary repair but replacement will be needed eventually.

If there is no attempt, motor, control chip, or front panel pushbutton (try with the remote if you have one to eliminate this possibility) could be bad. Sony players seem to have a built in timer that triggers the belt to go bad after the warranty runs out. Also see the section on "Small Motors in CD Players".

Another slight possibility is that the player has gotten into a "Dealer Antitheft" mode which prevents people from stealing CDs or DVDs from demo units in a store. Consult your user manual or ask the place where you bought it for the key sequence. to reset it.

Drawer operation is erratic

You are about to remove your favorite CD but the player beats you to it, closes the drawer, and starts playing it over again. Or, the drawer reverses course halfway out. Or, the drawer motor continues to whir even after the door is fully open or closed and the front panel is then unresponsive.

This is usually due to dirty contacts on the door position sense switches. There are usually 3 sets of switch contacts associated with the drawer mechanism. If any of these get dirty, worn, or bent out of place, erratic operation can result:

- Drawer closed sense switch - dirty contacts may result in the drawer motor continuing to whir after the door closes and the front panel may then be unresponsive. Eventually, the drawer may open on its own.

- Drawer open sense switch - dirty contacts may result in the drawer motor continuing to whir after the door opens and the front panel may then be unresponsive. Eventually, the drawer may close on its own.

- Drawer pushed sense switch - most CD players allow the user to start play by gently pushing on the drawer which depresses a set of switch contacts. If these are dirty, the result may be the drawer deciding to close on its own or reversing direction in the middle of opening or closing.

The solution to all these problems is usually to simply locate the offending switches and clean their contacts. These switches contacts are usually not protected from dust, dirt, and grime so that these types of problems are quite common.

If the drawer simply doesn't respond to your wishes - sometimes, there may be a bad belt or bad motor.

- Sometimes, how long the player has been powered will affect the 'stickiness' of the belt - leave it on long enough and the belt will loosen and be too weak to operate the drawer. See the section: Drawer does not open or close.

- The drawer motor may have a 'dead spot' or be partially shorted. See the chapter: Motors and Spindles.

Drawer does not close (or open) completely

This is a symptom that may not be obvious. The drawer may appear to close but a loose or oily belt can prevent the mechanism from completing the close cycle. This can result in erratic behavior since the disc clamping action is often controlled by the movement - sometimes not recognizing disc, sometimes just opening the drawer, or more subtle things like tracking problems, etc. Clean the belt and see if there is any improvement. Belt replacement will be necessary eventually. Check for gummed up lubrication as well.

If it goes through the motions of closing and then stops short without any further sounds, a gear may have jumped a tooth or broken some. The result is either that the mechanism is now incorrectly timed or not able to complete the operation. Examine the mechanism closely for broken parts. Cycle it manually by turning the appropriate motor pulley or gear to see if the drawer gets hung up or is much more difficult to move at some point.

If it continues to make a whirring sound after the drawer stops, there might be some other kind of mechanical damage resulting in an obstruction or really gummed up lubrication not allowing the operation to complete.

If you have small kids around, don't overlook the possibility that your CD player is being used as a storage cabinet! A favorite toy, rock, gummy bear, jelly bean, or other organic or inorganic object may have found its way into the CD compartment. Or, perhaps, someone, somehow, managed to lodge a disc inside despite the best efforts of the CD player's designers. (This might happen if it was transported upside-down, for example).

CD changer jams when selecting or ejecting CDs

Unfortunately, this is the sort of problem one has to see to be able to make specific recommendations.

- Check for flabby/oily belts (if any), dirt, or and gummed up lubrication.

- Double check that it is in good condition mechanically - no chipped gear teeth or broken parts.

- Gear timing may be messed up (especially if someone worked on the unit previously though I don't know which, if any CD changers, depend on this for proper operation).

Try to cycle the mechanism manually by turning the appropriate motor shafts.

- A defective sensor - either a microswitch or opto-interruptor - can result in improper commands being issued to the motors.

- If movement is weak, erratic, or non-exitent, check for bad connections, defective motors and drivers, and power problems.

- A logic problem is also possible but not very likely.

Get a bunch of garbage AOL or MSN (your choice) CDs to experiment with - it should be able to cycle them just fine but the audio may sound weird :-). (Hint: Turn the volume way down!) Then, try to determine exactly what it is trying to do and how it screws up.

For auto changers where one disc doesn't come out:

(From: Tony (tony@buffnet.net).)

Try removing all the CDs from the magazine and inserting the empty magazine into the changer. Now turn on the unit and see if the cd goes back into the magazine. If it does not, look for a reset button on the changer. It will be a tiny hole near the eject button that requires a paper clip or toothpick to be inserted to contact the switch. Try pushing this with the magazine inserted. If you do not see a reset switch on the changer look for one on the face of the radio or, if it is a removable face radio, remove the face and see if there is a switch on the panel behind the face and try that. If all of this does not work, the changer will have to be disassembled for the CD to be removed. If the unit is under warranty, take it back so as not to void your warranty by disassembling the unit.

CD player or CDROM drive damages CDs

Thankfully, this sort of problem is not very common - the last thing you want is for your equipment to damage the media!

First, use a garbage CD and attempt to determine exactly where it is hitting or scraping. That may be enough to identify the culprit. Most of the time, this will be a simple mechanical fault like a broken plastic part causing things to jam, or a bit of that part getting in the way. Or, perhaps, your ace system administrator got just a bit carried away in frustration and stomped on the top of the drive. :)

On cartridge type changers, a bad or missing belt or gear timing problem could result in the CD getting hung up or scraping as it is extracted or replaced.

In some cases, an electronic failure or improperly adjusted focus servo could result in the lens hitting the CD on the top of its excursion.

A lot of newer equipment - especially high-X CDROM drives - is built so cheaply that repair may not be possible or cost effective and replacement is the only viable option.

Spindle table loose or sticks to clamper upon eject

When you remove the CD, you may have an added surprise - the platform upon which the CD sits pops off as well, possibly jamming everything. There may also be startup and spindown problems.

Various models use different techniques to fasten the spindle table to the motor shaft but this is strictly a mechanical problem. Either a set screw has worked loose, adhesive has weakened, or a press fit has come undone.

If there is no set screw, a drop of Epoxy may be what is needed. However, height is important to guarantee proper focus range so some care will be needed if there no definite stop. The disc and rotating clamper magnet must be clear of any fixed structures and the correct distance from the optical pickup. Where something irreversible is involved like adhesive, checking the service manual is highly recommended - the specification is usually .1 mm accuracy.

A loose spindle table may also result in continued spinning upon eject or sluggish or noisy startup or seek since the if the spindle is loose, the motor will not be able to properly control disc speed during speed changes.

Intermittent or erratic operation

When a CD player appears to have a mood problem - playing fine sometimes or for only part of a disc or aborting at random times, there can be several possible causes including a dirty lens, dirty or worn interlock switch or bad connections to interlock switch (mainly portables and boomboxes), flex cable with hairline cracks in one or more conductors (or just misrouted and close to a metal part of the chassis!), other bad connections, marginal power supply, defective or extended length disc.

- Dirty, scratched, or defective CD - confirm that the CD is not the problem. Clean the disc and/or try another one. However, not all CDs are created equal. Both the overall quality of the information layer and plating as well as the amount of lead-in and blank space between music tracks varies. Thus, where some aspect of the CD player's optics or electronics is not perfect - or even variations in the microcontroller's programming - can result in the player not properly dealing with some discs. The use of CD-Rs represents even more variability since they are increasingly written on low cost equipment of questionable quality.

- Dirty lens - a player that accepts some discs and not others or accepts discs sporadically may simply need its eyeglasses cleaned.

- Extended length discs - some players will simply not play discs which exceed about 74 minutes (the legal limit for CD playing time) to the end (or possibly at all). Such CDs may be as long as 78 or 80 minutes or more. This means that certain aspects of the CD specifications were compromised. Both mechanical and electronic problems are possible. See the section: Problems with extended length discs.

- Mechanical - oily, flabby belts preventing full drawer closing or gummed up lubrication on the sled (may fail depending on ambient temperature). For example, if the music gets stuck at about the same time on every disc, then there may be gunk on the end of the sled track preventing the sled from moving any further. This is especially likely if you just purchased a disc with an unusually long playing time - it has nothing to do with the musical tastes of the CD player! (There was this Chinese restaurant where the Chinese cooking grease apparently collected on the unused end portion of the sled track and when they tried to play an extra long CD.....)

- Bad connections - there are often many little connectors used to get signals and power between the optical deck and main circuit board. These are usually cheaply made and prone to failure. Wiggling and reseating these may cure these problems. There may even be bad solder connections on the pins of connectors or board mounted switches. Slight flexing or just expansion and contraction may result in intermittent shutdown or other problems. These problems are more likely with portables and boomboxes which may get abused.

  The connectors for any flex cables are particularly prone to developing erratic contact. Where a locking bar is used, pull it up to release the cable; remove, clean, and reinsert the cable; and press the locking bar firmly into place may help. Where there is no lock, gently pull the cable out of the connector, clean, and install. I have seen problems of this type on a couple of CDROM drives - portable and component CD players use the same types of cables.

- A missing shield between the analog ground and the optical deck can result in all kinds of erratic behavior. If these weird problems started after you had the player apart for some reason, check that you replaced the grounding strap or metal strip and/or didn't accidentally disconnect or break any shield connection on the ribbon cable to the optical deck.

- Cracks in ribbon cable - The moving and fixed parts of the optical pickup are often joined with a printed flexible cable. Constant flexing may cause one or more of the copper traces to crack. This may show up as an inability to get past a certain point on every disc - the player may shut down or start skipping at around 23 minutes into every CD.

- Dirty switches - oily film or oxidation may be preventing any of the limit or interlock switches from making reliable contact. If this is the case, the player may stop at random times, fail to accept a disc, close the drawer without your permission, etc. Use contact cleaner and typing paper to clean the contacts. Disassembly may be required for enclosed switches.

- Power supply or logic problems are also possible but rare. However, if you have a scope, check the power supply outputs for ripple - a filter capacitor may have dried up and lost most of its capacitance.

- External interference from a powerful local radio station (probably AM but could also be CB or a ham operator), light dimmer, or other source. Sometimes reversing the AC plug, repositioning the equipment, or using higher quality cables may help. Unfortunately, there are often no easy solutions to these sorts of problems. A missing or broken optical deck shield ground (see above) could make the player more susceptible to this.

- Internal damage (e.g., loose parts) in optical pickup. A partially detached lens in Pioneer type pickups (see the section: Objective lens popped out) or loose grating in Sony pickups can result in all sorts of strange and non-reproducible behavior.

  (From: David Kuhajda (dkuhajda@locl.net).)

  What we normally see on some Sony pickups like the KSS240 is the grating plate glue breaks loose on one end inside the optics, which allows it to move around. The exact position of this is extremely critical to the proper operation of the cd player. Unfortunately the only way to fix this is to replace the optics and realign it as needed.

CD player or CDROM drive overheats

A CD player which becomes noisy or a CDROM drive that fails to recognize discs or reliably read data after a few minutes may have a component that is heating up and changing value.

Before blaming the CD player, confirm that the ambient temperature is not excessive - CD players may not like to operate in a sauna. High power stereo components surrounding the CD player may elevate its internal temperature enough to cause erratic operation or total failure. CDROM drives sandwiched in between high capacity hard drives (this used to be more of a problem than it is today) may overheat.

Assuming your CD player is in an environment which is cool as a cucumber:

In general, there should not be much change in behavior from the instant power is applied until the next millennium. There is not much in a CD player or CDROM which runs hot and might change characteristics. However, components do sometimes fail in this manner. Problems of this type need to be diagnosed in much the same way as one would find overheating components in a TV or computer monitor.

You will need a can of cold spray ('circuit chiller') and an oscilloscope, if available. Even a hair dryer on the no-heat setting will work in a pinch.

You are going to have to try cooling various components to try to determine which one is bad. However, on a unit that dies completely and suddenly after it warms this will not be much fun since you will not have ample opportunity to detect changes in behavior. On a CD player that will play but with tracking problems and/or audio noise, you should be able to monitor the playback quality by simply listening for improvement when you have cooled the flakey part. For a CDROM drive, play an audio disc if possible since this will provide the feedback you need to locate the bad part without (hopefully) it constantly shutting down due to data errors or inability to reliably access the file system.

First, I would recommend running with the covers removed and see if that has an effect confirming a thermal problem. Try blowing cool air over the exposed innards if nothing obvious occurs. Where components are mounted on both sides of the circuit board, it may be a bit tricky to get airflow to the bottom without disassembly. Assuming you can set up a situation where the problem occurs, use the cold spray on individual components like the LSI chips - quick burst, wait a few seconds for something to change. Where the unit behaves with the cover off, use a hair dryer instead. Make a funnel out of paper to direct the air flow. You will need to be more patient with this approach.

If you have a scope, it would be nice to look at the RF 'eye' pattern during this time and see if it decreases in amplitude and/or quality over the course of an hour. If it does, you may have an overheating problem in the laser diode or its power supply.

(For unknown reasons, the name 'RF' is often used to denote the raw signal from the pickup. Since it's at a few MHz, it is in the RF range of the electromagnetic spectrum. There is no radio transmitter inside a basic CD player! :) However, a few CD players DO have an RF modulator for transmitting the audio to a nearby FM radio for wireless operation but that is a totally different use of the term being AFTER the audio circuits.)

Operation is poor or erratic when cold

This is somewhat the opposite of overheating and is usually NOT due to a failing part - electronic components generally misbehave when hot, not cold.

For a system that is not exposed to the elements (e.g., a portable taken from sub-zero outdoors and immediately put to use indoors), the most likely cause is mechanical: Gummed up grease and dirt are stiffer when cold and inhibit motion of the sled and other moving parts until the unit warms up.

However, for automotive units and portables - which are not well sealed, condensation can form form on the optics if a cold player is exposed to a humid environment. This may be the case when you get into your car on cold days until the CD player itself warms up to ambient temperature. If a VCR or camcorder detects condensation, it will flash a DEW warning and refuse to do anything to protects itself. For VCRs, this is critical because you could end up with a mess and expensive repair bill if the video tape were to stick to the spinning video head drum. Unfortunately, CD players don't have this feature since nothing catastrophic would happen. A warning would be nice, however!

A third possibility is that there are bad connections or dirty contacts in the unit that are affected by temperature resulting in erratic behavior as they expand.

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Startup Problems

What is a startup problem?

Startup problems cover all situations where the player does not successfully read the disc directory. Nearly everything in the optical deck and much of the mainboard electronics needs to be functional to read the directory. Therefore, a single failure in any of a large number of places can prevent successful startup (and subsequent play).

- On a single play unit, failure of the startup sequence may result in a display of no disc, disc, error; a full calender but no disc info; or it may just open the door and challenge you to provide it with a proper meal.

- On a changer, failure of the startup sequence will likely result in a similar display but then the unit will move on to the next position in the carousel or cartridge. It will likely remember that it was unsuccessful at loading a disc for each position and eventually give up once all possible discs have been tried.

Possible causes for startup failure include: defective disc, dirty lens, defective laser or photodiode array, bad focus or tracking actuator or driver, dirty track, lack of or dried up lubrication, dirty or bad limit switches or sensors, defective spindle motor, faulty electronics or control logic, damaged parts, faulty optical alignment or need for servo adjustments, a missing optical deck shield, or outside interference.

On the one hand this is a large number of possibilities. The good news is that with such a large number of possibilities, there is a good chance the problem will be minor and inexpensive to fix.

Don't overlook the trivial: are you loading the disc correctly? Most CD players want the disc label-side up. However, some, like Pioneer magazine type changers want the label-side down. If you have just acquired the CD player, don't overlook this possibility.

On some poorly designed players - or where you are located in proximity to a high power (or possibly not so high power) radio station - outside interference can get into the player via the audio cables or line cord. A light dimmer on the same circuit might also produce interference via the power supply. Once inside, almost any type of behavior is possible. See the section: A HREF="#cdpwlygni">Player won't let you go near it and/or use your favorite lamp for testing procedures.

Startup sequence

There will be variations on the exact startup sequence of events depending on the type of player and its design. The result may be a blank display, display of the word 'disc', 'error', --:--, flashing display, etc. In any case, you don't get your music. By understanding the following summary as it applies to your player, you should be able to determine what is going wrong.

A dirty lens - perhaps not even visibly dirty to your naked eyeball - can result in any number of startup (or other) problems. Therefore, cleaning of the lens should be done before suspecting more obscure mechanical or electronic faults. See the section: General inspection, cleaning, and lubrication.

BTW, as hard as it may be to believe, there have been rare instances of the objective lens falling off! So, if you don't see one, check for it bouncing around in the bottom of the player! See the section: Objective lens popped out.

If this is a new player (at least for you) or has just been moved, check to see if it has a transportation lock to prevent the pickup from bouncing around during shipment. This is common on older units but you may find such a feature on the latest CD players and CDROM drives where a linear or rotary positioner is used to achieve high speed access. The lock migh prevent the sled from moving to the area of the disc directory (and of course, from playing properly).

What the CD player should do when a disc is inserted:

1. Drawer closes (or with portables, lid is closed manually) and CD is clamped to spindle.
2. Interlock (if present, always in portables) engages. In others, there may be an optical sensor or the optical pickup may act as its own disc sensor assuming a disc is present when it detects reflected light from the disc's reflective information layer.
3. Pickup resets to starting (index) location toward center of disc usually found with limit switch or optical sensor.

For the following, refer to the diagram below or the slightly nicer version: CD Player Front-End showing the photodetector organization typical in units with a 'three-beam pickup'. E and F will be absent in units with a 'single-beam pickup', though there may be other segments. The four quadrant photodetector is present in all systems.

The front-end circuitry shown is for descriptive purposes only; refer to an actual CD player schematic for details.

```
                     |<--- Photodiode Array ---->|
                               +---+---+
   ---------_________  +---+  +-| A | B |-+  +---+
   Track--->           | E |- | +---+---+ | -| F | _________
                       +---+  | | C | D | |  +---+          ---------
```

```
                        |    | +---+---+ |    |           Track--->
                  /|    |    |   |   |   |    |
    Focus       / +|----|----+---|---+   |    |
    Error o---<    |    |    |   |   *   |    |    |\
    (A+D)-(B+C) \ -|----|----|---+-------+    +----|+ \       Tracking
                  \|    |    |   *       |         |    >---o Error
              FE Amp    +--------------------------|- /       (E-F)
                             |           |         |/ TE Amp
    * Since the photodiodes  |           |
      are current sources,   |           |         |\
      the simple junctions   |           +---------|+ \       Data Out
      implement a sum.       |                     |    >---o RF Test Point
                             +---------------------|- /       (A+B+C+D)
    All Amps: current mode inputs.                 |/ DO Amp
```

The main return beam is detected by the array, ABCD. The tracking beams return to E and F. E is offset slightly off track on one side and F on the other. Average signals from E and F will be equal when centered on track.

The following three steps may or may not be performed concurrently:

4. Laser is turned on and focus search routine is started to position lens at correct vertical position. Once correct focus is achieved, focus servo is activated to maintain it. Focus, which must be accurate to 1 um, operates as follows: The optical path in the pickup includes a cylindrical lens (or this may be a thick beam splitter mirror or astigmatic objective lens) which causes the laser beam spot to be circular when correctly focussed but elliptical otherwise with the major axis of the ellipse being offset 90 degrees depending on whether the lens is too close or too far (e.g., major axis of +45 degrees for too close and -45 degrees for too far). Focus Error = (A+D)-(B+C) = 0 for correct focus since with the circular spot, the outputs of all four quadrants will be equal.

5. Disc starts spinning up to 500 rpm and Constant Linear Velocity (CLV) servo is activated to maintain correct speed. CLV servo uses a PLL to lock to clock transitions derived from data read off of disc. Data is derived from A+B+C+D. (A buffered version of this signal can be monitored at the 'RF Test Point'.) A partially shorted spindle motor can result in the disc spinning but never quite reaching the required 500 rpm.

6. Tracking servo is activated to maintain laser beam centered on track. With 'three-beam pickup', 2 additional laser spots are projected onto the disc in front of and behind main beam. These are offset on each side of the track just enough so that Tracking Error = E-F = 0 when centered.

   With a 'single-beam pickup', similar information is derived using only the main beam since Tracking Error = (A+B)-(C+D) = 0 for correct tracking.

At this point, data is available for digital processing.

7. Disc directory is read and displayed.

8. Unit shuts down awaiting command or goes into play mode depending on how it was activated.

If any of steps 1 to 7 fail, then the laser is turned off and the machine will display some kind of error no disc message (typically, it may display Error, Disc, or go blank) and return to idle mode, or in the case of a changer, load the next disc and try again.

Procedure for validating the startup sequence

The following procedure is used when the disc is not recognized but the drawer closes completely.

First, double check the drawer closing/opening mechanism. Without exception, Sony CD players which have belts need them cleaned and eventually replaced. If the drawer does not close completely, then the disc may not be clamped properly or other erratic problems may occur.

Once you have verified that this is ok, you need to determine that the lens is clean. In general, the lens should look shiny with a blue tinge. Any scum or crud can degrade performance. You may have to remove part of the clamping mechanism to be able to see the lens. If it is not perfectly shiny, clean it using the procedures in the section: General inspection, cleaning, and lubrication.

Assuming that this does not improve the situation, the next step is to verify that the pickup has reset itself to the inner (center) track of the disc. If necessary manually move the pickup away from the center by turning the appropriate pulley or gear, or in the case of a linear actuator or rotary positioner (no gears or belts), just push the pickup gently and observe the behavior when a disc is loaded. If you are not able to move the pickup smoothly from one stop to the other, make sure any shipping lock is disengaged! The pickup should move smoothly toward the center, usually tripping a limit switch and stopping. If there is no movement or movement is jerky or the pickup gets stuck at some point, then lubrication may be needed or the motor or drive circuitry may be faulty. Also, check for broken or damaged gear teeth, a slipping belt, and misaligned or damaged tracks. Measure the voltage on the motor that moves the pickup. If there is none or it is very low (under a volt or so), then there is a problem with the motor, its driver, or the system controller.

Determine if the machine attempts to focus. On portables, it is sufficient to defeat the door interlock to get the operations associated with reading of the disc directory to begin (you may need to press play - this is model dependent). In some component CD players, a disc actually has to be present to block an optical sensor. You should see the lens moving up and down (at least one of these directions will have smooth movement) once or twice about 2 mm. If a disc is in place, then the lens should quickly stop at the appropriate focus position. Admittedly, observing the lens may be difficult or impossible with the disc in place. Dentists are probably good at this!

If the focus action is identical whether a disc is in place or not - i.e., it keeps up the search pattern and then gives up - verify that the laser is being powered. In most cases, you should be able to see a tiny spot of red appearing light when the lens is viewed from an oblique angle during the focus search. From a safe distance of at least six inches and 45 degrees or more off to one side, you should be able to see this dim red light in a darkened room while the unit is attempting to focus. If you see this, you can assume that the laser is being powered though it is not a sure test for an actual IR laser beam or proper optical power output. In most cases, however, the red light indicates that the laser is working. If there is no dot of red light, then either the laser diode is bad, it is not being powered, or you are not looking from the correct angle. An IR detector would confirm at least that there is an IR emission which in most cases means the laser is working (though possibly not at the proper power level):

- You can purchase an inexpensive IR detector card from an electronics distributor.
- A tester can be constructed using a photodiode, a few resistors, a general purpose small signal transistor, and an LED running off a 9 V battery. See the section: IR detector circuit. This will useful for testing IR remote controls and other IR emitters as well.
- If you have a modern camcorder (one with a CCD pickup, not a tube), it may be sensitive to IR as well but using one to test a CD laser would be pretty clunky to say the least (you would probably need to grow an extra arm or two). However, viewing the beam pattern projected on a white sheet of paper will enable the gross alignment to be checked easily - it should be fairly symmetric and centered above the lens.

If there is no IR emission while the lens is moving up and down, see the section: Testing the laser diode while in the player for more info on determining if this is a laser diode or driver problem.

If the lens is hitting the disc at the top of its excursion, there is a possibility that the spindle table has been pushed too far down - by something falling on it, for example. (A bent shaft and wobbly spindle is also a possibility in this case.) Such an occurrence is much more likely to have happened to a top loading boombox or protable than a drawer loading machine. (A friend of mine used to pound on his Sony boombox when it would not cooperate and this didn't help matters.) While hitting the disc with the spindle table set at the correct height is not impossible on some players, it is unlikely. (On most lenses, a ring around the outside of the lens itself prevents the critical central area from actually contacting the disc so accidental contact does not usually damage the lens but may scratch the disc. However, I have a portable where even this was not enough - the lens was seriously scratched somehow).

Similarly, if the spindle is too high, the lens may not be able to reach up to the proper focus position.

On a player with the height adjusted properly, there is usually about 2 mm between the laser shroud and the bottom of the disc. The spindle height is not super-critical but if it is way off, proper focus cannot be established. See the section: Spindle motor replacement.

Incorrectly adjusted focus offset or gain may result in the lens search pattern being too high or too low as well.

Once focus is established (and sometimes concurrent with this operation), the spindle should begin to turn and quickly reach 500 rpm. The speed may be ramped up or controlled in some other search pattern since there is no speed feedback until the data coming off of the disc is available. A partially shorted motor will prevent the spindle from reaching 500 rpm even though the disc will spin. Check the voltage on the spindle motor when it starts the disc spinning. It should reach 2 volts or more. If less than this but not zero, a partially shorted motor or weak driver is likely. If zero at all times then there may be a bad driver or the machine may not realize that focus was established and is not issuing the spindle motor start command. The required speed of 500 rpm - just over 8 revolutions per second - can be estimated by using a disc with a dramatic label or putting a piece of tape on the side of the disc that is visible and watching it spin.

Note that a dirty lens can sometimes result in symptoms similar to a bad spindle motor so cleaning the lens should always be the first step when servicing a CD player. I almost learned this the hard way.

Once the disc reaches the correct speed, the speed control (Constant Linear Velocity, CLV) and tracking servos will be activated (or the tracking servo may actually have been active all along) and directory data will be read off of the disc. Either of these could be faulty and/or misadjusted making it impossible to access the disc directory.

During the time that the disc is spinning and the player is attempting to read the disc directory, listen for that 'gritty' sound that CD players make during normal operation. It is a byproduct of the focus and tracking servos constantly adjusting lens position - the rapid movements of the lens produce audible sound like a loudspeaker - and its presence is a good indication that (1) the laser is working and (2) focus is being maintained.

On certain CD players, for example many Pioneer models, there is a TEST mode which enables many of the individual functions such as focus and tracking that are normally automatic to be manually enabled. This is a very useful aid in diagnosis and in adjusting a machine from an unknown state as would be the case if someone else twiddled every internal adjustment they could find! See the section: Pioneer PD/M series test mode.

Disc spins in wrong direction or overspeeds and is never recognized

The CD should always spin clockwise as viewed from the label side of the CD. This is usually the top but for some players you load the CD upside-down (e.g. Pioneer magazine type changers). If the CD should consistently start spinning counterclockwise and continue for more than a fraction of a revolution, or should the CD ever spin at a much faster rate than normal - as though it is about to take off, there may be a serious problem with the optical pickup, spindle servo, or control logic. However, behavior of this type could simply be the result of any of a number of minor faults which you can diagnose and repair including a dirty lens, the disc being loaded upside-down, or the internal adjustments being messed up due to someone violating rule #1 - never wildly tweak any internal adjustments!

First confirm that the disc is loaded correctly and that the lens is clean.

Check for bad connections and cracks in any printed flexible cables to the optical deck as well. Clean and reseat connectors just to be sure. Where a brushless DC type spindle motor (rather than a PM motor) is used, even a bad connection to the motor could result in strange behavior due to a missing phase or feedback signal.

If this does not help, attempt to perform a servo system adjustment. If you have a service manual, by all means follow it! If not, see the chapter: "Servo Systems and CD Player Adjustments". If it is a Pioneer CD player or changer, see the section: Pioneer PD/M series servo adjustment procedure (this may also apply to other non-Pioneer models with only minor changes).

(From: Michael Caplan (cy173@freenet.carleton.ca).)

Two faults I've seen: The upper bushing in the spindle motor is worn, or the commutator brushes are bad. A worn upper bushing leads to disc wobble. The spindle motor servo can't get a good feedback signal from the disc and it starts to hunt. Similarly, if the brushes are worn and making poor contact, the motor does not respond properly to the drive and the servo starts to send full drive signals to the motor to get it going, only to end up with the disc spinning flat out. In the CDs I've had with these spindle motor related problems, the added noise is this on and off drive torque hitting the motor.

Pickup attempts to reset past inner track

Sled motor doesn't stop at the inner track but keeps clicking, clunking, or whirring until the controller gives up and displays an error.

This may be due to a dirty, worn, or gummed up limit switch, bad connections, bad mechanical alignment or broken parts, or logic problems.

Most limit switches are mechanical and easily checked with a multimeter. Those that use exposed contacts can be cleaned and burnished; sealed switches found to be erratic should be replaced though spraying inside though any openings may help. I have disassembled and cleaned similar type switches (they snapped apart) but it is not fun.

Make sure the limit switch actually gets tripped when the sled reaches the area of the innermost track.

Check for bad connections between the switch and the controller.

Logic problems may be difficult or impossible to locate even with schematics. However, you might get lucky as was the case with a CDROM drive with a bad 74LS04 in the drawer switch interface!

Player won't let you go near it and/or use your favorite lamp

Symptoms may include a player where the audio becomes noisy or even stops completely or stuttering or skipping occurs, if you touch or go near it!

Note that there is an entire chapter: "Tracking (Seek and Play) Problems". However, since a possible cause of this sort of behavior is more general in nature and can affect many different aspects of CD player operation, these faults are described separately.

- One area that may be overlooked as a cause is the shielding of the pickup low level signal cable and any metal parts of the optical deck. These should all be connected to analog ground of the electronics board. If this is missing or broken, there can be all kinds of strange symptoms. If you have recently disassembled the unit and it is now behaving in this manner, this is a very slikely - easy to fix - possibility. Check for a missing ground strap, jumper, or clip. Hint: it has probably fallen under your workbench!

- External interference from a high power (or not so high power) radio station or even a light dimmer on the same circuit may make its way into the electronics and produce all sorts of strange behavior.

  On some poorly designed players - or where you are located in proximity to a high power (or possibly not so high power) radio station - outside interference can get into the player via the audio cables or line cord. A light dimmer on the same circuit might also produce interference via the power supply. Once inside, almost any type of behavior is possible. If your problems seem to depend on the time of day, check out this possibility by relocating the CD player and seeing if the behavior changes substantially. Disconnect the audio cables and see if it now displays the disc directory and appears to play properly - try headphones if possible.

  It may be difficult to eliminate the effects of this interference without moving the radio station or not using your favorite lamp. However, relocating the CD player or even just its cables and/or plugging it into a different outlet may help. Fortunately, these sorts of problems are not that common.

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Tracking (Seek and Play) Problems

Description of seek and play problems

The term 'seek' refers to the operations needed to move the pickup and locate the exact position (time) on the disc to begin or continue play (during programmed track selection). The term 'play' is self explanatory and refers to the condition of reading off data continuously while outputting audio signals to the headphones or amplifier. Somewhat in between are the actions performed during audible search forward or backward.

When playing at normal speed (e.g., 1X for music), the fine tracking servo maintains the laser beam centered on the track (pits of the information layer) of the CD while the coarse tracking servo moves the entire optical pickup as needed to keep the tracking error within well defined limits. See the section: Servo systems. Failures or marginal performance of any of these systems can result in audio noise, skipping, sticking, or failure of seek and search operations.

The following types of problems are common:

- Seek failure resulting in the inability to locate the starting track.
- Short or long distance skipping backward or forwards or sticking.
- Occasional or repetitive noise, clicking, or muting.

A dirty or badly scratched or warped disc, a dirty lens, damage to the lens suspension or a smashed lens cover, a defective or improperly set AC adapter (voltage too high, too low, inadequate current capacity, poor regulation, or too much ripple), weak batteries or wrong type of batteries (NiCds may not work in a player designed for normal 1.5 V AAs), or a missing optical deck shield ground connection can result in similar symptoms as well.

Thus, if you experience any of the problems discussed in the next few sections, first confirm that the disc is not dirty, scratched, smudged, warped, or otherwise defective - inspect and clean it if necessary and/or try a different one. Check the AC adapter or batteries. If no problems are found, manually clean the lens. If you recently had the player apart, check the grounding of the optical deck.

The importance of doing these simple things first cannot be overemphasized as many apparently unrelated problems can be caused by a bad disc, dirty lens, or bad power.

Then, check for obvious mechanical faults like gummed up lubrication or a worn spindle bearing. Only after these efforts do not solve your problem or at least identify the cause, should you consider adjusting any of the servo systems.

The seek process

Proper readout of the digital audio or data on a CD depends on the proper functioning of the focus, and tracking servos and the system controller. The basic operation of these has been confirmed by successful reading of the disc directory. However, additional logic and drive electronics are called into action to actually seek to a particular track (even if it is the first) and switch to play mode.

When initiating play or seeking to a particular track, the player must go through the following 4 steps (exact details may vary depending on the design of your particular CD player):

1. The sled motor moves the pickup to the estimated position of the selected track based on its time code. For long jumps, this may be done partially open-loop. However, at some point - possibly from the start - the time code on the CD will be sampled periodically to determine instantaneous sled/pickup position.

   To access the time code, tracking must be stable for long enough to read 1/75th of a second of data (requiring tracking lock for up to 1/37th of a second if it just missed the start of a data block). This is possible even when the sled is moving since the fine tracking servo can backtrack to maintain tracking lock.

2. Once in the vicinity of the selected track, the sled is moved in small increments forward (and backwards if it overshoots) until the lens is within the 'acceptance window' of the fine tracking servo.

   Again, the time code is read and a direction and distance is selected by comparing it with the desired destination. On many players, you can actually hear this iterative process (by listening to the player - not the speakers) when using the >>| or |<< select keys.

3. With the fine tracking servo is engaged, the position of the lens is then jogged to home in on the exact time of the start of the track usually without moving the sled. Once it is within, say 25 frames prior to the desired starting location (1/3 second), it will just start playing but with the sound muted.

   Sometimes, it may be possible to have stopped at just the wrong position just out of range of where it wants to be (using the fine tracking servo alone) so that the sled would then move based on the normal tracking error criteria - exceeding a threshold (since the fine tracking locked).

4. Once the exact starting point is located, audio is unmuted and normal play begins.

Though all of these steps require the optical pickup to be operational, they each depend on different parts of the servo circuits - a failure could result in one of these steps not operating properly.

Audible search maintains the fine tracking lock but jogs the lens to move forward or backward. Audio is unmuted for a fraction of a second and then this process repeats. Thus, (3) and (4) are repeated (with the jog direction determined by which button is pressed) continuously.

Issuing a PAUSE command results in the fine tracking servo jogging the lens to maintain a constant position (time code).

While playing, searching, seeking, or in pause, focus must be maintained continuously despite spindle runout, a moderately warped disc, and minor bumps or vibration. Thus if focus adjustment is marginal, loss of focus may complicate your diagnosis of tracking problems - make sure focus is solid before moving on to tracking or rotation problems.

Diagnosis of erratic play

If you have a suitable oscilloscope, the following approach may help to narrow down and correct the problem. If not, you can use the alternative techniques outlined in the sections relevant to your symptoms. See the section: The CD player 'eye' pattern for a description of typical test points and signals.

Start with the RF test point. It probably should be about 1 V p-p. (However, the exact value will depend on model.) This should be the eye pattern.

Determine if it is weak, noisy, or erratic. If you can get it somewhat stable, try tweaking the various offsets (RF, focus, tracking) just a bit to optimize its appearance. The waveform should look approximately like the diagram in the the section: The CD player 'eye' pattern.

Adjustment of the focus controls will probably affect mostly the amplitude of the eye pattern and the amount of noise; adjusting tracking may also affect side-to-side jitter.

If the eye pattern is erratic, look at the focus error and tracking error test points. These should look like high frequency random noise but not be jumping or changing erratically. The DC offset of the tracking error should increase gradually as the lens moves to follow the spiral track and then jump back once the sled motor kicks in to re-center the pickup.

Use the buttons that move the sled to see if the rotation speed is correct at the beginning, middle, and end of a disc. (500-350-200 rpm). If it has trouble at the beginning, a bad spindle motor or driver is possible; if it has trouble at the end of the disc, a bad driver is possible. Adjustment of the PLL or VCO pot may correct for these types of problems. Check the eye pattern at the start and end of a long disc as well.

Seek operations take too long or fail to complete

This means that attempting to seek to a particular music track results in this never completing or going to the wrong place. Alternatively, even pressing the search forward or backward buttons may result in the failure to go where directed. The player may abort the disc and stop or (in the case of a changer) go on to the next one. Even the first track may never be played. However, it is assumed that the disc directory is read reliably.

Common causes: dirty lens, bad disc, tracking or CLV PLL adjustments needed, transportation lock engaged, mechanical problems with pickup movement, faulty sled motor or drive IC, faulty control logic, bad flex cable.

- If your CD player has a 'transport lock' screw, check that it is in the 'operate' position.
- Inspect the disc for badly scratched or smudged areas and other defects or try another one. Clean the lens.
- Eliminate the possibility of mechanical problems - see the section: Testing the sled for mechanical problems.
- Check for a printed flex cable that has hairline cracks in one or more traces. As the pickup moves past a certain location, a critical connection may open up resulting in this behavior. Such a cause is more likely if the player aborts without warning during a seek or search.

If none of this uncovers the problem, there may be sled motor driver, logic, controller, or other electronic problems.

Search, seek, or play starts correctly, then loses time or position

You may select music track 5, the player goes there quickly, starts to play but immediately jumps to another location forward or backwards or resets to the start of the disc. Or, if play is started at any location, instead of playing forward as would be expected, the numbers in the display count down.

Common causes include a defective disc, dirty lens, stuck button, need to adjust coarse tracking offset or tracking balance, bad sled motor drive IC, or faulty control logic.

- First, try a different CD to make sure it is not defective. Or, try different locations on the same CD as the CD would likely not be defective over its entire surface.

- A dirty lens is always possible. Clean it.

- This may be a problem with coarse tracking offset or tracking balance. See the section: .Adjustment procedure for noise or skipping.

- To eliminate the possibility of a stuck button, it may be possible to operate the player with the relevant part of the front panel control unplugged using the remote control (if it has one) or the 'press the drawer' method of starting play. If either of these results in the disc playing normally, then a stuck or dirty button is likely. This will most likely require the disassembly and cleaning or replacement of the affected push button switch.

- It is possible that the sled motor driver IC or its logic is bad: when the tracking servo is closed, its output is highly unbalanced due to an internal failure. Unless you want to take a shot in the dark and replace the chip, further troubleshooting of this problem will likely require a service manual. However, I have lucked out when the driver IC on a Pioneer CD player was running excessive hot - replacing it cured this problem.

Types of skipping problems

The general behavior will usually fall into one of the following categories:

1. It gets stuck and repeats a fraction of a second (1 rotation).

2. It gets stuck, jumps back, and repeats a few seconds.

3. It starts having repetitive noise at the disc rotation rate - about 200-500 rpm (3-8 Hz).

4. It starts skipping continously or every few seconds either forward or backward.

Assuming your CD is clean and undamaged (check with different CDs), then this sounds like a mechanical problem - proabably dirt in the optical pickup worm screw or lack of or dried up lubrication. It could also be a worn spindle bearing or an electronic adjustment.

If problems are most severe at the start of a disc, then spindle motor problems or PLL adjustments are likely possibilities.

If problems are most severe near the end of a disc, spindle bearing, track lubrication, and PLL adjustments are likely possibilities.

The next few sections deal with these types of problems in detail.

Short distance skipping

This means jumping forward or backward by a fraction of a second. It may occur occasionally or may appear as though the pickup is bouncing across the disc.

Common causes include dirty lens, dirty or damaged disc, need to adjust fine tracking offset/gain or tracking balance, weak laser or other defective part in the optical pickup.

First, inspect the disc for badly scratched or smudged areas and other defects or try another one. Clean the lens. See the chapters: "Servo Systems and CD Player Adjustments" and "Testing of Optical Pickup Assemblies".

Playback gets stuck (rapid repeat)

This means repeating the same track or a small number of tracks (meaning disc rotations, in this case). The effect is somewhat like a 'broken record' with an LP but at a much faster rate - 3 to 8 repeats per second when repeating only a single track.

The most common underlying cause is a damaged or dirty disc. However, if the tracking (and sometimes focus as well) servos are not properly adjusted, the CD player may exhibit excessive sensitivity to disc problems.

If the focus or tracking gain is set too high or the offsets/balance are not centered, slight disc imperfections, scratches, or dirt may result in this set of symptoms.

See the chapter: "Servo Systems and CD Player Adjustments".

Occasional long distance skipping or repeating

Usually, several seconds of music will play without any trouble and then there will be a skip forward or backwards by a few seconds or longer. In the latter case, the net effect may be to constantly repeat a section of the CD. Make sure you do not have any repeat modes enabled!

Common causes include a dirty lens; dirt, foreign materials, or lack of lubrication in pickup drive; defective disc (surface defects, dirt, or fingerprints); mechanical damage causing mechanism to bind.

- First, inspect the disc for badly scratched or smudged areas and other defects or try another one. Clean the lens.

- A mechanical fault is quite likely. These symptoms generally indicate that the coarse tracking servo is unable to properly move the pickup easily as it should - it is getting stuck and then either jumping back once the error is too great or breaking free and moving forward in spurts. Common problems include gummed up lubrication, dirt or other debris on the tracks or gears, bad belt slipping, misaligned parts.

  See the section: Testing the sled for mechanical problems.

  Note that some CD player models had problems like this due to poor design. For example, the Sony D2 Diskman would develop problems like this requiring reduction adjustment to a spring and wiper to reduce the force required to move the sled.

There could also be a problem in the electronics but first eliminate the possibilities listed above

Player gets stuck at approximately same time on multiple discs

Common causes: transportation lock engaged, gummed up lubrication on pickup tracks or worm gear, other mechanical problems like an obstruction or errant wire getting in the way. A flex cable with a hairline crack in one or more conductors might also cause this symptom.

- Make sure the transportation lock, if any, is disengaged.

- Carefully inspect the sled gears and tracks for dirt and gummed up lubrication. If the player has been in commercial service always playing the same CD or set of CDs and now you are attempting to one that is someone longer, this may happen as the end of the track is unused and dirt collects at the boundary.

- Check for mechanical damage and obstructions like wires or cables.

- If you are attempting to play a CD which is longer than 74 minutes, the player may not be capable of accessing the last part of the CD. It might either abort or get stuck and keep repeating a fraction of a second or several seconds. See the section: Problems with extended length discs.

- If play deteriorates gradually as the pickup moves toward the outer edge of the disc, the CLV servo may need adjustment or the spindle motor may be defective.

Various tracking problems on portions of discs

This means that one part of the disc (start or end) plays properly (or at least with less problems) than another. For example, the disc may play flawlessly until approximately the 30 minute point and then develop noise, skipping, or other similar problems.

Common causes: defective disc, faulty spindle motor, misalignment of spindle table and sled track, need for CLV adjustment.

- Try some other discs to eliminate a defective disc as a possibility.

- If the problem is most severe at the start if the disc, the spindle motor may have trouble reaching the required 500 rpm rotation rate consistently. See the chapter: "Motors and Spindles".

- The spindle table and track on which the sled moves may be misaligned. This is especially likely if the player was dropped or otherwise abused. See the section: Testing the sled for mechanical problems.

- An adjustment of the servo that controls the Constant Linear Velocity (CLV) drive to the spindle motor may be needed. See the chapter: "Servo Systems and CD Player Adjustments".

Repetitive noise at disc rotation rate

Common causes: dirty lens, bent spindle, excessive runout (wear) of spindle bearing, loose spindle, foreign material on disc table, disc not firmly clamped, warped disc, need to adjust focus or fine tracking offset/gain, weak laser.

- First, inspect the disc for badly scratched or smudged areas and other defects or try another one.

- Clean the lens.

- Check for a loose spindle (sometimes there is a set screw that needs to be tightened or some adhesive may have broken free.

- Make sure there is no dirt or other foreign matter on the spindle table that could cause the disc to seat improperly.

- Observe the disc as it spins. Is the edge moving up and down by more than a total of about 1 mm? If so, the disc may be excessively warped, or possibly the spindle bearing is worn resulting is unacceptable runout, or (unlikely unless the player was thrown off a cliff) the spindle is bent. The focus and fine tracking servos may be incapable of correcting such a large wobble.

  This could also be due to a disc clamper that is not working properly - the drawer closing mechanism may not be quite completing its cycle or possibly the magnet may have weakened. Gently press down on the rotating part of the clamper while playing - if this reduces or clears up the playback and/or if you can feel the disc seat better, then this is a possibility.

- If the problem developed gradually and has been getting worse, than a worn spindle bearing is a distinct possibility. Adjustment of focus and fine tracking offset (or possibly gain but usually less critical) may help.

- Alternatively, focus or fine tracking offset (or possibly gain but usually less critical) may simply have drifted a bit and adjustment is all that is needed.

- A weak laser may also result in these symptoms but do not attempt to adjust laser power until other possibilities have been investigated fully.

Marginal play - internal controls are not marked

This may mean that some discs play properly while others have problems with skipping, sticking, repeating, or noise in the audio. Unfortunately, many players, particularly portables and CDROM drives, do not have adjustments that are labeled. (For some portables, you may need the special test discs described in the section: Useful ways to mangle CDs.

Since one possible cause of these types of problems (after the lens and mechanics have been ruled out) are servo adjustments. See the chapter: "Servo Systems and CD Player Adjustments".

Then, I would mark the precise positions of all the controls. While playing a disc that works but has minor skipping, noise, or similar problems, carefully try adjusting each one on either side of its current position to see if that will help. Then if this helps, change to progressively more problematic discs to see if you can home in on the optimal settings. By observing the behavior as you tweak each control, it may be possible to determine their functions.

Testing the sled for mechanical problems

Binding or obstructions would be indicated by any long distance skipping, jumping, repeating, or failure to seek or search past some location (time) on multiple discs. Defective or erratic limit switches may result in jamming or overrun at start or end of disc or unreliable reset during startup.

Check for free movement of the optical pickup sled on its tracks or bearings. Manually rotate the appropriate motor or gear or in the case of a voice coil (linear or rotary) positioner, gently move the pickup back and forth throughout its range. There should be no sticky positions or places where movement is noticeably more difficult. If there are, inspect for mechanical problems like broken or damaged gear teeth, dirt or other material that should not be there, and gummed up lubrication - or that you didn't forget to release the transportation locking device! Damaged parts will need to be replaced (or repaired - sometimes a fine file, Xacto knife, or dental pick will work wonders but don't count on it). Otherwise, cleaning and lubrication may be all that is needed. Remove the dirt and the old gummed up lubricants and lubricate the tracks and/or gears using the proper oil or grease. (See the sections: "Lubrication of CD players"

Inspect the alignment of the track with respect to the spindle motor. If the spindle motor shaft is not at an exact right angle to the sled movement, tracking may be affected on certain portions of the disc. One best way to this is to clamp a disc onto the spindle table and then manually move the sled from end-to-end measuring the distance between the pickup and disc at both extremes. It should be equal. A variation of more than a fraction of a mm can cause tracking problems.

If these tests come up negative, check out the pickup (sled) motor for defects such as a shorted or open winding, dead spot, partially shorted commutator, or dry or worn bearings. See the section: Testing of motors.

As a double check, disconnect the motor from its driving circuit (extremely important!). Use a 3 V battery in series with a 25 to 50 ohm variable resistor or a variable low voltage (e.g., 0 to 5 V) DC power supply to drive the motor. Start at the highest resistance or lowest voltage and adjust it until the sled just starts moving. Run it from end-to-end in both direction. The sled speed should be fairly uniform with no sticking or binding. There should not be any excessive noise or grinding sounds. If this is not the case, there are still problems with motor or sled mechanism.

Another check would be to substitute a 15 ohm 1 W resistor for the motor and see if a few volts appears across this when the player should be resetting since this usually involves moving the sled to the inner limit. If there is none, the driver may be blown or lack power, or the controller is not providing the proper commands.

In addition, check the proper functioning of any limit switches that are present on the optical deck. There will almost always be one for the inner (reset - startup) track and there may be one for the outer track (end-of-disk) as well. Run the pickup manually or using the battery (see above) to both ends without forcing and check for reliable operation of the switch contacts.

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Miscellaneous Problems

Audio problems - muting, noise, or distortion

Silly me, what other kinds of problems are we talking about? OK, I should have said: audio signal chain problems. The player appears to be working fine (the disc is spinning; the time is incrementing correctly; seek, search, and play operations behave normally) but there is either total silence, noise, or distortion, on one or both channels.

However, also see the section: Types of skipping problems and those that follow since these sorts of audio symptoms may be mistaken for those caused by problems with servo alignment, the optical pickup, or front-end electronics.

There is a distinct boundary between the digital section where audio information is encoded digitally and the analog domain where it is an electrical waveform.

Problems with the digital circuitry

Problems in the digital domain will usually be obvious to the point of being gross - extreme noise, noise correlated with the signal level, extreme distortion, tones or frequencies that with no stretch of the imagination were present in the original music, etc.

Characteristics will be distinctly different than the kind of noise or audio distortion we are accustomed to in stereo equipment. Small errors in the digital reconstruction can result in totally gross changes in the audio output. For example, a single bit error if in the MSB can totally corrupt the resulting waveform. Simple errors can result in sound frequencies not present in the original. Fortunately, these sorts of errors are relatively rare as most of the circuitry is inside of very reliable LSI chipsets.

However, if the CD is recognized and appears to behave normally except that there is absolutely no audio output, there can be problems in the audio decoding LSI chips. Other than hoping for an obvious bad connection, this is way beyond the scope of anything you can hope to repair without the service manual, test equipment, and a miracle.

Problems with the analog circuitry

Problems in the analog sections - D/A(s), sample-and-hold(s), post analog filters, and muting relays - produce effects that are more familiar: noise, decrease in signal strength, and distortion. Except for parts of the D/A which may be shared, there will be identical left and right channels to compare if an audio problem develops.

If only one channel is affected, then the problem most likely has nothing to do with tracking, the laser, or the mechanism. Coming off of the disc, the left and right channels are interleaved on a sample (16 bit word) basis so any disc or pickup problem would equally impact both L and R.

You are left with the D/A and sample-and-hold or D/As or the final analog filter and muting circuitry. Many CD players multiplex the D/A between L and R, so in these, even the D/A is ruled out since most of its circuitry is common.

Swapping components one at a time between the identical left and right channels is also a valid diagnostic technique.

- With a single D/A, there will be sample-and-hold circuits for each channel as well.
- Players without digital filters (or oversampling) have fairly complex analog filters after the D/A. A bad or noisy component could conceivably be your problem. Even players with fancy oversampling have some kind of a final analog (antialiasing) filter. On an older player, there is probably a lot of discrete circuitry in the audio section.
- If you can get to the components in the analog filter (some are potted), then with a test CD which has a 'silence track' and a scope or signal tracer, you should be able to find out where the noise is being introduced. If it has separate D/As, then one of these would also be suspect.
- There may be separate power supply outputs for the audio section (this will be more likely with fancy expensive players). In this case, a failure of one of these may result in either distorted audio or no sound at all.

The following will mostly result in static type noise, hum, or erratic audio (sound not coming on or partial or total dropout for one or both channels):

- Don't overlook the simple problems of dirty contacts on the RCA jacks or bad connections where they are soldered to the main circuit board. Test by jiggling the cable connectors and/or prodding the circuit board near the RCA jacks. The cable may be bad (from flexing) as well - try another one.

  Check the connections and controls on your amplifier and other audio components as well! Any bad connection in the audio path can lead to these symptoms. Clean, repair, or replace as appropriate. Perhaps your poor, helpless CD player isn't even at fault!

- Dirty muting relay contacts may result in intermittent or noisy output. If tapping the relay affects the symptoms, this is likely the problem.

  To test, remove the relay and bypass the suspect contacts with jumper wires. CAUTION: Turn your amplifier's volume control down when you start to play a disc - there may be unusual loud noises during startup that are now not blocked by the muting circuitry.

If CDs now play without any audio problems, a bad relay is confirmed.

It may be possible to snap off the cover(s) and renew them with contact cleaner and a burnishing tool or a strip of paper. Otherwise, replacement will be required.

Problems playing/reading certain CDs

While you may be tempted to blame *Big Brother* and some sort of diabolical copy protection scheme, I doubt that CD dependent behavior has anything to do with a lower intelligence at work. :) More likely, it is a bad quality control on the pressing. (This assumes your CD isn't one of those which has 85 minutes of music squeezed into a 74 minute space. See the section: Problems with extended length discs.)

First, check for physical damage or imperfections on both sides of the CD. Even if you find nothing, trying a replacement disc would probably be a good idea before ripping apart your CD player.

However, it may just be CD which produces an unusually low signal level.

Depending on manufacturer, the signal level from CDs can vary by quite a large amount - maybe 30 percent (just guessing). Telarc discs were (maybe still are) particularly bad in this regard. CD-Rs are also quite variable and generally worse than normal CDs. (See the section: Problems reading CD-Rs). If the player is somewhat marginal to begin with (no way to really predict this), low signal level may mean either it won't recognize the disc at all or will be subject to skipping, audible noise, and other play problems.

An internal adjustment might help but my advice would be that if it only occurs with a small percentage of CDs, better to leave well enough alone.

However, a proper lens cleaning won't hurt! See the section: "General inspection, cleaning, and lubrication". If you really won't sleep knowing there might be something else you can do, see the "General servo adjustment procedure". I definitely don't recommend attempting to boost laser power - which would be considered a last resort.

Note that newer CD players and CDROM drives may be more tolerant of damaged discs as well as CD-Rs (which became popular only relatively recently) - you may just be expecting too much from that 15 year old machine!

Problems with extended length discs

The specifications for the length of an audio CD is just over 74 minutes. I have seen them as long as 78 or 80 minutes which means that some of the basic CD specifications have been compromised - either the track pitch has been reduced or the track extends closer to the outside edge of the disc - or both. If the track pitch has been reduced, there could be tracking or audible noise problems throughout the disc. If the track extends closer to the outer edge, there could be problems near the end of the discs. The player may not these discs at all. Any of the following symptoms are possible:

- No problems. Your player is one of those that is perfectly happy playing really long CDs. Most players will indeed be unaffected.

- The disc may be rejected resulting in the display showing 'disc' or 'error' as though damaged, improperly inserted, or missing. In this case, the CD player's microbrain simply thinks anything with a total playing time exceeding 74 minutes and 15 seconds is invalid.

  Unless you want to redesign the player, there is nothing you can do to play these CDs. It might only require changing a single byte in the player's firmware :-).

- There may be more of a tendency for skipping, sticking, or audible noise (probably near the end though it could happen anywhere if the track pitch has been reduced - including inability to read the disc's directory) since the servos are operating slightly outside their normal range. The actual likelihood of these types of problems are very slight, however.

  It may be possible to adjust the servos as described in the chapter: "Servo Systems and CD Player Adjustments". As with any adjustments, there is some risk of affecting performance for all discs - or totally messing things up. Or, if problems only occur near the end of these discs, just don't play them to the end!

- The sled on which the pickup is mounted ventures into new territory where no sled has ventured before (at least on this player). Dirt, gummed up grease, hair, and other garbage may have collected there resulting in the sled drive mechanism getting stuck. You may hear whirring, buzzing, or clicking as the motor attempts to move the immovable - or nothing at all. Eventually, the player should probably shut down. In any case, kill power or remove the batteries to prevent damage to the gears.

  With luck, all you need to do is move the sled manually toward the spindle by turning the proper gear (freeing it up first, if necessary). Then clean and relube the track and gears. Hopefully, nothing is actually damaged since locating a replacement part may prove to be a challenge.

- The sled simply overran the end of the rack and the drive gear no longer is capable of returning it to more familiar territory. You may hear some whirring, buzzing, or clicking as the gears attempt to mesh but do not quite succeed.

  Manually moving the sled so that the drive gear meshes with the rack - and then turning it a bit to be sure - should restore operation but, of course, you should not attempt to play these extended length discs to the very end in the future.

Problems reading CD-Rs

CD-Rs (recordable CDs, usually gold on the label side and greenish (or with newer ones like various PlayStation discs, some other strange color) on the readout side) can be quite variable in quality. They are often produced on a low cost writer of questionable design and calibration. It is quite common for a CD-R disc to play/read fine on one drive and not be recognized at all on another. There may not be any relation between cost of the CDROM drive and its reliability with CD-Rs.

Note that newer CDROM drives (and probably CD players as well) may be more tolerant of CD-Rs (as well as of damaged normal CDs). 1X and even 4X CDROMs (as well as older CD players) predated the wide availability of CD-Rs so they weren't designed with them in mind. As a byproduct, newer technology may be more tolerant of bad normal CDs as well. So, there may in fact be an advantage to using high-X CDROM drives! So, it still has nothing to do with the high-X part, just that the low level circuits are smarter!

Problems recording CD-Rs

Consistently recording high quality CD-Rs is by no means as fool-proof as reading typical CDs. Any problems affect the recording quality permanently.

- Media - there is significant variability in the quality and consistency of CD-R blanks from different manufacturers. You may have to experiment with multiple brands to determine those that work for you in your CD-R writer.

- Recorder - there may be significant variability in the performance of various manufacturer's hardware. High price may not translate into high quality especially considering the rapid changes in the industry.

- Writing speed - while it really should not matter whether you record at 1X or 4X (or whatever your machine supports), this may not actually be the case. If the servo systems are less stable at the higher rate, the quality of the recorded information may suffer. Thus, writing at a slower rate may be better - or may not matter. In any case, experimentation at different writing speeds should determine if this is an issue.

- Media cleanliness - you only get one shot. A speck of dust or fingerprint - which might just decrease the signal to noise ratio when reading a CD - can degrade the writing laser beam resulting in malformed pits (oh no, not the dreaded malformed pit disease!). Inspect each CD-R blank before inserting it into the writer. Reject it if you see any visible surface damage or manufacturing defects. Use clean, dry compressed air if necessary to blow off any dust or fluff. Clean the surface as you would a CD to remove any fingerprints or smudges.

- Equipment maintenance - keep the recorder clean - periodic inspection and cleaning similar to that used for CD players may be needed if it is used in a less than ideal environment - dust, smoke, and cooking vapors can quickly coat the lens leading to lower quality recordings. Inspect, clean, and replace (as necessary) the caddies (if used) as well since dirty or damaged caddies can cause problems as well.

- Data under-runs - where the recorder does not have an internal buffer of sufficient size (yeh, like 650 MB!), it expects to be fed at a high enough rate to always have data available to send to the writing laser. Any failure will likely result in incorrect data being written - and probably a ruined disk. Some recorder software will simply abort. Even running another application like a screen saver can result in uncertainties with respect to data availability. When in doubt or where time is available, run the recorder at a slower speed to reduce the required datarate.

- Mechanical shock - locate the recorder on a stable surface - not the top of a printer or other equipment that may be subject to movement during the duration of a recording session. Any vibration transmitted to the optical deck may cause a momentary shift in the position of the lens and laser beam reducing the recording quality. Bump it hard enough and the result will be mistracking and a ruined disk.

(From: Filip M. Gieszczykiewicz (filipg@repairfaq.org).)

There's an area of the CD-R disc used specifically to "calibrate" the laser. Since all disks have different needs (gold versus blue/green dye, for example) one-for-all power level won't do. If you laser has lost its power (they DO have a very finite life) which may be due to end-of-life OR dust on the lens (always consider a lens and any other accessible optics cleaning first!), it will FAIL this write-test and you will get what you are seeing. I would try a different color dye CD-R disc and see if there is one type it can still write to.

From what I read, there is enough "write-space" in the laser-power-test area of the CDR for close to 1000 tests - which is why a new drive may work fine with your rejected discs.

So, clean the lens, then try different types/colors of CD-R discs and then, if that still yields no results, write off the drive as "got my money's worth" and use it as a reader.

Voice (almost) missing from CD playback

My first thought would be to say "how can the electronics know about the voice separately?" Well, the answer is "it cannot". However, due to the way vocals are often recorded, this behavior is possible, if unlikely. What must happen is for the audio output to be the difference between the left and right channels mostly cancelling the centered vocal track but not having as much effect on the audibility of the instruments.

It is possible for this to happen as a result of a bad ground connection or an electronic fault in the analog circuitry following the D/A stage but it is quite unlikely to be due to a problem in the optical pickup or digital decoding - though not out of the question.

What is suggested below can happen by accident should the shield connection to the headphone or line out jack or cable become disconnected.

(From: Frank Fendley (frank.fendley@datacom.iglou.com).)

Actually, it is possible. Modify a headphone so that the two ground conductors are still connected together and to each earpiece, but no longer connected to the sleeve of the headphone jack. The two "hots" remain connected to tip and ring on the jack. Plug it in to a portable CD player and listen to a pop or country CD with (preferably) a solo vocalist.

The vocals will almost disappear, while the instruments will still be quite audible (although now in mono).

Normally, the lead vocals are 'centered' in the stereo imaging and are in phase on each channel. The instruments are panned more or less left or right. When you rewire the headphones, you effectively place the two transducers in series, and they are now wired out of phase with each other (the two "-" terminals are connected together on what used to be the ground lead, and the two "+" terminals are connected to their respective signal outputs from the channels - effectively since they are now in series, they are wired out of phase). Any signal which is "identical" and "in phase" on both left and right channels tends to cancel - the vocals. Signal which is not identical on each channel appears as the difference between the two sides - the instruments.

Some recordings are not made this way and this will have little or no effect - you may have to try a few CD's to experience the 'phenomena'.

Problems with anti-skip buffers

Newer portable CD players often offer an extra cost option of an 'anti-skip' capability - usually about 10 seconds of buffer memory. While there is probably little you can do to repair an electronic or logical problem with this memory, there are a couple of points to keep in mind which may lead to the repair of problems like erratic anti-skip performance, noise, dropouts, skipping, and other symptoms dealt with elsewhere in this document.

Anti-skip is actually implemented by reading ahead on the CD and storing up to 10 seconds of digital audio in dynamic random access memory (DRAM). This has a direct impact on optical deck performance and power requirements:

- To read ahead, the player must actually operate at a higher than normal (1X) speed. Watching a player with this feature, it would appear to be close to 2X. This puts a greater strain on motors and servo systems so anything in the optics or servo alignment that is marginal - or even a dirty lens - may result in problems which do not show up with the anti-skip feature turned off. In addition, there are likely to be more problems reading marginal CDs or CD-Rs. See the section: CD player with skip buffer fails with some CD-Rs.

- Power requirements are also greater with anti-skip on - the spindle motor and servos need to work harder and the buffer DRAM may require greater power when being accessed. Therefore, weak batteries or an inadequate wall adapter may result in erratic operation. If possible, try fresh batteries or a different adapter before warming up the oscilloscope.

CD player with skip buffer fails with some CD-Rs

This was an odd problem posted to the newsgroup sci.electronics.repair:

> "I am having an odd problem with my new portable cd player. It is a Panasonic with 10-second skip protection. I made an audio compilation CD with my CD-burner. This CD works fine with my CDROM

drive and home CD player. In fact it works fine with the Panasonic UNTIL I turn on the skip protection. Then it plays for awhile, and for no apparent reason the seconds run out and it hangs up and displays the message 'Sorry'."

(From: Mike Schuster (schuster@panix.com).)

Your player is having trouble tracking the CD-R. Likely causes:

1. The CD-R burner or software is producing discs whose layout is slightly off spec. A firmware or software upgrade may help if available.

2. The CD-R burner works better with some types of blanks than others; and you've just discovered the ones it DOESN'T work well with. Try a different brand and color.

3. You are using poor quality CD-R blanks which have an unacceptably high bit error rate, eccentricity of the spiral groove, or both.

4. You are burning the disc as a speed which does not give the lowest error count with the media you are using - try faster or slower. Usually 2X write speed gives the best pit structure on the widest variety of media.

5. Your CD-R burner is in need of calibration or laser replacement, resulting in poor pit shape. Have you tried an OPC test to see if it is delivering the right power?

I have a Panasonic portable and have experienced the same thing with two Maxell CD-R's received in a trade. Of the dozens of CD-R's I own, these two, burned by the same person, are the only ones that cause trouble. For that reason I believe it is not the player but the discs that are "off".

(From: Andy Cuffe (baltimora@psu.edu).)

In skip protection mode the disc is played a double speed so it can keep the memory full. It must be having trouble tracking these discs at the higher speed, but is able to play them at normal speed. It's either a problem with the CD-Rs or just the way the player is.

Problems with CDROM drives

The newest CDROM drives operate at 12X speed or greater. Such performance puts significant strain on the motors and servo systems. Even 2X speed means substantially higher demands of the electronics and power systems. Thus, you may find that a drive will play audio CDs flawlessly but have trouble reading data files. While there is probably little you can do to repair an electronic or logical problem without schematics - which are almost certainly not going to be available, there are some things to keep in mind which may lead to the repair of problems like erratic or total failure of data readback.

The first test for any CDROM problem is to force the drive to the 1X (or some slower speed than its maximum specifications) and see if that helps. Your drive may have come with instructions/software to operate at a selected speed.

Data readout must be flawless. Uncorrectable errors which may not be noticed for audio playback would result in corrupted files. Thus, anything that is marginal may significantly impact performance. If it still has trouble with data even at the 1X speed, something may be marginal or there may be a true problem in the decoding logic or computer interface.

- Multi-X performance puts a much greater strain on motors and servo systems so anything in the optics or servo alignment that is marginal - or even a dirty lens - may result in problems which do not show up with audio CDs played at the 1X speed. Thus, once a dirty lens is ruled out by cleaning it, some fine tuning of the servo systems may be needed.

- At the high rotation rates used with the latest drives, even the slight imbalance caused by a label that is not uniform across the disc can result in enough vibration to affect the servo systems and result in an increase in data transfer error rate, mistracking, or even loss of focus and shutdown. There may be no problem with the drive itself - just the disc. It may be possible to add a small sticky label to the disc in a strategic location to improve balance. However, if the label is not very secure, it may fly off due to centrifugal force at high rpms and create yet another problem inside the drive. Some quick drying paint might be better. If only there were a tire balancing type machine for CDs!

- Power requirements are substantially greater at the higher speeds - the spindle motor and servos need to work harder and even the electronics may require greater power. Therefore, weak batteries in laptop computers or CDROM drives operated off of laptop power or an inadequate wall adapter may result in erratic operation. If possible, try fresh batteries or a different adapter before warming up the oscilloscope.

Portable CD player/CDROM drive power considerations - batteries

As with all equipment operated from a batteries, there are specific requirements that must be met for reliable and safe operation.

Batteries must be of the proper type. Some devices will work on either Alkaline or rechargeable NiCd types. However, since NiCds put out less voltage than fresh alkalines, there may be a selector switch or the instruction manual may state that NiCds should not be used. Batteries should be fresh - the motors, servo systems, and electronics in a CD player or CDROM drive can be a significant load when seeking or spinning up. A weak battery may cause it to shutdown erratically or never be able to find the selected track. Do not mix new and used cells. This can result in poor performance and may actually result in damage to the cells where rechargeable (NiCd) types are involved.

Some CD players use a sealed lead-acid battery pack. For long life, these must be recharged immediately after use. Leaving a lead-acid battery pack in a discharged condition will significantly shorten its life. And these are not cheap! A pack for a typical Sony CD player may cost more than $20.

Portable CD player/CDROM drive power considerations - AC adapters

As with all equipment operated from a wall adapter, there are specific requirements that must be met for reliable and safe operation:

1. Voltage. The CD player or other device will specify the nominal input voltage. This must be adhered to - you cannot connect a 3 V CD player to a 12 V adapter (or auto battery, for that matter). It will become toast. However, not all wall adapters are created equal. Some are very poorly regulated meaning that even though its label says something like '9V', the actual output may be as much as double this (or more) with no load. This may not be acceptable. The device may overheat or be damaged or destroyed nearly instantly. Internal protection devices may blow (if you are lucky!). It is safest to follow the manufacturer's recommendations (though, admittedly, they may be pushing their own brand of adapter). My rule of thumb is that if the unloaded output voltage is within about 25% of the specified requirements, it is probably safe to use. However, when connecting for the first time, be on the lookout for any strange behavior (or strange odors!).

2. Current. The required current should be stated somewhere - either on the device itself or in the instruction manual. If only power is specified (i.e., 9 V, 4.5 W), then divide power in watts by voltage to get the current rating in A. (1 A = 1000 mA). The adapter must be capable of putting out at least this amount of current though a modestly higher current rating should be no problem. Using an adapter with an inadequate current rating may result in erratic behavior or overheating and failure of the adapter.

3. Polarity. All the portable CD players and CDROM drives I know of operate on DC. Thus polarity is critical. Get it

backwards and at best nothing will happen but nothing will work either. However, the equipment and/or adapter may be damaged - permanently. Internal protection devices may blow - if you are lucky.

4. Regulation. It is often impossible to determine whether the device expects regulated power or whether a given AC adapter provides it without tests. There are both types. Higher voltage AC adapters (say, 6 V or above) often tend to be just rectifier/filter capacitor types. However, low voltage adapters (e.g., 3 V) may have an IC regulator built in.

As noted in the section: CD player is totally dead, it is easy to destroy a portable device using an improper power adapter or a universal adapter that is configured incorrectly.

Boomboxes and compact stereo systems

These combine a stereo receiver and a single or dual cassette deck, and/or a CD player or changer, and a pair of detachable speakers, into a single unit. Most are fairly portable but larger boomboxes and compact stereos may require a forklift to move any great distance.

While the individual subsystems - CD player for example - are usually relatively self contained electrically except for a common power supply, mechanically, everything tends to be jumbled together - even on units that have an outward appearance of separate components. Both cassette transports are usually driven from a single motor. Getting at the CD player may require removal of both cassette decks, audio amplifier, and power supply. Working on these is not fun. As usual, take careful notes as you disassemble the unit and expect it to require some time just to get to what you are after. Be especially careful when removing and replacing the individual modules if printed flex cables are used for interconnections.

Refer to the relevant sections on cassette transports, loudspeakers, and power supplies for problems with these units.

Since these do get abused - bumped, dropped, dunked, etc., bad connections, and other damage is very common. See the sections: "Intermittent or erratic operation" as well as "Audio muting, noise, or distortion".

CD player was dropped or got wet

I have never heard of a component CD player being dropped or rained on. However, this does happen to portables. While a service shop may not even want to tackle such a unit, it is quite possible that damage is minimal - even for a CD player.

With a CD player that has been dropped, unplug it from the AC line or remove the batteries immediately. This will prevent further damage should anything be shorting internally.

For one that has gotten wet, dry it immediately (you knew that!).

See the document: Audio Equipment and Other Miscellaneous Stuff for more info on restoration of abused audio equipment.

Repairing flexible printed cables

It seems that more and more consumer devices from pocket cameras to laptop computers are being built with miniature multiconductor flexible printed cables. Very often one or more traces to develop hairline cracks due to repeated flexing. In addition, damage from moving circuit boards and modules during servicing is all to common.

Needless to say, repairing any kind of flex cable is a real pain. I have succeeded by carefully scraping the plastic off with an Xacto knife and then soldering fine wire (#30 gauge wire wrap for example) to the traces. This presumes that the conductors on your cable will even take solder. I then cover up the joints with a flexible sealer for electrical and mechanical protection.

However, you need to make sure that the wire you use can be flexed or that the joint is set up in such a way that the wire does not flex much - else you will just end up with broken wires pretty quickly.

Here is another alternative if the flexing of the cable prevents the use of ordinary wire for jumpers: Find a piece of somewhat similar flex cable cable from a dead piece of equipment. Use it to jumper across the high stress area and then solder it to the other cable with short wires if necessary. Then coat the connections as above.

Soldering from end point to end point if possible may be preferable. Even going to only one endpoint would reduce the risk of immediate damage and reliability problems in the future.

With multiple traces broken or damaged, you are probably better off replacing the cable entirely. With the typical flex cables found in CD players, there is often no way to repair a large number of broken traces and retain your sanity.

CD player whine

CD players are generally nearly silent during play (though they may make a variety of whirring and clicking noises when loading discs, initializing, or seeking). The only sound normally eminating from inside the machine during play might be a very faint gritty noise from the focus and tracking actuators.

Thus, a sustained whine would generally be considered abnormal.

(Portions from: Larry Sirignano (sirig@esslink.com).)

There are two likely causes:

1. Worn spindle motor bearings can result in a high pitched whine. In this case, adding a drop of oil may quiet it down temporarily but replacement will eventually be needed.

2. The whining noise may be the laser/chassis assembly resonating with the CD as it spins. Depending on the model, there is a cure - adding a weight or damping material to the pickup or the chassis to change the resonant frequency.

   To confirm that this is your problem, gently rest your finger on the rotating clamper disk and/or other parts of the optical deck while it is whining - the whine should change or disappear. If you can locate a particularly sensitive spot, try gluing a piece of heavy rubber to this location (even if it is the clamper disk) with rubber cement. If this solves the whine problem, confirm that discs seek and play correctly for all tracks before buttoning it up.

For more details on Sony problems, see the section: Audio whine (not from speakers) and/or muddy sound with Sony CD players.

(From: Joel B. Levin (levinjb@gte.net).)

If this were the problem it would be highly dependent on the CD's speed of rotation, which varies as the disc is played. If it always happened N minutes into the disc and went away a few minutes later as the disc slowed down (and came back if you repeated the track) I would consider that definitive of a resonance problem.

(From: Mark Z. (mzacharias@aol.com).)

I would try lubricating the shaft of the spindle motor, and check to see if the motor brushes might be partially shorted. (not to worry you at this early stage, but sometimes Sony pickups, especially the KSS240 and KSS212 and 213, have resonance problems, often just as the disc is coming to speed.) This is the subject of at least a couple service bulletins. Can often be heard as a whistling tone coming from the mechanism usually intermittent, and can be observed in the focus error and tracking error lines as a sine wave overriding what should be essentially a random noise signal. Occasionally the resonance gets so pronounced the disc won't even spin up.

It happens with some Pioneers as well. It's not a common symptom, but it is the pickup at fault. Look at the focus error line and you'll see a sine wave riding on it. There is essentially a feedback loop existing between the spindle motor/subchassis and the pickup. I've seen various attempts to damp it out but replacing the pickup fixes it every time in my experience.

(From: Matt Kruckeberg (sackmans@ndak.net).)

It's possible that a loose lens can result in a resonant condition so check that the lens is secure. If it falls out in your hand, gluing it back in place should solve the whining and prevent a future problem.

Noisy CD player

CD players are not silent despite all the hype to the contrary. The focus and tracking actuators act like voice coils in loudspeakers produce various chirps and hisses while playing a CD. When seeking, the sled motor adds its own additional instrumental accompaniment. :)

As they say, "If it ain't broke, don't fix it." Assuming it plays CDs fine and has always been this way (or you don't recall how it was when you first got it), leave well enough alone.

If you do decide to twiddle pots, mark their original position carefully before doing anything! The ones most likely to have any effect are the gain controls for focus and tracking. Lowering the gain slightly (perhaps 1/8th of a turn counterclockwise) will reduce the noise level - but may also result in more susceptibility to skipping from vibration. Turn them too far and the disc will no longer even be recognized. These adjustments don't generally change on their own so think several times before possibly making matters worse.

Perhaps, putting the CD player in a box padded with sound deadening insulation would be a simpler solution if the noise bothers you!

Also see the section: CD player whine.

Objective lens popped out

Don't expect to see this one too often. However, on some Pioneer changers in particular, where the pickup is mounted upside-down, tired pickup suspension grommets, excessive heat, age, long use with warped discs, or just bad luck, has apparently resulted in the adhesive holding the objective lens in place to come unglued, as they say. :-) In some cases, it is still attached but loose, which will also prevent the player from working but may be easier to fix than one that is rolling around at the bottom of the cabinet.

The best solution is to replace the entire pickup. However, you have nothing to lose by attempting to reattach the lens IF you can locate it AND its optical surfaces are undamaged from the ordeal. If either of these is not the case, you will probably have to install an entire new pickup. Swapping of a lens from another player is even less likely to work unless it uses a similar pickup from the same manufacturer and then only with great pain.

It may be essential to line up the lens in EXACTLY the same position as it was originally in terms of centering as well as the same orientation to have any chance of success:

- The lens must be centered for the return beam to be properly aligned with the photodetector array.

- It is possible that some lenses are astigmatic (not circularly symmetric) to implement the focus servo (rather than using a separate cylindrical lens or thick beam splitter mirror for this purpose). For these, the orientation is also critical. When this is the case, there will be a reference on the lens for this purpose. On Sony pickups, for example, there is a flat filed on one edge of the lens. (You always wondered why the lenses in all your Sony CD players appeared to be 'damaged', didn't you?) However, I do not know of any Sony or other models that actually use an astigmatic objective lens. (Sonys usually have a thick beam splitter mirror for this purpose. Pioneer players for which the dropped lens syndrome is quite common don't have an astigmatic lens because people have reported replacing the lens in any position without problems.)

  However, matching up the lens position with the old glue line will likely result in it being better aligned with the internal optics so it's still worth doing if possible.

Alignment isn't so bad if you can see the failure line in the old glue or if the lens isn't completely detached. Otherwise, you will need to compare the orientation with an intact sample of a pickup from the same manufacturer that uses a similar optical configuration. Just guessing may not work!

Carefully position the lens and put the tiniest drop of adhesive such as 5 minute Epoxy at three points roughly equally spaced around the edge of the lens. DO NOT use anything with a volatile solvent like windshield sealer, Duco Cement, or especially instant glues like (Gasp!) Krazy Glue (cyanacrylic, even if you have mastered that disaster!) The vapors may condense on the lens or other (more inaccessible optical surfaces). Take care to prevent any glue runing down into the suspension or elsewhere. Once the glue has set, reinstall the pickup and try it. If behavior seems reasonably normal, put a tiny bead of adhesive all around the lens to anchor it securely. Some servo adjustments and/or optical alignment may still be needed to correct for the slight shift in lens position that is unavoidable from this surgery.

I experienced the problems of instant glue when a colleague brought in a Pioneer changer in which he had attempted to reattach the lens. Looking into the lens, it appeared as though there was an aperture behind it. After prying the lens back off, it became apparent that the effect was caused by a haze which had formed a sort of ring around the underside of the lens. Fortunately, multiple cleanings with isopropyl alcohol removed most of it and allowed the player to recognize and play discs, though I don't think it will ever have quite the same performance.

Before powering up, check the pickup suspension grommets for wear or deterioration, your discs for serious warp, and any other mechanical problems that could cause the same thing to happen again. Don't use seriously warped discs. Replace bad grommets or at least raise the pickup by installing washers under it for testing.

(From: Dave (albrecht@se-iowa.net).)

A local radio station uses about 20 Pioneer PD-M510s. I've been replacing a lot of lenses that are starting to fall out. I usually do a "shake" test, recover the lens and glue it back in place. Not bad considering most haven't been shut off and have played for 4 years now.

(From: David Kuhajda (dkuhajda@locl.net).)

The lens falls out because of 2 factors: (1) The laser is mounted upside down or (2) the rubber grommets that support the pickup wear out after time as does the spring in the optical pickup allowing the lens to be hit by the disc slide tray in the changer as the player loads each disc. (In marginal cases, the lens may actually scrape and scratch the disc during loading or play but will still be attached.)

Sometimes regluing the lens is enough to allow the unit to play, but not a good repair unless the rubber grommets are replaced and the sagging height of the lens measured to ensure enough clearance. Then the laser output and RF level must be checked. I have only found one laser that had the lens fall out that was not way below specification and needed replaced to make for a reliably playing unit.

That being said, most people are happy to pay just the minimum to have the lens glued on and the 3 ring paper hole reinforcement pads put in as spacers to allow the unit to play as the cost of the optics and rubber grommets alone are close to replacement cost of the unit.

Testing the optical pickup

See the special section "Testing of Optical Pickup Assemblies" for detailed procedures for determining basic functionality of most of the optical, electronic, and mechanical components in the pickup assembly. These techniques do not require sophisticated test equipment and will identify most common failures. However, you should not consider such involved tests until you have eliminated other possibilities for your particular problems.

Replacing the optical pickup

If after these tests (or for other reasons) you are fairly confident that the optical pickup is defective and not salvageable, replacements are usually available from both the original manufacturer and service parts suppliers like MCM Electronics and others. If the sticker fell off and you need to identify the type (or are just curious), the ANEX Laser Pickup Page has photos of pickups from many manufacturers. (ANEX is a Polish company so I'm not advocating buying replacements from them, just thought the photos might be of interest!)

Costs range from less than $40 to well over the price of several new CD players so you need to decide (1) how confident you are in your diagnosis (pickups are probably not returnable) and (2) how much you are willing to invest in a repair.

The actual replacement procedure is usually straightforward but care must be taken to avoid damage to the usually fragile flex cables. Also, take ESD precautions since the laser diode, in particular, is quite sensitive to static. There will usually be a solder jumper between a pair of traces shorting across the laser diode to prevent such damage - remove this only after the pickup is fully installed and its connectors are plugged in. (However, if you don't recall such a jumper and you are experiencing a 'dead laser' symptom, check for it!

Note: Some pickups like those from Pioneer apparently come from the factory unaligned. I have no idea how the test them! :) In any case, this means that substantial work is needed to get them to work, probably requiring a service manual, oscilloscope, and a test disc (though I don't believe the latter is absolutely necessary).

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Servo Systems and CD Player Adjustments

Servo systems

There are several servo systems in a CD player:

1. Focus - maintains a constant distance to within 1 um (1/25,000th of an inch!) or so between the objective lens and the disc. This must be maintained even with a slightly warped or uneven disc and in a portable player, with a certain amount of movement as well. Focus is accomplished with a voice coil type of positioner (similar to operation of a loudspeaker) using optical feedback from the disc surface. See the chapter: "Startup Problems" for a description of how this and fine tracking (below) operate.

2. Fine tracking - centers the laser beam on the disc track (to within a fraction of a um) and compensates for side-to-side runout of the disc and player movement. This also uses a voice coil positioner and optical feedback from the

disc surface. (Note: on rotary type pickups, there may be no separate tracking coil as its function is combined with the rotary positioner.)

3. Coarse tracking - moves the entire pickup assembly as a function of fine tracking error exceeding a threshold or based on user or microcontroller requests (like search or skip). Coarse tracking uses several types of positioners depending on performance requirements. It may either be a worm drive, a gear drive, a linear motor, or rotary positioner - in order of increasing access speed.

   The linear motor and rotary positioner have no gears and simply use a coil and permanent magnet to move the entire pickup very quickly - similar to a voice coil but on a larger scale. CDROMs, especially the high performance models, usually use this type of actuator to achieve their relatively fast access. These may have some type of lock to prevent the pickup from banging around when the unit is moved with power off. Note: for a CDROM drive that uses a caddy - always remove the caddy before transporting the drive or the equipment that it is in. The loading of the caddy often unlocks the pickup permitting it to flop around during movement and possibly being damaged.

   A linear motor or rotary positioner driven pickup should move very smoothly and easily by hand when unpowered and unlocked.

   Note that the use of a rotary positioner is no guarantee of fast response. One of the earliest CD players - a Magnavox unit apparently manufactured by Philips - has about the slowest track seek time I have ever seen and uses a rotary positioner. Watching it go from one track to another is like watching an inch worm crawl along - ssst, ssst, ssst (the sound made as the focus actuator vibrates while crossing tracks), ssst, ssst.

4. Spindle speed - maintains constant linear velocity (CLV) of disc rotation based on a PLL locking to the clock signal recovered from the disc. Spindle drive is most often done with a permanent magnet DC motor connected to the disc platform. It may be similar to the other motors in CD players and VCRs, (as well as toys for that matter), or a higher quality brushless DC motor.

Play adjustments

You will see a circuit board, hopefully in your unit it is readily accessible with component markings. For each servo, there will be 1 or 2 pots to adjust. Unfortunately for our purposes, some CD players have no adjustments! In this case about all you can do is confirm that the lens is clean and clean and lubricate the mechanism.

The adjustments will be labeled something like:

1. Focus - F.G. (focus gain), F.O. (focus offset)
2. Tracking - T.G. (tracking gain), T.O. (tracking offset), maybe others.
3. Spindle PLL, PLL adj., Speed, or something like that.

DO NOT TOUCH THE LASER POWER ADJUSTMENT - you can possibly ruin the laser if you turn it up too high. Sometimes, just turning it with power applied can destroy the laser diode due to a noisy potentiometer. This adjustment can only be made properly with the service manual. It may require an optical power meter to set laser output. Very often the adjustment is on the optical pickup itself so it should be easy to avoid. Sometimes it is on the main PCB. The laser optical power output is feedback controlled and unlikely to change unless the laser is defective - in which case adjustments will have little effect anyway. If you run out of options, see the section: Laser power adjustment - last.

DO NOT JUST GO AND TWEAK WILDLY. You will never be able to get back to a point where the disc will even be recognized (without test equipment and probably a service manual).

First, somehow mark the EXACT positions of each control. Some of these may require quite precise setting - a 1/16 of a turn could be critical, especially for the offset adjustments.

Sometimes, there will be marked test points, but even then the exact procedure is probably model dependent.

Adjustment procedure for noise or skipping

The assumption here is that you can get the disc to play but there is audio noise skipping, or other similar problem.

Play a disc at the track that sounds the worst - put it into repeat mode so it will continue for awhile. Get it to play by whatever means works.

Repetitive noise at disc rotation frequency

Try to locate the adjustments for focus. Try the focus offset first, just a hair in each direction. If you go too far, you will loose focus lock totally, the servo will go into focus search mode and/or the unit will shut down. Return the control to the exact original position if there is no improvement. You can also try gain, but in my experience, the gain controls are not critical to normal play but determine how the unit will handle dirty and/or defective discs. However, if they are way off, there could be general problems. Too low a gain setting (this applies to focus as well as tracking) will make the unit very prone to skipping as a result of minor bumps. Too high a setting will make the unit skip as a result of minor disc defects.

Short distance skipping or sticking

Try to locate the adjustments for tracking. Try the fine tracking offset first, just a hair in each direction. If you go too far, you will loose servo lock totally, the pickup will slew to one end of the disc, and/or the unit will shut down. Return the control to the exact original position if there is no improvement. Then try the other tracking offset if there is one and also the gain (though this is probably not the problem).

Always return each control to its original position after the test so you don't confuse things more.

General servo adjustment procedure

If you have a service manual for your player, by all means follow its recommendations or at least read through its adjustment procedures before attempting the one given below. If you have an oscilloscope of at least 5 MHz bandwidth, using it to monitor the RF testpoint during these adjustments will be of great value. However, a scope is not essential.

- Once focus lock is established, there should be a strong signal at the RF testpoint - typically around a volt or so. It may initially appear somewhat random, however.

- Once tracking lock is established, this signal should appear similar to the 'eye' pattern (see section: The CD player 'eye' pattern for details. However, while seeking, this may be jumping around somewhat as it attempts to home in on the correct track location.

If your CD player has a TEST MODE, see the section: Pioneer PD/M series servo adjustment procedure and modify it accordingly. The following procedure is for a typical unit without such a test feature. It assumes that the unit is functional but internal controls are not in their correct position. This might be the case if you violated rule #1 - never wildly tweak any internal adjustments! Or, if a major subassembly like the optical pickup or mainboard has been replaced.

If you have not touched the internal controls and no major parts have been replaced, there is no need to perform this procedure. Use techniques and observations discussed elsewhere in this document.

The following are assumed:

- Controls on the main board are in an unknown state but not any laser power adjustments (hopefully, these were on the optical pickup itself or its flex cable and were not touched.

- The player is otherwise functional - there is no physical damage.

You may need to modify this procedure based on your particular model. Some of the adjustments may go by different names or be non-existent. Use your judgement. Except for the laser power adjustment, which should be avoided, it is unlikely that any settings of these controls will result in permanent damage.

Some of these adjustment will need to be performed while the unit is in the startup sequence attempting to read the disc directory. Until focus and possibly tracking and CLV lock are established, it may give up fairly quickly. You will just need to keep cycling power or opening and closing the drawer to get it to repeat the attempt. Once some subset of the servo adjustments are set within reasonable limits, the player may continue to spin the disc ad-infinitum.

Hopefully, the adjustments on your player's mainboard are clearly marked. This is not always the case. I have restored a totally messed up portable with totally unmarked controls to a marginal state of happiness using an incremental procedure while observing changes in behavior and the signal at the RF testpoint with an oscilloscope. It was not fun and I never was able to really make it fully functional - seeks still have a problem though it will start track 1 most of the time and once started, play is flawless. (I suspect that there may be actual electronic/optical problems with this player in addition to the randomly tweaked controls). I even had to poke at random (testpoints were marked only with TP numbers) to locate the RF testpoint!

Use both your eyes and ears. The following may not apply but are probably worth considering:

- If the sled slews to one end of the track immediately upon power-on or loading of the disc, there may be a coarse tracking balance control that is set incorrectly.

- If the disc does not start spinning at all, focus lock is probably not being achieved. Concentrate on the RF and focus adjustments.

- If the disc spins hessitently or in the wrong direction or the sled slews to one end of the track after the disc starts spinning, there is a good chance that the tracking adjustments need attention.

- If the disc goes into overdrive, check the PLL/VCO/CLV adjustment (whatever it is called on your model).

- If the disc starts spinning and continues to spin at the correct speed (500 to 200 rpm depending on track position) without the player shutting down, a valid data-stream is probably being read. This indicates at least marginal RF, focus, tracking, and PLL/VCO/CLV settings. This doesn't mean you can ignore these adjustments but at least it is progress!

- If the disc directory (TOC) is read successfully but the player has trouble locating a track to begin play (even track 1), concentrate on the tracking adjustments - focus and PLL/VCO/CLV are probably fine.

If the player works but there are noise or tracking problems and you have an oscilloscope, see the section: Diagnosis of erratic play first as the simplified procedure described there may be more appropriate.

1. Precisely mark the current positions of all internal adjustments - just in case they were already set correctly!

2. Set all main board controls to their midpoint.

3. Adjust TR BAL (Tracking Balance) to the center of the range over which the sled remains stationary. Outside this range, the pickup will slew to one end or the other. Not all CD players have this control. A CD may need to be in place for this adjustment to have any effect. If you are unable to get the pickup to remain stationary, try fine tracking offset (TR.OFF) as well.

The following two items should be done with no disc in place. If your player does not have suitable test points or if these controls have no effect without a disc in place, skip them.

4. While monitoring the testpoint for focus error (e.g., TP.FE), adjust focus offset (FO.OFF) for 0 volts (+/- 10 mV or so). This may not be the optimal setting but will get you in the ballpark.

5. While monitoring the testpoint for tracking error (e.g., TP.TE), adjust fine tracking offset (TR.OFF) for 0 volts (+/- 10 mV or so). This may not be the optimal setting but will get you in the ballpark.

6. If you have a DMM, VOM, or scope, put it on the Focus OK testpoint if there is one.

7. Load a disc and press PLAY if necessary to initiate the startup sequence.

8. Confirm that focus is established. There is an adjustment range for Focus Offset over which focus will be reliably achieved. Outside this range:

    - he lens will hunt up and down - possibly with clicking sounds as it bumps into the end stops.

    - The Focus OK testpoint will not be asserted or will be jumping around as well.

    - The disc may never start spinning or spin erratically (model dependent).

    - Single play units will give up and enter stop more with display of 'disc', 'no disc', 'error', etc. Changers will come up with similar display and then move on to the next position of the carousel or magazine.

    Center the focus offset within the range for which focus is stable if it was not already there.

At this point there is a fair chance that the disc has started to spin and even that the disc directory has been displayed. If not, there are still two sets of adjustments remaining.

9. With focus stable, the disc should spin up. It needs to reach and lock at about 500 rpm - roughly 8 revolutions per second. If it does not move or overspeeds, try adjusting the PLL/CLV control (may be called PLL.ADJ, VCO.FR, CLV.ADJ, etc.). Note: this assumes that the spindle motor and driver are in good condition. If there is any doubt, see the section: Testing of motors.) WARNING: if the disc spindle speed runs away, turn power off and wait for spindle to stop completely. PLL/CLV control may be set to high; turn it counterclockwise 1/4 turn and start try again. There will be some range of this control where the speed will not run away but will be within the required limits.

Now, there is an even better chance that the disc has started to spin and that the disc directory has been displayed. If not, there is still one set of adjustments remaining.

10. Fine tracking offset may still not be quite right. Try some slight adjustments on either side of the current position. You may have to cycle power or open and close the drawer if you go too far. Some adjustments of alternately fine tracking offset and PLL/CLV may be needed.

Hopefully, you now have a disc directory and play may be operations though perhaps with audio noise and/or skipping or sticking.

The following are best done with a scope monitoring the 'Eye' pattern or other testpoints but if you do not have one, use your ears.

11. Adjust PLL/CLV control to midpoint of range in which disc plays correctly. Test this at both the start and the end of a full length (74 minute) disc. The optimal setting will result in the control being centered within the range over which the player works reliably at both ends of the disc.

12. Adjust any RF Offset (RF.OFS) control to the midpoint of the range over which play continues normally with no audio noise.

13. Set Focus Gain (FO.GAIN or FO.G) to the midpoint of the range over which it locks. CAUTION: the disc may enter a runaway state if you go to far. Check at both the beginning and end of the disc. Focus gain may need to be increased if the player is overly sensitive to bumps or disc wobble It may need to be decreased if sensitivity to disc defects is too high.

14. Set Tracking Gain (TR.GAIN or TR.G) to the midpoint of range over which it locks. CAUTION: the disc may enter a runaway state if you go to far. Check at both the beginning and end of disc. Tracking gain may need to be increased if the player is overly sensitive to bumps or disc wobble. It may need to be decreased if sensitivity to disc defects is too high.

15. Press STOP and then PLAY again to confirm that the disc loads properly and the directory comes up quickly and the music starts without excessive delay, hunting, or hesitation.

16. Test forward and reverse search and seek functions for proper behavior. Some slight adjustments to tracking balance or fine tracking offset may be needed to equalize the forward and reverse search or seek speed.

17. Player should now operate normally. However some tweaking of the gain controls may be necessary (as described above) for optimum defective disc and track seek performance over entire disc.

If you have an oscilloscope capable of at least 5 MHz bandwidth, you can now optimize the amplitude and stability of the 'eye' pattern at the RF testpoint by going back and touching up the various offset (RF, focus, fine tracking) adjustments. Unless otherwise instructed by the service manual, it is probably safe to assume that the RF signal should be maximum when everything is properly adjusted. For example, if the tracking offset and/or E-F balance is not set properly, you may find that the RF signal amplitude *decreases* when the tracking servo is closed since the laser beam is consistently off-center with respect to the row of pits and lands. (With the servo loop open, the beam was crossing tracks more or less at random so it was sometimes centered!)

Tips for adjusting CDROM drives

The following assumes that your CDROM driver and MSCDEX load without errors and that your IRQ, DMA, and any other software settings are correct but that seeks take a long time to complete or fail and/or data reads are unreliable.

If you can get the CDROM drive to play an audio CD, that can be used to do an initial alignment. The procedure below provides a way of monitoring data read performance while performing final servo adjustments since this is more critical than audio. Assuming, of course, that (1) there are any controls to adjust and (2) that you can get to them with a disc in place!

If after using the procedures described in the section: General inspection, cleaning, and lubrication, and possibly even servo alignment using an audio CD, the drive still produces data errors or cannot be read at all, it is time for more serious testing:

(Portions from: the_tooth_wraith (the_tooth_wraith@ptel.net))

Locate a copy of Disk Detective or another CD-ROM diagnosis program.

I'm pretty sure that Disk Detective (the limited version rather than professional version) can be downloaded over the internet from filelibrary.com (click on DOS collection, followed by Utilities-Disk then files beginning with C). I use the limited version that ships with a new Mitsumi IDE drive. It works perfectly on IDE, Mitsumi, SCSI, and likely any other interface drives, and it does not require the presence of any Mitsumi drive or controller. If you can't find Disk Detective, then search for CD-ROM, CDROM, or CD ROM at: http://www.shareware.com, and you'll find CD-ROM diagnostic programs.

In Disk Detective, there is a Test Disk menu option that scans the entire disk, and gives a continuous output to the screen of read errors it encounters, giving the type of error and the average data throughput.

Now using Disk Detective (or a comparable program), load a disk into the drive and select the test disk option, and tell it to scan the disk from beginning to end, and tell it not to stop when it encounters an error. Disk Detective should start trying to read the disk at sector zero, and will display read errors as it encounters them.

You might have to load an audio disk rather than a data disk in order to be able to get to the Test Disk screen.

With the Test Disk screen displaying the errors as it attempts to read the drive, it will be possible to carefully tweak each of the servo adjustments (as described elsewhere in this document) to minimize errors and maximize throughput.

Low laser power

Indications of reduced laser power include erratic startup, noisy playback. excessive variation of playback quality depending on the particular disc, or total lack of startup.

WARNING: improper adjustment of the laser power may result in the absolutely instant destruction of the laser diode - the heart of your CD player. There will be no warning. One moment you have a working laser diode, the next you have a DELD - Dark Emitting Laser Diode. Read the relevant sections fully before attempting any adjustments.

Nothing will help a dead laser diode - whether as a result of your efforts or natural causes - short of replacing the optical pickup.

Very likely, low laser power indicates a sick laser as well and adjustments will have limited if any effect since optical feedback normally maintains laser diode output at the proper level and it may be doing all that is possible.

However, sometimes due to component drift (this one way of saying: I haven't got a clue), the power will drop slightly or the sensitivity of the photodiode array will decrease resulting in a marginal signal.

If you have the service manual and it provides a procedure not requiring a laser power meter (which you probably do not have), then by all means follow that procedure.

Otherwise, see the section: Laser power adjustment for procedures that may be used as a last resort.

Optical alignment

Unless the unit was dropped, optical realignment of the laser assembly is not likely to be needed. All critical components are screwed, sealed with loctite, or glued, and should not change alignment under normal use. Don't fall for the line 'CD players are very delicate and will need frequent alignment - buy our extended service plan'. CD players are remarkably robust. Portables, even when nibbled on by large dogs, often survive unscathed. I even carried a component type CD player home from a garage sale 5 miles on the back of a 10 speed road bike over city streets complete with potholes! No problems. In fact, it improved. The seller claimed that it was broken but I could find nothing wrong! One possible exception is for automotive units which are subjected constantly to bumps and vibration which eventually take their toll.

If you really believe that optical alignment is needed, I strongly recommend that you obtain the service manual. Special test discs or jigs may be required and some test equipment will be required. As with other adjustments, make sure you can get back to your starting point should the need arise. Again. eliminate other possibilities first if possible.

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Motors and Spindles

Small motors in CD players

Conventional miniature Permanent Magnet (PM) motors are usually used for:

- Drawer/tray opening/closing.
- Spindle rotation.
- Pickup position (coarse tracking) unless the unit uses a linear motor or rotary positioner drive.
- Disc changing (changers and jukeboxes only).
- Optical pickup tilt (laserdisc players only).

These are DC motors with commutators and metal brushes and are very similar in construction and quality to typical motors found in cameras, toys, portable tools, and other electronic equipment like VCRs and audio cassette decks.

They usually run on anywhere from a fraction of a volt up to 10 or 12 volts DC on-off (e.g., drawer) or from a servo controller (spindle).

Some CD players and CDROM drives use brushless DC motors for spindle driver rather than the cheap PM brushed variety. The commutation circuitry for these may be external to the motor itself. Troubleshooting beyond searching for bad connections will probably require a schematic.

Sled movement in high performance CD players and CDROM drives often uses either a linear or rotary direct drive (voice coil) mechanism. Since these are integral parts of the coarse tracking servo system, the only thing that can be tested without a schematic is for coil continuity.

Problems with small PM motors

These motors can fail in a number of ways:

- Open or shorted windings - this may result in a bad spot, excess load on the driver, or a totally dead motor.
- partial short caused by dirt/muck, metal particle, or carbon buildup on commutator - this is a common problem with spindle motors which fail to reach proper startup speed.

- dry/worn bearings - this may result in a tight or frozen motor or a spindle with excessive runout.

Testing of motors

If your player uses a brushless DC motor for the spindle then you may not be able to perform any electrical tests as the commutation control may be external on the circuit board somewhere. These do not fail very often, either.

An open or shorted winding may result in a 'bad spot' - a position at which the motor may get stuck. Rotate the motor by hand a quarter turn and try it again. If it runs now either for a fraction of a turn or behaves normally, then replacement will probably be needed since it will get stuck at the same point at some point in the future. Check it with an ohmmeter.

Also check between each terminal and the case - the reading should be high, greater than 1M ohm. A low reading indicates a short. The motor may still work when removed from the equipment but depending on what the case is connected to, may result in overheating, loss of power, or damage to the driving circuits when mounted (and connected) to the chassis.

Clip the ohmmeter leads to the motor terminals and rotate the shaft extremely slowly. The motor will act as a generator as your spin it resulting in the resistance readings increasing or decreasing depending on direction. However, the readings should stabilize once you stop.

The resistance should be fairly constant as the shaft is rotated with periodic dips where pairs of commutator segments are shorted by the brushes. The number of cycles per revolution is determined by the number of commutator segments used (most use only 3). Any extremely low reading may indicate a shorted winding. An unusually high reading may indicate an open winding or dirty commutator.

Cleaning may help a motor with an open or short or dead spot as noted below.

Typical resistance of these motors will be 10 to 25 ohms (though I have seen some apparently good motors reading as low as 5 ohms), fairly constant as one rotates the shaft except for dips at 3 points where the brushes short out each pair of commutator segments (there are generally 3 segments on these motors).

A motor can be tested for basic functionality by disconnecting it from the circuit board and powering it from a couple of 1.5 volt alkaline cells in series (3 V) or other power supply up to 9 V or so.

WARNING: Never attempt to power a motor with an external battery or power supply when the motor is attached to the circuit board - you may blow electronic components on the circuit board and complicate your problems. Disconnect *both* terminals and label the wires or motor orientation so you can reconnect it with the proper polarity.

If you use a variable power supply, the motor will start spinning slowing at less than a volt and continue without tending to stop at some point in its rotation. Using your fingers to monitor the torque produced as it rotates can also provide an indication of its health. It should be fairly uniform with slight periodic dips due to the commutator construction and number of segments.

Another approach is to power the motor from the low voltage source through a low value series resistor and monitor the voltage on the motor with an oscilloscope. It should have a periodic ripple at the rotation times the commutator (probably 3) rate. If there are sharp dips at the based rotation rate, there is a short either due to conductive gunk or actual shorted turns in the windings. If there is excessive noise in the waveform, the brushes and/or commutator may be dirty or worn.

It is also possible to confirm that the electronics are attempting to drive the motor by substituting a 15 or 20 ohm 1 W resistor for the motor. The driver circuit should develop a few volts across this load when it is supposed to be active. If there is no voltage at any time, then the driver may be blown or not have power, or the logic is not instructing the motor to spin!

Reviving a partially shorted or erratic PM motor

Conductive material bridging the gaps on the commutator of these small permanent magnet DC motors can result in intermittent contact and erratic operation. One theory baseed on an analysis done for a major manufacturer was that the origin of the contamination is the original lubricants used in the motor. Carbon or metal particle buildup can partially short the motor making it impossible for the controller to provide enough voltage to maintain desired speed. Sometimes, a quick squirt of degreaser through the ventilation holes at the connection end will blow out the shorting material. Too much will ruin the motor, but it would need replacement otherwise anyway. This has worked on Pioneer PDM series spindle motors. I have heard of people using carburetor cleaner successfully but I would recommend something a little less harsh to start. Contact, circuit board, or tape head cleaner may work.

Another technique is to disconnect the motor completely from the electronics and power it for a few seconds in each direction from a 9 V or so DC source. This may blow out the crud. The long term reliability of both of these approaches is unknown.

WARNING: Never attempt to power a motor with an external battery or power supply when the motor is attached to the circuit board - you may blow electronic components on the circuit board and complicate your problems. Disconnect *both* terminals and label the wires or motor orientation so you can reconnect it with the proper polarity.

It is sometimes possible to disassemble the motor and clean it more thoroughly but this is a painstaking task best avoided if possible.

If you do manage to revive it, also see the section: Spindle motor drive modification to minimize chances of future problems.

Replacement motors

The spindle motor should be replaced with an identical unit though it doesn't have to be the exact manufacturer's part number - universal substitutes are often available at a much lower price.

However, there may be alternatives for other types. Most of the other small PM motors found in CD players and CDROM drives (as well as VCRs and other consumer electronics and small appliances) are basically pretty similar. The important differences are mainly mechanical - size, mounting, shaft length, etc. There may be variations in nominal voltage and current usage but for non-critical applications like drawer loading or disc changing, if you can make a generic replacement fit the space and attach to the drive components, There is a good chance that it will work well enough. Such replacements may be available from companies like those listed in the section: Recommended parts suppliers. Check a few catalogs!

Motor bearing problems

A dry or worn bearing can make the motor too difficult to turn properly or introduce unacceptable wobble (runout) into the shaft as it rotates.

Feel and listen for a dry bearing:

The shaft may be difficult to turn or it may turn with uneven torque. A motor with a worn or dry bearing may make a spine tingling high pitched sound when it is turning under power. A drop of light machine oil (e.g. electric motor oil) may cure a dry noisy bearing - at least temporarily.

For spindle motors (these are the only motors in CD players where runout is critical), try wiggling the shaft from side-to-side - any detectable movement is an indication of runout. At some point, this will be bad enough such that the focus and tracking servos will be unable to compensate for the runout and audio noise and skipping may result. Some oil may help but a spindle motor with a worn bearing will require replacement eventually. Furthermore, it may prove impossible to reach the bearing(s) to lubricate them properly.

See the section: Spindle motor problems for more information.

Spindle motor problems

The following are some indications that the spindle motor may be defective or need attention. However, insufficient spindle motor voltage or current could also be due to spindle motor driver faults, incorrect power supply voltages, or logic problems.

Note: If the disc doesn't spin at all, try rotating it by hand while it is trying (or with the servos enabled if it has a TEST mode). If you hear that 'gritty' sound, the focus and probably tracking servos are working but the spindle motor or driver are faulty.

- Focus is successful but disc does not spin (dead motor or dead spot on motor, shorted motor, bad connection).
- Disc spins but at too slow a rate or is erratic or needs some help (weak motor or dead spot). Reading of disc directory may be erratic. (Try helping motor out by hand).
- Voltage across spindle motor is only 1 V or less while attempting to spinup and read the directory and climbs to 5 V or more with the motor disconnected (partially shorted motor).
- Spindle bearing runout is excessive (i.e., detectable by wiggling the spindle from side to side) or spindle motor bearing is dry or tight (try lubricating if possible).
- Repetitive noise or dropouts at the disc rotation frequency or twice the disc rotation frequency. This may get worse toward the end or outer tracks of the disc. (Excessive spindle bearing runout or bad windings).

Check the motor before replacement (see the section: Small motors in CD players for general motor problems and testing). You should be able to easily confirm or eliminate the spindle motor as the cause of your problems. If either of the cleaning or rejuvenation techniques make a significant difference in performance, then the motor is almost certainly at fault. If the player now functions normally - leave it alone or, perhaps, try the circuit modifications suggested in the section: Spindle motor drive modification to minimize chances of future problems.

The spindle motor is often blamed for everything from long distance skipping (coarse tracking problem) to disc spinning too fast or in wrong direction (a control problem). Spindle motors do fail but they are not at the root of all problems.

If you suspect a dry or bad spindle motor bushing (bearing):

(From: Jeff Cook (jacook@ibm.net).)

A little trick I came up with when my Sony CDP-550 player started skipping: Tape a coin (a penny seems to work fine) to the top of a CD that skips. If it cures the skipping, then the problem is likely the spindle motor bushings need lubricating.

Spindle motor drive modification to minimize chances of future problems

This suggestion is directed toward Pioneer players of the PD and PDM series with known common spindle motor problems. It may apply to other Pioneer models and other brands as well. It can be used whether you have just rejuventated an existing motor or installed a replacement.

For Pioneer players, there is actually a circuit modification to reduce the possibility of repeat problems but it requires changes to the wiring - cuts and jumpers - which I prefer to avoid.

My recommendation is to try the following which can usually be added at the motor terminals. (I have not done this yet, so no guarantees):

Put a series string of 4 1N400X diodes in parallel with another similar string in the opposite direction across the motor terminals. This will limit the maximum voltage to about 3 V instead of the 6 V or more that it is now. The reduced voltage should reduce chance of damage to the commutator at spin-up. On the Pioneers at least, the motor driver should not mind the extra load during any peaks where the diodes kick in.

It may take a couple seconds extra to start up but I believe it will still work fine otherwise.

If you do this, let me know how it works.

Spindle motor replacement

Mark the height of the old spindle platter before you attempt to remove it. The best approach is to make a shim that will fit between the bottom of the spindle platter and the motor as a stop. The height is usually specified to a precision of 1/10 of a mm. Too low or too high and the disc may rub. This is probably overhill - 1/2 mm is probably good enough but try to get it as close as possible. The focus servo offset adjustment will make up for any height error in so far as focus is concerned.

The spindle is often press fit and difficult to remove without damage. It is critical that when the spindle is replaced, it be mounted perfectly with no wobble. If you can obtain a new spindle platter with the new motor, this is the best option. If not, take every precaution to prevent damage to the spindle platter during removal - even it it means destroying the old motor in the process. See the section: Spindle platform pulling.

When press fitting the new spindle, the use of an arbor press or drill press is highly recommended. Put a block of wood under the bottom of the motor and your previously made shim between the spindle platter and the motor. Press straight down - slowly and firmly. Err on the side of being to high and check the height. Repeat until you get it perfect. It is much easier to press a little more than to raise the height if you should go to far.

If there is a set screw, your job is much easier. Other mounting schemes may be employed - use your judgement in replacement procedure. For non-press fit installations, a drop of loctite or nail polish will reduce the chance of it working loose.

The new motor may come with a shim to set the proper height or it may be included as part of the player:

Note that the precise length of the spindle motor shaft may be critical on some CD players to help center the disc. Thus, when you order a replacement, don't assume that a slightly shorter shaft will be adequate just because it will hold the platter securely - check it out first.

(From: Mark Z. (mzacharias@aol.com).)

Most Pioneer models have a spindle height jig molded onto the subchassis. It snaps off and slips between the disc table and motor base to set the height.

Unknown spindle platter height when replacing spindle motor

What was your excuse for not marking it? Oh, an elephant sat on the player and that is why the motor needed replacing but the height was already messed up :-).

If the player operates normally after spindle motor replacement, as they say "If it works, use it". I wouldn't worry about it. The focus servo has a wide range. If you are curious, try to locate the test point for focus error. It should probably be a noisy waveform centered around zero volts. However, this may not be the case and you would need the service manual to be sure of what it should be. As long as the player seems to locate the disc directory quickly and plays normally, leave it alone!

However, if it now has problems either taking a long time to start play or exhibiting unusual noise or skipping during play, you should probably try to obtain the spindle platter height specification and set it more accurately.

I definitely would not recommend mucking with the spindle platter height unnecessarily if it is a press-fit. You would probably end up with a bent shaft and need for yet another replacement motor. However, if the spindle platform is secured with a set screw, you can try to adjust it to minimize focus error and/or optimize playback performance.

Spindle platform pulling

I was able to remove the spindle platform on a Philips CD pickup using the lawn mower engine flywheel pulling approach - levers under both sides of the platform so the pressure is upwards and not sideways while tapping on the center of the shaft with a thin punch. Thus, there was no shaft bending. I believe that the motor survived without damage.

I was actually going to 'machine' a mini-flywheel puller but then I said: "What the heck, that is too much work :-)"

In any case, the spindle platform is completely undamaged and the motor could probably be reused.

However, be careful what you are prying against - the mounting may use tiny screws into plastic or something equally fragile.

Of course, if you plan on doing any serious hammering, remove all the delicate optical and electronic components first!

Correcting spindle platform wobble

This assumes the bearings are in good condition but the shaft has somehow gotten slightly bent. You might ask: How could this happen? Once cause could be using an improper technique to remove or attempt to remove or install the spindle platform from/to the motor shaft or something heavy falling on the player. Right, I know; in this case, a bent shaft will likely be the least of your problems! :-)

(From: Filip M. Gieszczykiewicz (filipg@repairfaq.org).)

I use something as simple as a pencil. Start the motor going and put the pencil right above - but not touching - the part that is bent. Now move it in tiny increments towards the bent part. When you hear the first tiny "scrape", stop the motor and note where the pencil mark appears. This is the place you want to press down to even it out.

This is loads of fun with a CD spindle motor and sometimes it's just easier to get a replacement. Trust me.

Sled motor problems

The following applies to sled positioners using conventional permanent magnet motors with the typical gear or screw mechanism. (Those using linear motors use closed loop servo systems with a drive coil and sense coil. About all you can do to test these without a schematic is to check for continuity of the two coils.)

Sled motors tend to be less likely to fail than spindle motors but can suffer from similar afflictions.

The following are some indications that the spindle motor may be defective or need attention. However, insufficient sled motor voltage or current could also be due to sled motor driver faults, incorrect power supply voltages, or logic problems. These problems could also be of an erratic nature if the motor has a dead spot or is partially shorted.

The sled motor (or its driver and associated circuitry) may be at fault if:

- The sled fails to reset to the inner track.
  - Focus is established and the disc begins spinning at the proper speed for the current pickup location but the pickup fails to move to the selected track location.
  - There are problems with discs repeating more-or-less the same musical segment every few seconds (the sled gets stuck) or long distance skipping (the sled sticks but then once enough of a fine tracking error develops, breaks free and overshoots the proper location).

The motor may have a dead or weak spot in its rotation. Rotate it by hand 1/4 turn or so and see if it now spinds normally or a fraction of a turn. See the section: Testing of motors.

Of course, any of these could also be due to mechanical problems as well so eliminate these as possibilities first.

Sled motor drivers

The sled motor may actually receive its drive from two sources (maybe more) as shown conceptually in the diagram below. These may or may not be separate physical outputs tied together:

```
                               Slew+ o--------+
                      |\                      |
         Tref+ o------|+ \                    |
                      |    >------------+     |
                   +--|- /              |     |    |\  Sled Drive
                   |  |/ TE+ Comp       |     +----|+ \
                   |                    +----------|+   \
Tracking Error o---+                               |      >--------o + Sled
                   |                    +----------|-   /      +---o - Motor
                   |  |\ TE- Comp       |     +----|- /       _|_
                   +--|+ \              |     |    |/          -
                      |    >------------+     |
         TRef- o------|- /                    |
                      |/                      |
                               Slew- o--------+
```

1. Slew driver - this is used when the pickup is resetting or moving across the disc. The motor is commanded to move smoothly in either direction or is searching for the general vicinity of the starting location (time code).

   Where the pickup is unable to reset to the inner track or unable to move to an outer track during seek operations, a part of this driver or its associated circuitry may be at fault.

2. Coarse tracking driver - this is used to move the sled a small amount during play to recenter the pickup once the fine tracking error exceeds a threshold. Many designs will do away with explicit comparators (as shown above) and just use the friction of the sled motor/mechanics to result in movement once the voltage on the motor becomes large enough. This would seem to waste power, however, and be undesirable for battery operated portables, at least.

   Where the seek operation completes normally and the music starts playing but then gets stuck or jumps back and repeats after a few seconds, the coarse tracking driver or its associated circuitry may be at fault.

Any of these symptoms may also be caused by a defective sled motor or mechanical problems - probably more likely than bad electronics.

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Notes on Specific Equipment

Pioneer PD/M series players/changers do not recognize discs

(Refer to the photo of the Pioneer CD Player Optical Deck for parts identification.)

Where a Pioneer player or changer does not recognize discs, the most common causes are:

1. Partially shorted spindle motor due to 'crud' on commutator. Cleaning may be possible. Generally, disc will spin but at insufficient speed. Try TEST MODE toward latter (outer) part of disc as the required rotation rate is lower and/or check voltage to motor, below. See the section: Reviving a partially shorted or erratic PM motor.

2. Cracks in flex cable to optical pickup assembly - replacement of flex cable will be required. This may also result in erratic operation while playing. The Pioneer replacement part number for the improved version of one common cable is PNP-1343 but confirm this is correct for your model before you order. Sometimes, the flex cable is just not positioned properly (clear of the metal cover) and just needs to be 'adjusted'.

3. Collapsed rubber suspension grommets. There may be a scraping or clicking sound associated with this failure. For changers, gently lift up on the optical pickup assembly while the disc is attempting to spin to see if the disc is recognized and will play. Replace the deteriorated grommets.

4. Lens fell out. This is somewhat rare and applies mostly to changers (possibly only those made by Pioneer) where the pickup is mounted upside-down, but apparently the adhesive dries out and may fail completely during use or as a result of the player being moved. See the section: Objective lens popped out. Note: If you do attempt to reattach the lens, replace the rubber grommets as well as collapsed rubber grommets are common on these pickups as well - and may even have been the cause of the lens problems (disc contacting lens).

For general information, see the sections starting with: "Startup sequence".

Pioneer PD/M series test mode

The TEST mode available on some CD players is extremely useful for narrowing down problems. The following are for the Pioneer PD/M series of CD players and changers:

- To enter TEST mode, press the TEST button while turning POWER ON and then hold it on for at least 1 second.

    - Some models only have a set of contacts - Pioneer saved 2 cents on a switch! Short between these with a piece of wire or a paper clip instead of pushing the button.

    - On players with a standby mode (not a hard on/off switch), plug the unit in while pressing the TEST button or shorting the contacts.

  The TEST button or contacts are located on the main board (usually near the front right corner - may be obscured by cables).

Once TEST mode is engaged, the servos can be controlled from the front panel:

- STOP turns all servos OFF.
- TRACK FWD (>>|) enables FOCUS servo (and loads disc 1 in changer).
- PLAY enables SPINDLE servo.
- PAUSE enables TRACKING servo.
- MANUAL SEARCH FWD (>>) or REV (<<) to move the optical pickup.

Depending on model, the specific functions and behavior of the front panel buttons in TEST mode may vary slightly. Some may use PROGRAM to turn on laser, PLAY to enable focus servo, second push of PLAY to enable tracking servo, etc. You may have to experiment.

WARNING: Normal safety checks are disabled in TEST mode. Thus, the laser may remain on as long as focus/tracking/spindle servos are engaged even if no disc is in place. Take care.

Power cycle (by unplugging if necessary) to return to normal mode.

Pioneer spindle motor voltage (operating normally)

Here are the typical measurements for the PD/M series players:

- Spinup: >2.5 V.
- Time to lock (est): 1 to 2 sec.
- Start of disc (500 rpm): 1.0 V.
- End of disc (200 rpm): 0.5 V.

Pioneer spindle motor problems

When bad, spindle servo drive tops out at .6 V and 100 ma. Player is unable to spin up to required 500 rpm to read disc directory.

While exact cause is unclear, theory is that large voltage applied at startup followed by long periods of very low voltage (.5-2 V) operation allows conductive crud (carbon) to build up on commutator eventually reducing resistance to the point where the driver cannot apply enough voltage to achieve 500 rpm.

A short squirt of degreaser through motor access hole had an immediate dramatic effect returning operation to normal. It is not known how long this will last. (Also see the alternative procedure in section: Reviving a partially shorted or erratic PM motor.)

Collateral symptom: Spindle motor servo drive IC becomes quite warm when attempting to power shorted motor. However, it does not appear to be harmed.

Use TEST mode to play disc at outer track. If this is normal, then spindle motor is probably bad as the rotation speed at the outer tracks is less (200 rpm) and a partially shorted motor may still run fast enough for this.

Pioneer PD/M series servo adjustment procedure

The following procedure assumes that unit is functional but internal controls may have been moved from their correct position. This procedure has been determined experimentally and is subject to change without notice. If you have not touched the internal controls, there is no need to perform this procedure. Use techniques and observations discussed elsewhere in this document.

A number of Pioneer CD players have used very similar designs. However, technology sometimes the implementation changes dramatically between units with virtually identical model numbers. It is known that this adjustment procedure applies to many older Pioneer single disc players (e.g., PD5100) and magazine changers (e.g., PDM400/500/600 etc,). However, newer models that appear virtually identical to these may require a totally different adjustment procedure. Therefore, use at your own risk! With minor (and obvious) modifications, this general approach should also apply to many CD players from various other manufacturers as well.

I also recommend you read the section: General servo adjustment procedure in its entirety before proceeding to tweak your Pioneer player.

Assumptions:

- Controls on the main board have been moved or are in an unknown state but not on the flex-cable or optical pickup assembly.
- The player is otherwise functional - no physical damage.

And now for the fun:

1. Set all the main board controls to their midpoint.
2. Power up the unit in TEST MODE (hold down the TEST button while powering on.
3. Adjust TR.BAL (Tracking Balance) to the center of the range over which the sled remains stationary. Outside this range, the pickup will slew to one end or the other.
4. While monitoring TP1-6 (FO.ER, Focus Error) with a VOM or DVM, adjust FO.OFS (Focus Offset) for a reading of 0V +/- 10 MV. Note: I have found that on some players, this may not actually be quite optimal and fine adjustment be beneficial.
5. While monitoring TP1-2 (TR.ER, Focus Error) with a VOM or DVM, adjust TR.OFS (Tracking Offset) for a reading of 0V +/- 10 MV. Note: I have found that on some players, this may not actually be quite optimal and fine adjustment be beneficial.
6. Load a magazine with a disc in slot 1 and press >>|, TRACK SEARCH Forward. This should load the disc and enable focus servo.
7. Use MANUAL SEARCH REV (<<) to position sled at beginning of disc.
8. Press PLAY. This enables the spindle servo. Disc should now spin up and lock at at around 500 rpm. If disc does

not start or appears not to reach correct speed, check voltage on spindle motor. It should be greater than 2.5 volts during spinup. The most common cause of low voltage is a dirty partially shorted commutator/brush assembly inside the motor; clean or replace as necessary. WARNING: if the disc spindle speed runs away, turn power off and wait for spindle to stop completely. VCO control may be set to high; turn counterclockwise 1/4 turn and start from the beginning.

9. Press PAUSE. This locks the tracking servo. The display should show the disc TRACK and TIME. Alternately pressing >> or << should move pickup, then press PAUSE to start play again. Audio will be correct at output. Correct display and sound only near end of disc indicates a spindle motor unable to achieve sufficient speed (see above).

10. Adjust the VCO control to the midpoint of range in which disc plays correctly.

11. Set RF.OFS to the midpoint of the range over which play continues normally.

12. Set FO.GAIN to midpoint of range over which it locks. CAUTION: the disc may enter a runaway state if you go to far. Check at both the beginning and end of the disc. FO.GAIN may need to be increased if the player is overly sensitive to bumps or disc wobble. It may need to be decreased if sensitivity to disc defects is too high.

13. Set TR.GAIN to the midpoint of range over which it locks. CAUTION: the disc may enter a runaway state if you go to far. Check at both the beginning and end of the disc. TR.GAIN may need to be increased if the player is overly sensitive to bumps or disc wobble; it may need to be decreased if sensitivity to disc defects is too high.

14. Press STOP. The disc should unload. Exit TEST MODE by turning power off and on again. Confirm that the disc loads properly and that the directory comes up quickly and the music starts without excessive delay, hunting, or hesitation.

15. Test forward and reverse search and seek functions for proper behavior. Some slight adjustments to tracking balance or fine tracking offset may be needed to equalize the forward and reverse search or seek speed.

16. The player should now operate normally. However some tweaking of the gain controls may be necessary (as described above) for optimum defective disc and track seek performance over entire disc.

If you have an oscilloscope capable of at least 5 MHz bandwidth, you can now optimize the amplitude and stability of the 'eye' pattern at the RF testpoint by going back and touching up the various offset (RF, focus, fine tracking) adjustments. Unless otherwise instructed by the service manual, it is probably safe to assume that the RF signal should be maximum when everything is properly adjusted. For example, if TR.OFS is not set properly, you may find that the RF signal amplitude *decreases* when the tracking servo is closed since the laser beam is now consistently off-center with respect to the row of pits and lands. (With the servo loop open, the beam was crossing tracks more or less at random so it was sometimes centered!) For the Pioneers I have seen, it appears that the FO.OFS and TR.OFS may *not* be set optimally by the static adjustments (4) and (5), above.

Pioneer 6 disc cartridges (magazines)

There are usually pretty robust but if something was forced, in addition to damaged plastic parts, a bunch of steel balls (about 1/8" diameter) may escape. DO NOT attempt to use the cartridge without these - they are part of the mechanism which assures that only one tray will come out at a time. If they are missing, as one tray is pulled out, another may come along and jam up the works. :(I believe there are 5 total (for a 6 disc cartridge) and you need every one of them! Assuming there is no actual damage, it is possible to reinstall the balls by carefully disassembling the cartridge. If I recall correctly, they go in a channel formed by a hole on each tray next to the hinge and a spring holds them in place. Buying a new cartridge may be the way to go. :)

Comments on Pioneer CD Player Adjustments

(From: David Kuhajda (dkuhajda@locl.net).)

There are a lot of adjustments that must be done per the service manual, but the guide is much easier to follow.

1. Grating.
2. Tangential tilt.
3. focus offset.
4. tracking offset.
5. focus gain.
6. tracking gain.

The spindle motor height is also extremely critical in these older Pioneers. Recommend you get the correct one.

If it has the old white flat cable going to the optics it also must be replaced, the white ones would go bad and intermittent.

If the lens fell out, the 4 rubber grommets must also be replaced. We typically reglue the lens on very carefully (works about 75% of the time), replace the rubber grommets, check the spindle motor, and do the adjustments to fix ones like these.

(From: TEX (zedex@geocities.com).)

The grating is the most important. The laser are not adjusted and you will need a small hex driver or a small blade screwdriver to adjust this. I only worked this out after spending two weeks on a unit and wondering why a second hand laser woked fine and a brand new unit didn't. If you want a copy of the service manual, try your local pioneer distributor - they may be able to Fax it to you.

Pioneer PD-7010 adjustment procedure (from Davidson)

Note: See Pioneer TEST mode description in the section: Pioneer PD/M series test mode.

1. Laser Power - Normal mode. Press PLAY - Laser power should be set to:

   .26 mW +/- .02 mW. Adjust VR1 to spec.

2. PLL VCO Free Run Frequency:

   - Set the player to TEST mode.

   - Press STOP to switch all servos off.

   - Press TRACK FWD to enable the FOCUS servo.

   - Press PLAY to enable the SPINDLE servo.

   - Observe the waveform at pin 8 of IC8 (2/2) using a scope set to .5 V/div. This waveform can be found easily at the legs of C47.

     Note the center value of this waveform.

- Using a core driver, adjust VL1 (VCO coil) so that the center value of this waveform is the same when PAUSE is pressed to switch on the TRACK servo.

3. Tangential Adjustment:

    - Enter TEST mode and load the TEST disc??
    - Use the MANUAL SEARCH FWD key to put the pickup at the end of the disc.
    - Press TRACK FWD, PLAY, and PAUSE in that order to enable all servos.
    - Use the Scope to observe TP2, Pin 4 (RF Output). Adjust the Tangential Adjustment Screw to obtain the clearest eye pattern. This is the midpoint between the places where the pattern begins to deteriorate.

4. Tracking Offset and Focus Offset:

    - Enter TEST mode.
    - Adjust the voltage at TP1, Pin 9 TR (Tracking Return) to 0V +/- 10 mV by turning VR2 (Tracking Offset).
    - Adjust the voltage at TP1, Pin 3 FO.ER (Focus Error) to 0V +/- 10 mV by turning VR6 (FO.OF, Focus Offset).

5. Focus Gain:

    - Enter TEST mode.
    - Press STOP to disable all servos.
    - Adjust the frequency and output voltage of CH1 of the F.T.G. to 878 Hz and .2 V P-P. What if I do not have an F.T.G.?
    - Connect the F.T.G. adjuster. Right :-).
    - Press TRACK FWD, PLAY, and PAUSE in that order.
    - Adjust VR3 FO.GA so that the green LED just comes on. Right.

Alignment after replacing Pioneer optical pickups

Unlike Sony pickups, which are aligned at the factory and then sealed with something like hot-melt glue to prevent tampering, Pioneer pickups require alignment, possibly even before a disc will be recognized. I wonder whether this is just due to cost cutting (but how could they even test the pickup?) or they just feel that it needs to be matched to the CD player....

Both optical alignment of the pickup itself and then possibly servo adjustments will be needed. I have done these adjustments without the service manual using just an oscilloscope and a music CD (no test disc) on an existing pickup (not a replacement) by basically maximizing the amplitude of the 'eye pattern' but the proper equipment and documentation would help!

(From: Mark Z. (mzacharias@aol.com).) d

Pioneer pickups are shipped unadjusted. Some of the newer models happen to work without additional adjustment but not all of them. Unfortunately some of the service manuals OMIT the final adjustment on the grating. One should adjust for a smooth null THEN for maximum output with a slight adjustment either clockwise or counterclockwise depending on whether the pickup is upside down or not. I can never remember which. I have seen at least a couple Pioneer manuals where the adjustment instructions END with the reference to the "smooth null". Frustrated technicians result because they think they've done what the instructions say, which they have - they just didn't get a full set of instructions. This is a common discussion point at Pioneer training schools.

Radial and tangential adjustments must be done first. These are the metal screws visible through the pickup PC board. Have a scope on the RF test point and adjust each for maximum while playing a disc. Some discs may work better than others during initial adjustments. If you're lucky you may not have to adjust the grating after the other are done.

The older Pioneers' pickups were shipped with the tangential adjustment ALL THE WAY to one side. This applies ONLY to the older ones with the mainly metal chassis. It was a white nylon screw which jammed the underside of the spindle motor mounting plate, and actually prevented the pickup from moving on its' track until loosened.

On the newer models, there are radial and tangential adjustments which can be adjusted in test mode. Both older and newer ones have grating adjustments, but the newer ones don't generally need adjusting. Don't get into grating adjustment unless you really have to.

Pioneer pickup replacement saga

(From: Stefan Toftevall (stefantoftevall@swipnet.se).)

As a guy around here had problems with his Pioneer PDS-501 CD player, he asked me if I could help him to fix it. Ok, I thought, just a cd-player, probably a bad spindle-motor or a dirty lens. Well, I sure got a surprise after taking away the cover. I heard something's gone loose somewhere into it and soon I noticed the lens on the pickup had popped out. I spoke to the owner and he told me to change the entire pickup, as he didn't wanted to throw it away yet. Said and done. The new pickup were easily changed, about 10 minutes or so. Time for the first test. I suspected nice music streaming out of the player, but unfortunately all I could hear was: Sccchhh, stk, stk, stk... And off it went. What the heck! It didn't even recognize my test CD! The display showed all zeros. I started to check for bad connections. Didn't find any. Didn't find anything unusual. Hmm....

After several days of investigation and a new spindle-motor, no improvement. I felt real stuck. Until I got a tip (from here) that they solder a jumper on the flex cable to prevent damage to the laser diode until the pickup is installed. OK, I threw myself over the player and unsoldered the jumper. Hopefully testing again: Sccchhh, stk, stk, stk... Off! God, what's wrong?

After several hours of thinking I noticed that the pickup were not in horizontal position. I adjusted it for a proper position. Testing again... Scchhh, stk, stk, stk..

After this I realized that new Pioneer pickups come totally unadjusted from the factory. After adjusting the grating, I made the player able to recognize CD's again and even play them! So, be awake when changing a Pioneer pickup, cause they'll not make it easy for you!

Sony KSS240 optical pickup adjustments

The functions of the pots on the pickup itself (from left to right): Focus, Tracking, Laser Power. (This determined from one sample. I don't know if all revisions are the same!) See other sections of this document for adjustment procedures. DO NOT touch laser power except as a last resort.

Yamaha CD3 adjustment procedure (from Davidson)

1. Laser Power:
   - Remove the flapper.
   - Player should be in focus search mode.
   - Short terminals FD1 and R together.
   - Laser power should be .24-.30 mW.

     (Apply -9V +/- .5 V if the pickup is off the circuit board.)
2. HF Level:
   - Monitor HS with scope. Peak to peak level should be between 1.5 and 2.5 V.
3. Focus Offset:
   - Set the TEST disc to PLAY. Make the adjustment at the center of disc rotation (35 DHS).
   - Connect the oscilloscope to HS. Adjust VR101 for the best eye pattern.
4. Tracking Gain:
   - PLAY mode.
   - ACVM to terminal Q and VE.
   - Apply 800 Hz, 100 mV rms to TD1 and GND with a 220K resistor in series from the audio oscillator.
   - Adjust VR104 so that ETE = (EQ + 5 dB) +/- 1 dB.

Audio whine (not from speakers) and/or muddy sound with Sony CD players

Generally, the only symptom is a CD players that sounds unhappy - there are no audio or tracking problems. However, in severe cases, there may also be audio degradation described as "muddy sound".

(No doubt, a non-Sony approved weight would work equally well for the solution below.)

(From: Lance Edmonds (lanceedmonds@xtra.co.nz).)

The whine problem usually occurs with KSS240A and KSS213A optical pickups, and is caused by a mechanical resonance. There are at least 2 service bulletins describing the fault and the cure.

Sony sells a special weight to fit to the pickup, and also a felt pad to add to the bottom of the top clamp assembly. Both these items cure this problem. Some machines may only require the weight.

In rare circumstances the resonance can interfere with the tracking/focus servos enough to cause skipping. Usually the problem is not easily repeated, however certain light weight disc's may trigger the problem repeatably.

Note that the resonance usually only occurs on the first few tracks if at all, and some disc's will play with the problem never showing up. Seems to be a disc weight/thickness/density problem.

Contact your official Sony service office for the part numbers etc.

Notes on Sony CDU31/33A CDROM drives

(Refer to the photo of the Sony CDU-31/33A CDROM Optical Deck for parts identification.)

Both these drives use similar optomechanical technology. The CDU31A is 1X (though I have heard that some versions of this may be 2X, unconfirmed) and CDU33A is 2X.

Many have complained about the lack of a motorized tray. What this does provide is a very simple robust mechanical design. A solenoid latch keeps the drawer shut. When the solenoid is activated (or the emergency release is pressed) the drawer pops out about an inch. Pulling the rest of the way is manual. The movement of the drawer clamps/unclamps the disc to the spindle with a powerful magnet. Except from gross abuse, there is little to go wrong mechanically.

There are only two major components: the Printed Wiring Board where all the active electronics are located and the Optical Deck including laser, optics, and pickup worm drive mechanism.

The other parts include the upper plastic casting and metal shroud, solenoid latch assembly, right and left guide rails, drawer assembly, and front bezel, two springs, bottom plate, 6 screws.

There are only two electrical connectors inside: one flat printed cable linking the PWB and optical deck and a two pin connector supplying power to the eject solenoid. This is in pleasant contrast to some other CDROM drives I have seen with a half dozen or more small connectors spread all over the PWB making removal and testing very difficult and risky.

Disassembling the Sony CDU31/33A CDROM drive

The only major cautions are to not lose any of the small screws or springs and to avoid damaging the multi-conductor flexible cable linking the electronics to the optical assembly.

The following procedure takes about 5-10 minutes:

0. Place the unit upside-down on a soft surface.

1. Remove 4 philips head screws securing bottom cover. Set bottom cover aside.

   You will now have access to the electronic adjustments for focus, tracking, etc. If this is what you are after, no further disassembly is needed.

2. Unclip the front bezel. Slide it out with the tray as far as it will go. You may need to manually activate the eject mechanism with a paperclip.

3. Remove 2 philips screws securing Printed Wiring Board (PWB). Gently lift PWB and disconnect connector to latch solenoid assembly in front of unit.

4. Gently lift PWB further and disconnect flexible cable connector on optical assembly. Mark the orientation so there

will be no doubt about getting it correct if you need to reassemble on the workbench for testing. There is a latch at each end which you push away from the connector 1 mm or so. The cable will than come out easily.

You now have partial access to the optical assembly sled drive. Cleaning and lubrication of these components is now possible.

5. Lift the latch solenoid assembly up, remove and set aside.

6. Using a pair of fine needlenose pliers or tweezers, disconnect and set aside the two tray retraction springs. Note their position and orientation.

7. Remove the two plastic guides - one on each side. There are little tabs that you will need to depress and then lift each guide straight up.

8. The entire deck can now be slid forward and lifted off. The opto/mechanical assembly can then be removed from the tray. Set the tray aside. The mechanism shown in the photo of the Sony CDU-31/33A CDROM Optical Deck is screwed into the rubber shock mounts.

9. If you prop up the PWB and reconnect the flexible cable - note the orientation marks you made previously - you can then run the drive with full visibility of the mechanism and optics. With a CD in place, there is no danger to you from the laser beam. Just make sure the PWB cannot short to anything and that the whole affair cannot tip over.

Reassemble in reverse order. Be especially careful reinstalling the flex cable. Make sure no wires are being pinched and that nothing is obstructing free movement of the optical pickup. This is actually pretty easy for this drive.

Sony Playstation (and other game machine) problems

The following information applies directly to the Sony Playstation but other CD/CDROM based systems use similar technology.

Note that the Playstation (and other newer game machines) are programmed to only work with discs released for the same country or general geographic location in which it was purchased. Thus, if you got a good deal on a used system, you may now know why: it might only work with Japanese software! :-(.

I believe Sony has a flat rate ($100 or so) repair fee for these - probably toss the guts and replace them - but this is barely justifiable for a $200 system. Many complaints are similar to the following with symptoms of marginal play of audio or game discs, skipping, erratic operation, etc.

Other service centers have both cheaper and DIY kits for Playstation repair. For example, Video Specialties advertises a $45 flat rate and also sell a repair kit they say will handle loading, skipping, and other optical pickup problems. I have no idea of its price or whether these claims are accurate.

There is an excellent comprehensive PSX repair site at:

- Modstation PSX Repair/Adjustment Instructions

The repair page includes many diagrams and photographs to guide you through the diagnostic, adjustment, and replacement procedures. There are links to much other useful information.

The following appears to be a sort of a mirror site for the above:

- Game Junkez

Some PSX info including specifications, circuit description, photos, and block diagrams at:

- SONY Playstation's Inside Unveiled

Playstation appears dead

(From: Jerry Jessop (jjessop1@home.com).)

Quick test for symptoms of no power:

With the Playstation top cover off and no CD installed press down on the door switch. What should happen is the CD will not spin, but the laser pickup should move up and down attempting to focus on a CD.

WARNING: Laser is exposed - don't stare into it! See the section: SAFETY. --- Sam.

If the above does not happen the following problems may exist, in order of probability:

1. Door switch broken
2. No 8 VDC to CD, usually a blown ICP "fuse" on the motherboard, or bad power supply.
3. CD controller toasted (bad)

PSX controller unreponssive

(From: Jerry Jessop (jjessop1@home.com).)

For no response from controller problems:

The controller port ICP (integrated circuit protector) is blown and you are not getting 3.3 VDC to the controller ports. Check for continuity on each ICP, they are near the front of the PCB just below the CD ROM ribbon cable. They will have a 15, 20, 50 etc labeled on each. The one labeled as 15 is blown :). It is an 800 ma fuse.

BEWARE of non-Sony approved peripherals as they blow these fuses, especially non-Sony mem cards inserted with the power on.

General problems reading PSX discs

> "I have a Sony Playstation, it starts up OK as in power-up etc. But, insert a disk and it does not seem to want to read the TOC. The disc spins up to speed and the laser goes through the motions of focusing, but then zilch, nada, no-zinks! Funny thing is it seems to play audio disks correctly, but not Playstation game disks"

Of course, first clean the problem discs and lens. See the relevant portions of this document for instructions and other general troubleshooting tips. All the usual problems of normal CD players and CDROM drives apply.

Note that in general, it may be possible to play music discs with few or no problems and still not be able to reliably play games (or as applied to CDROM drives, reliably access data). Readout of programs and data must be totally error free while errors can be tolerated for audio tracks with little or no detectable degradation in sound quality. Another reason is that audio is always read at the 1X rate; the system may be more tolerant of a marginal disc or servo alignment at the 1X compared to 2X or higher rate.

Some of these problems may actually be a result of poor design due to extreme and unacceptable cost cutting on Sony's part. After all, the Playstation reader is essentially the same as a 2X CDROM drive - which should be mature technology by now!

(From: Rusty Burke (rustyb@maritronix.com).)

A common problem on Playstations is the lens 'sled positioning' assembly. The lubricant that they used on this gets 'a little' solid.

Solution: remove old lube (all the way back to the motor worm gear) and use a long-lasting lubricant. I use a mixture of tri-flow and graphite grease. This seems to cure the problem.

Apparently what happens is that the CPU requests a read of a certain sector of the CD, and the sled can't get the lens to the proper location quickly enough.

(From: (mj1129@aol.com).)

A lot of Sony Playstation had this problem. Sony knows this problem, and they suggest to adjust the optic laser power to 1 V p-p (at the RF test point) or change the optic.

CAUTION: adjusting laser power is always a risky operation. Replacing the optical pickup may not be a realistic option as Sony probably charges more for the replacement part than for an entire Playstation! --- sam.

(From: Malik Dad (psxpic@goliath.mersinet.co.uk).)

Check the focus bias adjustment. These machines are really very finicky when it comes to laser alignment.

There are many machines out there with similar problems to yours. This is usually caused by a laser servo that has been badly set up. The symptoms are jumping and/or skipping on the FMV (full motion video) intro sequences and jumping and/or skipping on the music. In the worst case, certain gold (CD-R) discs will not boot. The pits on CD-R are never as well defined as a pressed disk resulting in around a 1/4 to 1/2 volt reduction in the RF eye pattern.

The problem can generally be cured by carefully adjusting the bias control on the main board near the laser ribbon connector. turn this a little bit clockwise or counter-clockwise until you have decent results. when you are happy leave it alone. It can be tempting to keep adjusting for different disks trying to get it spot on. There are not many machines that will play every single gold disk perfectly. Most will skip and jump occasionally no matter how carefully they are tweeked. DO NOT touch any other adjustments!

See: http://www.gpl.net/paulmax/psx for more info on Playstation modifications.

Not sure of which of the following it more appropriate. Just make sure you mark the original positions of the pots --- sam.

(From: Mike Walker (vdospec@werewolf.net).)

Caution: for the following, I would avoid touching the pot on the pickup itself unless you have exhausted all other possibilities - this is laser power and can easily result in a ruined laser --- sam.

Sony will not give out any procedure, we have done it before many times...

As far as the beam, the adjustment is on the CD sled itself right by the eye.

The gain is located on the main board listed as gain, don't mess with the bias adjustment, try moving the gain about 1/8 inch or less clockwise, then check the play of your CD's, most of the time this takes care of the problem, if not try moving the beam focus about the same and same direction. Not to much on either it's been known you can burn out the laser.

We like to mark our original postion with a red marker pen, you can lose where you were and really goof it up.

Use ESD precautions, the laser is sentitive to static also.

Also, try and replace the grease on the gear drive also, we have found that this helps a great deal also. Remove old, use new lubriplate or similar.

(From: Jerry Jessop (jjessop1@home.com).)

You have it backwards, adjust the Bias and leave the gain alone. If you set the bias level on wiper of the Pot to around 1.60 vdc with a CD loading that is "generally" a good figure. Now adjust the gain during an FMV sequence until it stops reading at one extreme. Then the other, and set it in the middle. Regrease the rails using "LaBelle 106" a white grease with teflon designed for plastic components found in hobby stores.

Of course more than likely the optical sled has groves worn in it and now the laser azimuth is out of alignment. The only solution is to replace the entire pickup assembly. MCM claims to be getting a new shipment of Playstation optical pickups soon - their price is $39.95 (as of November, 1997).

(From: Cyberchaos (cyberchaos@aol.com).)

All earlier productions of the playstation utilized a plastic sled rail construction which collapses and causes this problem. These must be replaced with the upgraded steel versions. Cleaning is a very short term cure.

Bouncing picture on some (Zenith) TVs when using Playstation

The problem of a shaking picture on some TVs (notably, Zenith models) is due to a problem in the PlayStation sync generation, not really a TV failure.

(From: Jerry Jessop (jjessop1@home.com).)

PlayStations will sometimes slowly "bounce" on older Zenith chassis sets, this is due to the way the vertical sync is outputted on the PlayStation.

Call the PlayStation 'hotline' and explain the problem, it is well known and the system will be modified at no charge to you and you will get a free game for your trouble!

A small daughter board will be installed that will correct the problem.

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Testing of Optical Pickup Assemblies

Introduction

Identifying front-end problems in CD players, CDROM drives, laserdisc players, and other optical drives is often thought to be a mysterious and difficult task. This section describes basic techniques confirming functionality of the laser diode, focus voice coil actuator, tracking voice coil actuator, and photodiode array. No exotic test equipment is required.

It is strongly recommended that you read and become familiar with the other information in this document. For general optical pickup information, see the section: CD optical pickup operating principles. For a description of some common types, see the section: Sony KSS series optical pickups.

Don't immediately conclude that your problem is in the optical pickup. It is likely elsewhere and you will not need to undertake the testing described below.

If the unit is able to read the disc directory, if even erratically, then these tests are unnecessary (unless you suspect an intermittent in one of these subsystems) as all of major parts of the laser pickup assembly must be properly functioning in order to do this. However, this does not guarantee that there are not some marginal components such as a weak laser diode or shorted turns in the focus or tracking coil - more on these problems later.

Don't ignore the trivial: have you cleaned the lens? Sometimes a dirty lens will result in symptoms that may be mistaken for much more serious problems.

For intermittents, first carefully inspect the pickup assembly for bad solder connections and hairline cracks in the flexible printed cables. Interlock switches may be dirty or worn. Mechanical problems may result in intermittent behavior as well.

When and why to test the pickup

If you have examined the 'RF Test Point' with a scope and found a proper 'eye pattern', then as noted, these tests are not needed as this indicates proper functioning of all the major components of the optical pickup. If, however, any of the following are observed, then testing of the laser diode, focus and tracking actuators, and/or photodiode array is suggested:

- The startup sequence does not complete due to obvious failure of the pickup to perform some action. For example, there is no attempt to focus.
- Focus appears to be established but the directory is never displayed even though the disc spins at the correct speed - or overspeeds or does not spin in correct direction (clockwise as viewed from the label side is correct for CDs).
- The 'eye pattern' is weak, distorted, or missing at the RF test point.

Try to eliminate alternative causes before undertaking these tests as there is a slight chance of damage due to accidents or electrostatic discharge.

Will it be worth the time and effort? Only you can decide how much your time is worth. There is a good chance that these tests will only confirm that the pickup is dead - not many of the faults you will be able to locate have easy fixes. You will learn something if that matters. However, with the cost of new single disc CD players less than $70 and changers less than $100, any rational analysis of the expected value for this undertaking may recommend the dumpster. But, we all know that hobbiest's time is not worth much - as in free.

The descriptions below assume that the pickup is still installed in the player but selected portions are disconnected when required. This enables us to conveniently use the circuitry of the player to control certain functions for the 'live' laser diode and photodiode tests.

It is also possible to test the pickup stand-alone but this will require an alternative power supply to drive the laser diode. Since the microcontroller will not be imposing its own will on those parts of the pickup still connected to the player, this may be preferable. However, if you are uncomfortable in providing a substitute power supply for the laser diode, then leave that function to the player.

Caution: whenever applying external power to any component, totally disconnect it (by unpluging or unsoldering - label each wire if there is any ambiguity) to prevent damage to the circuitry on the logic board.

Required tools, documentation, and test equipment

Only a minimum of tools and test equipment are required for these testing techniques to be effective. An oscilloscope is desirable but a VOM or DMM can substitute in a pinch since no high frequency measurements are needed. However, we will assume a scope is available. This section does not address mechanical problems in the sled drive, or the drawer or spindle motors. These problems are adequately handled in the elsewhere in this document. It is assumed that these components have been verified to be functional as there correct operation may be required for some of the tests described below.

A schematic will help greatly if available. Depending on the design of the unit, you may be able to infer enough about the front-end electronics to get away without one. The design of the components of the optical pickup are sufficiently similar among manufacturers to make the tests relatively model independent. What may differ are polarities of photodiodes, laser diodes, connector pinouts, etc. These can usually be determined fairly easily.

Despite the incredible precision of the focus and tracking servos, we can perform meaningful tests without sophisticated or specialized test equipment.

Also see the sections: "Troubleshooting tips" and "Test equipment".

The following tools and test equipment will be required:

1. Basic hand tools including precision jeweler's screwdrivers.

2. A VOM or DMM.

3. An oscilloscope (for photodiode/RF tests). For most of the tests, almost any scope will do as long as it has a DC coupled vertical amp. As noted above, a scope is not essential but is highly desirable.

4. A 0 to 5 volt variable DC power supply (400 mA). The power supply can be a 4-5 V 'wall wart' with a Variac. Alternatively (but not as desirable), you can use a fixed 5 V supply with a series adjustable resistor (100 ohms for focus and tracking actuator testing, 250 ohms for laser diode testing). A highly regulated supply is not needed.

5. Resistors: 22 ohm 1W, 5 ohm 1W, 50 ohm, 1 M ohm.

6. Assorted test clip leads, a few feet of #24 solid hookup wire (RS232 quad or multiconductor phone cable is good source).

7. IR detector circuit, IR detector card, or IR sensitive camcorder (for laser diode tests).

8. (Optional) Slow speed sweep or function generator (1-10 Hz) with low impedance output or amplifier, see text.

For the following discussions, a component CD player is assumed to be the unit under test. Make appropriate adjustments in interpretation if it is a portable CD player, CDROM drive, or optical drive.

Precautions

Reread the section: SAFETY for your own protection.

To minimize the chances of damage to the laser diode - which is extremely sensitive to static and excess current - leave its connector plugged into the main board as much as possible and do not attempt to test the laser diode with a VOM (which on the low ohms scale may exceed the current rating of the laser diode - poof, even if only for a microsecond.

As with all modern solid state equipment, preventing electrostatic discharges to sensitive components is critical. An antistatic wrist strap is desirable. In any case, work in an area where static is minimized - not on a carpet prone to static. Make it a habit to touch the metal chassis first to discharge yourself.

Basic description of optical pickup

Also see the more detailed description (including a diagram) of the typical optical pickup components and operation found in the section: CD optical pickup operating principles.

In order for information or music to be read off of a CD, several systems must work closely together:

1. Laser must be emitting a coherent beam of sufficient power and stability. Optical system must be clean and properly aligned. Laser power is maintained constant via an optical feedback loop controlling laser diode current. Therefore, a weak laser may not be salvageable as the feedback loop may have done all that is possible.

2. Photodiode sensors must be functioning correctly for data recovery and focus and tracking feedback. In a 'three-beam pickup', there are six segments: the central segments A-D are used for focus and data recovery; the outer segments E and F are used for tracking feedback. In a 'single-beam pickup' segments E and F are omitted.

3. Lens must be focused to within a fraction of a um of optimal to produce a diffraction limited spot. This is less than 2 um in diameter at the disc 'pits'. The lens is actually positioned several mm from the disc surface and is maintained at the correct distance through optical feedback controlling the lens position using the focus coil. Note: um = micrometer = 10E-6 meter; mm = millimeter = 10E-3 meter. 1 meter is 39.37 inches.

4. Lens must align to within a fraction of a um of the center of the track. Tracks on a CD are spaced 1.6 um apart. Tracking is maintained via optical feedback controlling the radial lens position using the tracking coil (or radial positioning unit on some rotary positioners).

Note that if the behavior while the CD player is attempting to read the directory changes whether a disc is in place or not, (and there is no separate disc sensor), then some or all of these components are functioning correctly. For example, many CD players will not attempt to rotate the spindle until proper focus has been established. Thus, if the CD rotates when in place but the bare spindle does not, it is likely - though not guaranteed - that focus is being established successfully.

Identifying connections to the optical pickup

In order to perform many of the tests described below, you will have to locate the drive and/or signal connections to the optical pickup. While there are many variations on the construction of optical pickups even from the same manufacturer, they all need to perform the same functions so the internal components are usually quite similar.

Here is the connection diagram for a typical Sony pickup:

```
              R1                  +---|<|----o A   |            +----o F+
           +-/\/\---o VR          |      PDA       |           (
      PD1  |   |                  +---|<|----o B   |           (    Focus
  +---|<|--+---+----o PD (sense)  |      PDB        > Focus/   (    coil
  |                               +---|<|----o C   |  data     (
  |   LD1                         |      PDC       |            +----o F-
  +---|<|--+--------o LD (drive)  +---|<|----o D  _|
  |       _|_                     |      PDD      _             +----o T+
  |       --- C1                  +---|<|----o E   |           (
  |        |                      |      PDE        > Tracking (  Tracking
  +--------+--------o G (common)  +---|<|----o F  _|           (    coil
                                  |      PDF                   (
   Laser diode assembly           |                             +----o T-
                                  +----------o K (Bias+)
   (includes LD/PD and                                        Focus/tracking
    flex cable with C, R).       Photodiode chip                actuators
```

The laser diode assembly and photodiode chip connections are typically all on a single flex cable with 10 to 12 conductors. The actuator connections may also be included or on a separate 4 conductor flex cable. The signals may be identified on the circuit board to which they attach with designations similar to those shown above. The signals A,C and B,D are usually shorted together near the connector as they are always used in pairs. The laser current test point, if present, will be near the connections for the laser diode assembly.

It is usually possible to identify most of these connections with a strong light and magnifying glass - an patience - by tracing back from the components on the optical block. The locations of the laser diode assembly and photodiode array chip are usually easily identified. Some regulation and/or protection components may also be present.

Note: There are often a pair of solder pads on two adjacent traces. These can be shorted with a glob of solder (use a grounded soldering iron!) which will protect the laser diode from ESD or other damage during handling and testing. This added precaution probably isn't needed but will not hurt. If these pads are shorted, then there is little risk of damaging the laser diode and a multimeter (but do not use a VOM on the X1 ohms range if it has one) can be safely used to identify component connections and polarity.

Testing the laser diode while in the player

Without a laser power meter, it will be difficult to fully verify laser functionality. However, determining that IR is emitted will provide a reasonable assurance of laser operation.

For this test you will need an IR detector. A simple circuit is described in the section: IR detector circuit. This unit is also useful for testing of remote controls and other IR emitters. You can also use an IR detector card - available at an electronics distributor. In a pinch, CCD based camcorders are often sensitive to IR. It will appear as a bright spot if the laser beam is projected onto a white paper screen. However, you will probably need 3 or 4 arms to position the screen, push the play button, and hold the camcorder while attempting to view the detected spot through the viewfinder!

You will need to gain access to the lens. This may require the removal of the clamper assembly.

Once this is accomplished prepare to position the photodiode of the IR tester within 1/8" of the lens. Plug the unit in and turn it on. On portables, you will need to defeat the door interlock - use a toothpick or bit of cardboard. Sometimes a CD player will have a disc detect sensor separate from the laser assembly - this will need to be defeated in order for this test to work without a CD in place. If it is a simple optical sensor, a piece of black tape or paper should suffice.

The first thing that should happen once a CD is in place and the play button is pressed is for the laser to be powered. You should be able to detect this in a darkened room because there is usually a very faint red appearing emission which you can see as a tiny red dot of light if you look at the lens from a safe distance of at least 6 inches at an oblique angle (WARNING: Do not look directly into the lens from directly above or from very close as the invisible IR is much stronger than the faint red emission and potentially hazardous). If you see the faint red light, you know that at least power is being applied to the laser diode.

With the laser lit, the lens should go through a few focus search cycles - between 2 and 8 typically. While it is doing this, position the IR detector above the lens. If the laser is working, you will get a positive indication of IR in about a 30 degree cone on either side of the lens. While you have no way of knowing if the power output is correct, this is a reasonable indication of laser operation. Due to the wide angle of the beam, the power decreases rapidly with distance so you will need to be very close to the lens for a positive result.

Note that if the lens moves smoothly in at least one direction (up or down), you have also confirmed that the focus actuator is functional.

If the IR detector does not pick up a beam and you do not see the red dot, then either the laser diode is really dead or there is no power being applied by the control circuits.

At this point, you have four options:

1. You can give up. However, you would not have gotten this far if you were likely to be defeated so easily.

2. You can attempt to obtain a schematic if you do not already have one so that you will be able to test the control circuits to determine if the laser diode is being powered.

3. You can attempt to trace the laser power circuits in the hope that you will find something absolutely obvious that is amiss - a bad connection or open resistor, for example, resulting in no power to the laser diode. See the section: Electrical testing to see if laser diode is being powered.

4. You can perform some simple but risky tests on the laser diode itself in an attempt to light it from an external power supply. As noted below, laser diodes are easily destroyed and you will have no warning. One nanosecond it will be a laser - the next it might be a DED - Dark Emitting Diode. See the section: Testing the laser diode with an external power supply.

Electrical testing to see if laser diode is being powered

Where there is absolutely no indication of an IR emission or that tiny red dot of light, but the lens is moving up and down attempting to focus, the next step is to determine if the laser diode is being powered - or is totally dead.

- If you have a service manual, follow the instructions in there for checking the laser diode - usually a place to check laser diode current by measuring a voltage drop across a sense resistor or other testpoint.

    - If the reading is very low or 0, there is likely a fault in the driver or optical feedback circuitry.

    - If the reading is very high, the laser diode is likely bad and the driver is unable to compensate for low or no emission.

- Without a service manual, look for a testpoint labeled 'laser power'. Even if you don't know what a correct reading should be, anything other than 0 would be a good indication that the driver is being enabled.

- Where you have no service info, it may be possible to *carefully* measure across the laser diode with a multimeter to determine if there is any voltage there when it is supposed to be active. A normal reading would be 2 to 3 V.

  - For Sony and other similar pickups, there is a chip capacitor across the laser diode. The trick is in being able to attach meter probes to these points without destroying everything!

  - The flex cable may also have a pair of solder pads. It should be possible to attach fine wires to these for your multimeter. But, you must use a fine point - preferably grounded and temperature controlled - soldering iron to prevent damage.

  WARNING: Improper testing of the laser diode can damage it but a DMM with ESD precautions can probably be used. Make all connections with power OFF as the momentary glitch from attaching the probes and/or an accidental short circuit can easily toast the laser diode and other parts.

Testing the laser diode with an external power supply

Consider the following only if there is no indication of laser output while connected to the player and you do not have schematics or a service manual to determine if the laser power circuits are functional.

Typical currents are in the 30-100 mA range at 1.7-2.5 V. However, the power curve is extremely non-linear. There is a lasing threshold below which there will be no output. For a diode rated at a threshold of 30 mA, the maximum operating current may be as low as 40 mA. A sensing photodiode is built into the same case as the laser diode to regulate beam power. It is critical to the life of the laser diode that under no circumstances is the safe current exceeded even for a microsecond!

Laser diodes are also extremely sensitive to electrostatic discharge, so use appropriate precautions. Also, do not try to test them with a VOM which could on the low ohms scale exceed their safe current rating. Even connecting the test leads can blow the laser diode from static on a bad day. In addition, always make or break power or test connections with the player turned off.

Locate the laser power connector by tracing back from the three pins on the laser diode assembly. Note: the following only applies if the laser diode is directly connected to the cable. If the power regulating circuit is on the pickup, you will need to trace its circuit or obtain the schematic as there are now too many variations to recommend a specific procedure.

Use the 0 to 5 VDC linear supply (a switching supply may put out laser diode destroying pulses) with a 50 ohm resistor in series with the diode. This is preferred over the variable resistor power supply as there is less likelihood of any potentially laser destroying overshoot or noise. If you do use the variable resistor, make sure it is at its maximum resistance when you start and that this is sufficient to keep the current under 20 mA. Keep in mind that a wall wart rated at 5 V may actually put out 8 V or more when unloaded - check the current into a short circuit before connecting the laser diode.

Slowly bring the current up until you get a beam. Use an IR detector for this! If you get the polarity backwards or are actually measuring across the internal photodiode, the voltage across the diode will go above 3 volts or will be less than 1 V. Then, turn power off and reverse the leads. Note: some laser diodes will be destroyed by reverse voltage greater than 3 V - a spec sheet will list the reverse voltage rating. The ones I have tried out of CD players were fine to at least 5 V in the reverse direction.

Without a laser power meter, however, you will have no way of knowing when the limit on safe beam power (safe for the laser diode, that is) is reached. For this test, increase the current only until you get an indication on the IR detector or you see the red dot. You are not trying to measure power, just to see if it works at all. A typical threshold is around 30 mA. Sometimes, the operating current is marked on the pickup. If this is the case, do not exceed this current.

If you detect a beam and there was none before, then your problem is most likely located in the player's control or power circuits, not in the pickup.

Laser power adjustment

If you have the service manual and it provides a procedure not requiring a laser power meter (which you probably do not have), then by all means follow that procedure.

As noted elsewhere, it is possible to destroy the laser diode by attempting to adjust its output power. However, if you suspect a weak laser as indicated by noisy playback or poor tracking performance (not a dead one as this will not help), and have exhausted all other possibilities such as the servo adjustments - and feel you have nothing to lose, you may attempt one of the procedures described below (with some risk) to determine if the laser diode is at fault.

Note that what adjusting laser power is probably doing isn't compensating for a decrease in laser diode intensity, but rather a buildup of dust and other junk on the optics (possibly internal and inaccessible) which reduces the beam intensity at the CD and the return beam intensity even more. There is a subtle difference as the optical output of the laser diode itself is feedback controlled and shouldn't drift much and the result of an adjustment will be an increase in laser output power beyond its normal range - which may indeed shorten its life substantially. If the laser output power HAS actually decreased, there is probably nothing that can be done as the feedback circuit is maxed out and the adjustment will have little effect. Thus, make sure the optics are as clean as possible before you touch laser power!

The following requires that you can play a disc - even if it has some problems with noise or tracking. This is best done with an oscilloscope. However, if you do not have one, you can still try the procedure. The risk is that without a visual indication of the signal amplitude, you will turn the control too far before you realize it and destroy the laser diode.

- If you have an oscilloscope, put a probe on the RF test point. While the disc is playing, you should see the eye pattern. Mark the exact amplitude of the peaks. Also, note the 'playback quality' so you will recognize if it changes. Note: while the correct voltage for the eye pattern is not the same in all players, typical values are in the 1 to 2 V range. If you see a few hundred mV or less, there is likely a problem. Caution: a weak eye pattern can also be due to improper focus bias adjustment (check it) or an electronic problem. The laser power may be normal.

  It may be safer to turn the laser power adjustment with player power off to avoid the possibility of electrical noise causing current spikes. Your choice. Mark the exact position of the laser power adjustment so you can get back to it if there is no effect or it makes things worse.

  Turn the control the slightest amount clockwise. Caution: this control may be very sensistive - 'slightest' really does mean just a very small amount. Turn power back on and/or note the eye pattern amplitude. If the laser diode is not at the limit of its power and thus bad, you should see the amplitude change from what it was. If it has decreased, try the other direction.

  Note the playback quality. Has it changed any? If not, then laser power is probably not your problem. If the amplitude of the eye pattern is unchanged, you either are turning the wrong control or the laser is at its power limit - and probably near the end of its life. Try the same test in the counterclockwise direction if the amplitude decreased - not every designer knows left from right.

  If there is improvement, you can risk leaving the control at the new (most likely) higher power setting realizing that you may be shortening the ultimate life of the laser diode. Do not push your luck by continuing to turn up the power unless you have exhausted all other alternatives.

- If you do not have an oscilloscope. you can still attempt the procedure above, using audio listening exclusively to determine if there is any change. It is just a little bit riskier. As noted, the laser power adjustment may be very sensitive you will have no direct way of knowing how much you have increased the setting.

Testing the focus and tracking actuators

If there is a question of whether the lens is focusing or tracking properly, perform the following. Again, if the unit is able to read the disc directory at all, then these tests are not needed. Note that if you have a CD player with a rotary positioner, there may be no separate tracking coil as coarse and fine tracking may be combined.

Typical linkages between the lens/coil assembly and the body of the pickup are (1) a sliding shaft (focus) and rotation on the shaft (tracking) or (2) a hinged-hinge. With (1), the slide can get gummed up preventing reliable focus and tracking. With (2), one or both hinges can break - they are often made of thin flexible plastic. Repair is not really possible.

First, identify the cable leading to the focus and tracking voice coil mechanism. This is usually a 4 conductor cable separate from the data and laser cable (at least at the pickup end). Disconnect it from the mainboard before testing. Using a DMM or VOM, you should be able to locate a pair of coils with very low resistance - a few ohms. One of these is focus coil and the other is the tracking coil.

Construct one of the following test circuits:

1. Your 4-5 V DC wall wart plugged into a Variac with its output connected to a 22 ohm 1W resistor in series with a pair of 2 foot #24 insulated wires.

2. Your 5 V DC power supply connected in series with the 100 ohm variable resistor and 22 ohm 1W resistor with a pair of 2 foot #24 insulated wires.

Gain access to the lens for visual inspection. This may mean ejecting a disc, opening the drawer, or in some cases, actually removing the clamper. In a portable or boombox, the lens will be readily accessible. Unplug the CD player from the wall or remove the batteries - you will not be using its internal power.

Locate one pair of the two pairs of low resistance connections you identified above. With your power supply off or the Variac turned all the way down, connect the #24 leads to one of these pairs. Now, turn on the power and slowly adjust the Variac or reostat while watching the lens. If you are connected to the focus coil, you may see the lens moving up and down. If you are connected to tracking coil, you may see it moving from side to side.

If there is no motion, turn off the power supply, reverse the polarity and try again. For a typical pickup, the 4-5 V power supply and minimum of 22 ohms should cause the lens to move through the entire range of motion up and down or side to side as appropriate. Once you have exercised the first coil, switch connections and repeat for the other. If the motion is jerky, the lens assembly may be dirty.

Clean it carefully first with a bit of compressed air (not high pressure, a photographic air bulb is fine) and then with Q-tips and isopropyl alcohol. Do not lubricate. Repeat the tests after the cleaning.

If both the tests are positive, you have confirmed operation of the focus and tracking actuators. If either you were unable to locate both pairs of coils or one or both actuators did not move, then you have located a problem. An open coil can be due to a cable problem or a break at the coil. If the break is right at the solder connections which are usually visible once the plastic protective shroud is popped off, then it may be possible to repair it. This will require a great deal of manual dexterity and patience - the wire is really really fine.

It is still possible for there to be shorted turns in the fine coils or an intermittent that was not detected.

- Shorted turns would reduce the frequency response of the servo, reduce the reliability of focus or tracking, and increase the needed servo driver power. A CD player that is overly sensitive to slight disc defects even after all the proper adjustments have been performed may conceivably be a result of this type of fault. An additional symptom may be an unusually hot servo driver IC. However, many of these ICs run hot normally so don't panic as the possibility of shorted turns is really quite remote.

- An intermittent may only show up during dynamic operation or with certain particularly finicky CDs or other peculiar circumstances. The intermittent could be at the solder connections or the fine printed ribbon cable that connects the moving lens assembly to the remainder of the pickup.

Testing the photodiode array

The photodiode array in a optical pickup consists of an IC with typically 4 or 6 detector segments. Four segments may be used for the less common 'single-beam pickup' while 6 segments are used in the 'three-beam pickup'.

These segments are usually designated A-F. A, B, C, and D are the main detector which is used for both focusing and data recovery. Segments E and F are used in a 'three-beam pickup' for fine tracking feedback.

We will assume a three-beam pickup for the remainder of this discussion.

All 6 photodiodes are connected to a common point which during operation has a DC bias voltage on it typically around 5 V. If they are connected common anode, it will be negative; if common cathode, it will be positive. The reason is that the photodiodes need to be reverse biased for normal operation. The outputs of the photodiodes feed several operational amplifiers which are set up to amplify the current from the photodiodes. The normal connections may be at virtual ground potential or they may feed into large value resistors.

The connector to the photodiode array is usually separate and will typically have at least 8 wires - photodiodes A-F, ground, and bias voltage.

You will need to identify the wiring. First locate the ground using the ohmmeter. Then locate the bias - it will probably go to a low value resistor and then to the supply. Another way to identify the bias wire is to turn on the player and measure each of the possibilities. The bias will be the highest or lowest and will be solid with no noise or ripple. It will probably be powered all the time.

Now for the photodiode segments. Very often the connections or some of the connections are marked on the circuit board. For example, there may be several labeled test points designated A+C, B+D, E, and F. Since the A and C segments and B and D segments are usually shorted together on the circuit board, this provided all the info needed to identify the photodiode connections. It is not important to distinguish between A and C or B and D for the following tests though you will want to be able to separate them.

With power off, there is essentially no light on the photodiode array. Unplug the photodiode connector from the main board.

Using your ohmmeter, test each diode for opens and shorts as you would test any signal diode. There should be a junction drop in the forward direction and very high resistance in the reverse direction. If you are using a DMM with a diode test mode, the junction drop will typically measure .7-.8 V. There may be a very slight difference between the readings for segments A to D and those for E and F.

An initial test of photodiode response can be made using an external light source - a flashlight or other incandescent bulb or IR remote control shining into the lens from directly above. With the multimeter connected to reverse bias each diode segment, shine the light into the lens. The resistance reading should drop somewhat - possibly dramatically. Segments A to D should show reasonably similar sensitivities but these may differ from segments E and F (which should be similar to each other).

Similarly, with with the photodiode connections restored to normal, you can use an oscilloscope to monitor the RF test point. A source of IR directed into the lens from above may result in a detectable change in the signal - but only when the photodiode array is properly biased. This may be all the time that the CD player is turned on or only when it is trying to focus or perform some other operation. With an IR remote, you should actually see the pulsed signal for each key-code. On a typical Sony CD player, I was able to get about a 0.1 V signal at the RF test point using a VCR remote control as an IR source.

However, even on a functional pickup, due to the nature of the optics, these responses may be very weak or undetectable. Thus, failure of either of the above tests is not strong evidence of a bad photodiode array.

Any unusual readings such as a significantly lower resistance for one of the diodes, a short or open of a particular diode, a short between diodes, or variations in sensitivities is an indication of a problem. While it is possible for there to be a cable or soldering defect, this is somewhat unlikely though bad solder connections or breaks in the flexible cables are not out of the question.

A defect found in the photodiode array will usually mean that the laser pickup is not salvageable with reasonable effort. Even if you could locate a replacement photodiode array, aligning and soldering the (most common) surface mount package would be quite a challenge without the factory jigs.

Assuming these tests do not turn up anything, the next step will verify that the photodiodes are picking up an optical signal and will evaluate the relative strengths of each segment using the laser diode, optical system, and disc combination. Note that for these tests to confirm proper operation, the optical alignment must also be correct.

For the tests using the internal laser diode, we will need to setup one of the following. Method (2) is more straightforward but requires the optional signal generator for best results. In each case the objective is to cause the lens-disc distance to sweep through perfect focus without requiring that the focus servo loop be closed. This will then result in a signal that will include the point of maximum signal amplitude on a periodic basis. Alternative methods may be used to accomplish the same purpose.

Both techniques require the adjustable power supply previously used to test the focus coil.

1. Adjustable focus with continuously rotating spindle. For the spindle motor, you will need a 1.5 V battery or your power supply with a suitable series resistor to cause the spindle to turn at approximately 1-2 Hz (rps). Warning: disconnect the motor from the mainboard! The unavoidable wobble of any disc is essential in this case and will sweep the focus distance by more than enough to cover the entire focus range of interest.

Note: this assumes that the spindle is driven by a conventional PM DC motor. If it is a brushless DC motor, then some of the control electronics may be external to the motor and you will not be able to just provide a DC voltage to get it to rotate. If this is the case, you must use method #2.

2. Stationary spindle but sweeping focus. This is the better method but requires a signal generator for easiest use. You can do this by hand using a Variac or reostat (this is easier if you have three functioning hands). A better method is to use a 1-10 Hz sinusoid or triangle wave from a low frequency signal generator with a low impedance output or feeding an emitter follower or audio amplifier to boost the current. This signal is then fed into the coil along with the focus offset derived from your power supply.

Note: it may be possible to dispense with these test setups and just use the normal focus search of the CD player to provide the sweep. However, since we will be interfering with the proper feedback by removing selected sensors, there is no telling what the microcontroller will do. Therefore, breaking the feedback loop as we are doing is preferred. If the CD player appears to make many attempts at focus, this may be worth a shot, however.

You will also need a disc - preferably one you do not care much about as sometimes it will get scratched due to opening the drawer accidentally or something equally idiotic while the disc is still rotating.

Locate a 1 M ohm resistor and securely fasten it to a ground near the photodiode connector. Put your scope probe on the other end with its ground clipped to the same ground point as the resistor. Bend the free lead of the resistor completely over so that it will be able to hold the end of a wire like a mini-clip lead.

Make sure you remember or mark down exactly how the connector is wired so that as you remove individual wires, you will be able to get them back in the proper spot. Presumably, you have already made a diagram of the photodiode connector wiring. Component players often have connectors with individually removable socket pins. A fine jeweler's screwdriver or paper clip may prove handy in removing these one at a time.

Turn on your power supply and adjust the focus to about midrange. Start the spindle rotating or turn on the signal generator to provide a small sweep - about 1/10 V p-p as measured on the coil should be fine.

Making the photodiode measurements

Remove the wire corresponding to the photodiode (say, A) to be tested from the connector but leave the connector itself plugged into the main board. Set the scope for 1 V/div. vertical on a slow free running sweep.

Clip the A wire into the resistor. Now, turn on power to the CD player. While the player thinks it is focusing, slowly adjust the focus voltage while observing the scope. As you approach proper focus, you will see the signal increase (depending on polarity) greatly, pass through a maximum, and then decrease. Depending on the design of the CD player, you may need to turn it off and on several times before you locate the signal as the microcontroller may give up pretty quickly with no focus or tracking coil servos (since you disconnected the actuators). If you have the service manual it may tell you how to force the laser to be powered all the time. Leave the focus set near the middle of the region of high signal.

If you are using the signal generator to perform the focus sweep, you may need to optimize the amplitude of the signal by adjusting the signal generator output and offset from your power supply.

You probably should not need to touch the settings for the remaining photodiode segment tests.

Repeat the above procedure for each of the photodiodes A-F. All should produce fairly similar signals, say within 20 % of one another in amplitude. If A,B,C,D or E,F differ from one another by more than say, 20 %, there may be a serious optical alignment problem in the pickup (the player may have been dropped or bounced around without securing the hold-down screws, if any). Alternatively, the photodiode array may be bad. It is also possible for there to be partially shorted photodiode segments in which case, the outputs will not be independent as they should be. Loading one segment's output with a resistor may affect the output of one or more other segments.

In any of these situations, such a discrepancy in A-D will prevent the establishment of proper stable lens position at the optimal focal distance. This will prevent the formation of a proper 'eye pattern' and subsequent data recovery. A significant difference between E and F (beyond the adjustment range of the tracking or E-F balance control) will prevent proper tracking. Note, however, that the signal amplitude from A-D and E,F may differ as A-D operate off of the main beam and E,F operate off of the first order diffracted beams which are weaker. As with the basic photodiode tests above, a failure here usually will require the replacement of the entire optical assembly.

As noted, if the pickup's optical alignment is way off, there could be significant differences in photodiode responses. On component type units, it is unlikely that the optical alignment would shift on its own. Portables that have been dropped or automotive units subject to constant bumps and vibration could have alignment problems, however. If this is your last hope, then some experimentation with adjustment of the optical alignment on a successive approximation basis might be worth the effort. Mark the original position of any adjustments and try small variations on either side to determine their effect. You might get lucky. If this eventually results in improved uniformity of photodiode response, alignment may be the problem. If you can more or less equalize the response, reconnect the servos and attempt to get an eye pattern. If you can, optimize the eye pattern stability and amplitude using the optical alignment adjustments and servo adjustments.

Sony KSS series optical pickups

Note: For general information on optical pickups see the section: CD optical pickup operating principles.

These are probably the most common optical pickups in the universe. Many variations - many dozens if not hundreds - on the basic design have been produced from before 1988 until the present. In general, they are compact, simple, robust (despite what you may have heard), and no doubt dirt cheap to manufacture. The ANEX Electronics Sony Pickups Page has photos of just a few of the common KSS models. (ANEX is a Polish company so I'm not advocating buying replacements from them, just thought the photos might be of interest!)

Depending on the type of player and mechanical constraints, the specific optical arrangement and construction will differ. Many brands of CD players and CDROM drives actually use Sony pickups. While these are all recognizable for their octagonal black lens cover and parallelogram type lens suspension for focus and tracking (neither of which has changed noticeably in 10 years), the construction of the fixed optics has gone through quite an evolutionary process:

- Early KSS pickups were quite complex with most of the components described in the section: CD optical pickup operating principles mounted as separate components. These had accessible optical alignment adjustments and were also quite large and bulky compared to today's pickups. An example of one of these is the Sony KSS110C Optical Pickup.

- Most of the KSS pickups found in consumer CD players and older CDROM drives combine some optical elements and eliminate others. For example, types like the very common KSS361A do not have a separate collimating lens or cylindrical lens. All parts are totally glued at the factory so no possible optical alignment adjustments are possible.

  A diagram showing the organization of the Sony KSS361A optical pickup is available in PDF format: CDKSSP.

- The newest KSS series pickups appear to have combined the laser diode and photodiode into a single package. They are offset by a very small distance so the outgoing and return beams pass through the same optics and thus there is no longer a beam splitter - more cost reductions! By eliminating the optical components for redirecting the two beams, performance should also be better since this operation was not 100 percent efficient and additional optical surfaces can only degrade the beam quality. The small reduction in the clarity of the detected analog signal resulting from the very slight non-perpendicular (with respect to the disc 'pits' surface) beams should be more than made up for by these simplifications.

  While I do not yet have a sample of a Sony pickup of this design, the CMKS-81X Optical Pickup and Optical Pickup from Philips PCA80SC CDROM combine the laser diode and photodiode array into single package and eliminate all of the other optical components except the diffraction grating and turning mirror. I expect that Sony versons are similar.

The description below is for pickups similar to the KSS361A and KSS210A. These are horizontally organized and less than 1/2 inch thick. The laser diode, grating, and beam splitter are mounted inside the casting of the optical block. The turning mirror is glued to its base plate, the photodiode array is glued to a port on its side and the objective lens and its focus and tracking actuators are mounted on a self contained removable unit.

Please refer to the closeup views of the Sony KSS361A Optical Pickup.

The following can be seen from the underside after removing a cover plate (1 screw). The descriptions are for the outgoing beam which originates at the laser diode, passes through the diffraction grating, then reflects from the dichroic beam splitter mirror on its way to the objective lens:

- Laser diode. This is clamped and glued in place in a nicely finished brass barrel which is itself clamped and glued in place in the optical block. An adjustment for optical power sensitivity, is mounted on the flex cable next to the laser diode. This may mean that identical model pickups should be interchangeable without laser power adjustments - hopefully. Many players don't have a laser power adjustment pot on the electronics board.

  The front face of the laser diode package is angled so that the exit window (anti-reflection coated) is also mounted at what may be the Brewster angle, probably to further prevent stray reflections from the window's surfaces from feeding back into the laser diode's cavity or interfering with the detected signal. (At the Brewster angle, light polarized parallel to the window is totally reflected and light polarized perpendicular to it is totally transmitted. The output of these edge emitting laser diodes is polarized.)

  The Closeup of Laser Diode from Sony KSS361A Optical Pickup shows the angled front face and optical window. The reason it appears so HUGE is that the photo was scanned at 600 dpi - this is not a monster laser diode! It can be seen more like 'actual size' in the upper left corner of the group photo, A Variety of Small Laser Diodes.

- Diffraction grating. Glued onto the end of the barrel in which the laser diode is mounted. The grating is at a 45 degree angle to produce the 3 spots for tracking in the appropriate orientation. (Once reflected through the lens the spots are in the direction tangential to the tracks).

- Collimating lens. On some versions, there is an actual collimating lens. However, the most common models do not appear to have one. There is nothing really wrong with such a design, it is just unexpected. Their optical efficiency will be lower since some of the beam will be lost to the side walls but other than that, a shorter focal length objective lens should be able to compensate fully for a non-parallel beam. The optical path is so compact in these pickups that the losses are likely to be small. It is also not clear why otherwise very similar model pickups in very similar model CD players differ in this respect.

  A test of the laser diode barrel assembly removed from a KSS361A pickup shows that its output is an ellipsoidal beam with a divergence of at least 10 degrees on the narrow axis (across the grating) and somewhat greater than this in the orthogonal direction. These angles are consistent with a raw laser diode. If there were a collimating lens, the beam should be much less divergent. (My curiosity finally got the better of me and I ripped the laser diode from the barrel to confirm that there was indeed no collimating lens hiding inside!)

- Polarizing dichroic beam splitter mirror. This thick mirror is mounted at a 45 degree angle and glued in place. The outgoing beam is reflected by the mirror toward the turning mirror and/or objective lens.

  The thick mirror also introduces astigmatism into the beam and this is how focusing servo feedback is accomplished. See the section: What happened to the cylindrical lens?.

The outgoing beam reflects off of the turning mirror and then passes through the objective lens:

- Turning mirror (models with horizontally oriented optics only). This is implemented as a coated glass front surface mirror glued to a 45 degree angled support which is in turn glued to the casting. The coating is mostly transparent to visible wavelengths of light - it is not aluminized.

- Lens assembly. This appears to be very similar for all models. Of course, there are probably variations in focal length and other optical properties which cannot be determined by inspection.

  - Objective lens uses a double convex plastic molded design glued into a plastic frame which mounts the focus and tracking coils and is attached to the lens' suspension. Both surfaces are coated and the top surface, at least, is aspheric. A raised guard ring protects the optical surface from damage should the lens come in contact with the spinning disc.

- Focus actuator is a pair of rectangular formed coils surrounding a pair of vertical magnet pole pieces.

- Focus suspension is a parallelogram molded plastic design. This assures that the lens remains parallel to the disc as it moves up and down. The four hinges appear to be just very thin portions of the molded 4 sided box structure. These hinges are susceptible to weakening or failure.

- Tracking actuator is a set of 4 circular coils glued to the outside surfaces of the focus coils and moving with respect to the same magnetic fields.

- Tracking suspension is a single vertical molded hinge of similar design to that of focus. A second vertical hinge is also present but is restricted from free movement by a resilient rubber material. This appears to protect against sideways shocks. These hinges are susceptible to failure.

- The magnets appear to be of a rare-earth type - very strong for their size.

- A short flex cable links the terminals of the coils to 4 solder pads where the flex cable would normally connect from the electronics board.

- Optical alignment is achieved with a 3-point mounting arrangement for the lens assembly. One of 3 screws with a spring clamps the frame. The two other screws are used for adjustment. The entire affair is aligned and then glued in place at the factory so adjustment in the field is virtually impossible - and unneeded in any case.

- The lens assembly can be removed by unsoldering the 4 solder pad flex cable and unscrewing two very small Torx type screws from the top (these will succumb to a roughly .7 mm hex wrench. It then lifts off. Optical alignment should not disturbed.

  Note: Just loosening the Torx screws permits lens assembly to be shifted slightly though some small amount of adhesive may need to be removed to free it. This should have an effect on optical alignment. I will do some experiments at some point to determine its precise effect.

After passing back through the objective lens and reflecting off of the turning mirror, the return beam passes through the dichroic beam splitter mirror and hits the photodiode array.

- Photodetector array. Glued to a plate with the 8 pins (7 connected) poking out the back and soldered to the flex cable. Approximate dimensions of actual sensor area shown.

```
              |<---------- .6 mm ------------>|

         ---- +-------------------------------+
          ^   |       |        |        |     |
          |   |       |        |        |     |
          |   |       |   A    |   B    |     |
          |   |       |        |        |     |
          |   |       |        |        |     |
       .3 mm  |   E   |--------+--------|  F  |
          |   |       |        |        |     |
          |   |       |        |        |     |
          |   |       |   C    |   D    |     |
          |   |       |        |        |     |
          v   |       |        |        |     |
         ---- +-------------------------------+
```

These are the 6 segment silicon photodiodes (for a three-beam pickup. (For a single-beam pickup, there will be 4 but as far as I know, all Sony pickups are all 3 beam types). Note that the entire active area is a fraction of a mm in each dimension. This emphasizes the likely critical nature of optical alignment. Nonetheless, with everything screwed and/or glued in place, the likelihood of this ever changing is small.

- Flexible cables. In most cases, there are two - a 12 or so conductor cable for the laser power and photodiode return signals and a 4 conductor cable for the focus and tracking actuator drive. However, there are many many variations on the specific layout. These are either soldered to the electronics board or more commonly, terminate in clamp-type connectors.

What happened to the cylindrical lens?

It would appear that the mystery is solved:

(From: Vlad Chekavinskii (vchek@usa.net).)

Dear Sam! I've just read your greatly updated article on CD repairment and found out that your investigation on SONY KSS pickups is pretty similar with mine (I've spent a half year aligning KSS210A and was successful with it at last), but your uncertainty about where the astigmatic element should be very disappointed me... because I've screwed my head chewing out the same thing! Nonetheless I've come to conclusion that the THICK mirror is thick very intentionally - the astigmatism of flat parallel surface plate turned on a 45 degree angle is a very sizable thing and corresponds with dimensions of ABCD photodiodes.

(From: Sam).

Fabulous! That has to be it. I even just did an experiment with a 1.5 inch think piece of Plexiglas and a lens - the astigmatism was clearly visible and it isn't a subtle effect. The astigmatism of the laser diode may contribute but probably is small compared to the result of passing through the thick beam splitter. I should have wondered why Sony would use extra material if there weren't a good reason! :-)

A possible explanation of my version is the position of ABCD diodes on its chip: they are always tailored to the mirror in different systems with different mirror position: compare SONY and SANYO, so that the A-C (or B-D) line is parallel to corresponding sides of the mirror, at the same time the axes of astigmatic spot of the inclined mirror are also parallel to the mentioned sides. Interesting, that the position of EF can be either on the A-C line or between A-C,B-D lines, that means that diffraction grating molded with laser unit can be so or other way turned in the whole system but I suspect that it is always tailored to wedge beam of laser, so the proposed astigmatism of laser is hardly used.

Interchangeability of Sony KSS pickups

If you have looked inside a variety of CD players, you probably have noticed (1) that many use Sony pickups (the characteristic octagonal black lens cover) and (2) that many of *these* appear similar even if their model numbers differ. A closer examination will reveal that many many different types use what would appear to be the identical optical block - the casting that mounts the lens and its actuators, the laser diode, and photodiode array. If you delve even deeper, you would find that the optical paths are identical as well. The only obvious difference in many cases are in the mounting and the way the sled is driven, and in the configuration of the flex cable and its connections. So, are the optical blocks themselves indeed interchangeable?

The answer is a definite 'maybe' and servo adjustments may be needed in some cases (where none would possibly be necessary with an exact replacement). However, there could be cases where where differences are too great.

I am not sure I believe the differences listed below since much of the pickup behavior in terms of bump immunity and drop-out performance is based in the servo loop electronics, not the pickup. So, while I do not know for sure, my guess is that the A and B versions would be totally interchangeable if the CD player electronics have enough adjustment range.

(From: Lance Edmonds (lanceedmonds@xtra.co.nz).)

Sony KSS150A is compatible with KSS210A and KSS212A. However, due to signal levels KSS210A and KSS210B have differing specs. The rule here is that a KSS210B can be used in place of a KSS210A, but for optimal performance, an A should not be used in place of a B.

- B versions designed for "ghetto-blasters" (lower drop-out performance and higher vibration resistance).

- A versions for desk-top models (higher drop-out performance, lower vibration resistance).

Source of info: Sony Japan Designer who visited me a few years ago. Yes they actually send their technical staff around the world to get an idea of what happens to the products after sale! Not often, but it does happen. Over the years I've met designers, technical managers, technicians, and a load of marketing folks from Japan and Singapore.

Super simple optical pickups

Some of the modern generation designs are about as simple as possible and still perform the needed functions of a single-beam or three-beam optical pickup. While the objective lens assembly with its focus and tracking actuators is of standard construction, there are few additional components.

The CMKS-81X Optical Pickup and Optical Pickup from Philips PCA80SC CDROM are typical of such designs. Sony also manufactures such a pickup, apparently used in some revisions of its PlayStation PSX and elsewhere.

The smallest ones such as the Optical Pickup from the Philips CR-206 CDROM are only about 1/2" x 5/8" x 3/4" overall - just about the size of the lens cover!

A diagram showing the organization of these simplified three-beam optical pickups is available in PDF format: CDS3BP.

This diagram shows the three-beam type. The only difference for a single-beam pickup would be to eliminate the difraction grating (and its side beams) and segments E and F from the photodiode array (or simply not use them).

- The laser diode and photodiode array (LD/PDA) are combined into a single package about the size of a larger LD by itself but with 10 pins - 3 for the LD and its monitor photodiode and 7 for the PDA (a single-beam pickup such as used in Philips/Magnavox products would only need an LD/PDA with 8 pins).

- A glass block or plate roughly 3 mm on a side is glued to the front of this LD/PDA package. In the center is a spot about 1 mm in diameter etched on the surface which is the diffraction grating. This is directly over the emitting facet of the LD. The laser beam passes through this diffraction grating on its way out but the return beam is offset to hit the PDA and misses the spot entirely. (A single-beam pickup would not even require this diffraction grating!) DVD Laser Holographic Optical Element shows a similar HOE glued to the front of a DVD laser diode assembly.

- The LD/PDA is pointed at the objective lens (either directly or via a simple turning mirror depending on design).

  The pickups in the photos use a turning mirror but this is not needed if there is adequate space below deck since the turning mirror's only function is to redirect the beam to minimize physical height.

By placing the LD and PDA very close together, the outgoing and return beams can follow almost the same path forward and in reverse through the optics. This eliminates all parts associated with separating these beams including the polarizer, polarizing beam splitter, and quarter wave plate. There may be a very slight reduction in signal quality since the optical 'stylus' does not strike the disc at a precisely perpendicular angle but this is probably very minimal and more than overcome by the reduction in losses due to the multiple surfaces and less than perfect performance of the redirection optics. Thus, performance is probably better overall, robustness and reliability are improved, and manufacturing cost is greatly reduced. Everyone wins!

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Itmes of Interest

CD technology basic specifications

```
    Parameter                  Compact Disc/CD-R
 ---------------------------------------------------------------------------

   Full Disk diameter:      120 mm (4.75").
   Disk thickness:          1.2 mm.
   Disk material:           Polycarbonate.
   Track width:             .6 micron (um) approx.
   Track pitch:             1.6 microns (nominal).
   Playing time (audio):    74 minutes, 15 seconds (>78 minutes by cheating)
   Data capacity (CDROM):   >650 MB
   Sampling frequency:      44.1 kHz per channel.
   Number of channels:      2.
   Sample size:             16 bit linear, two's complement code.
   Bit rate:                4.3218 M bits/second average (1X).
   Data rate (CDROM):       150-2400 KBytes/second (1X-16X).
   Spindle speed:           200 to 500 rpm (1X, constant linear velocity).
   Linear speed:            1.2 to 1.4 meter/second (1X).
   Modulation:              Eight-to-fourteen modulation, RLL(3,11).
   Error Correction:        Cross Interleave Reed-Solomon Code - CIRC.
   Laser type:              Semiconductor Diode GaAlAs.
   Laser wavelength:        780 nm (most common).
   Laser power:             .1-1 mW. typical (at lens).
   Frequency response:      5 to 20,000 Hz +/- 3 dB.
   Harmonic distortion:     .008 % at 1 kHz.
   Dynamic range:           Greater than 90 dB.
   Signal to noise ratio:   Greater than 85 dB.
   Wow and flutter:         Below measurable limit (as good as crystal).
```

Comparison of CD, DVD, BD Specifications

CD = Compact Disc/k, DVD = Digital Versatile Disc/k, BD = Blu-Ray Disc/k.

```
    Parameter                         CD          DVD          BD
 ------------------------------------------------------------------------
   Disk diameter                    120 mm      120 mm       120 mm
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Disk thickness	1.2 mm	1.2 mm	1.2 mm
Disk structure	Single substrate	Two bonded 0.6 mm substrates	??? 0.1 mm substrate
Laser wavelength	780 nm	650 nm	405 nm
Numerical aperture	0.45	0.60	0.85
Track pitch	1.6 um	0.74 um	0.32
Minimum pit/land lgth	0.83 um	0.4 um	0.138 um
1X speed (CLV)	1.2 m/sec	4.0 m/sec	
1X data rate (mode 1)	1.2 Mb/sec	11 Mb/sec	36 Mb/sec
(mode 2)			
Number of data layers	One		One or two
Number of sides	One		One or two
Data capacity	~680 MB	4.7 GB (1L) 8.5 GB (2L) 17 GB (2L/2S)	27 GB

The reduced track pitch and pit length made possible by the shorter wavelength and advances in optical readout technology accounts for the almost 8-fold increase in data storage capacity on a single layer.

For more information on DVD and BD technology, check out the following sites:

- DVD FAQ.
- Digital Video Disc (DVD) Technology
- Philips Optica l Storage
- DVD Central @ etown.com: The Home Electronics Guide Matsushita Blu-Ray Disc Announcement
- Blu-Ray Disc

A down-to-earth comparison of digital and analog recording

Digital solutions to anything are not inherently superior to old style analog approaches. Digital storage and playback can result in truly terrible sound if the underlying technology specifications and implementation are inadequate. However, for storage, there is a fundamental difference which can be expressed in simple terms:

(From: Michael A. Covington (mcovingt@ai.uga.edu).)

The way I explain digital recording to people is this:

- Digital recording is like hiring somebody to type a paper for you, from a typed original. If they hit the same keys you did, there is no loss of fidelity at all. If they make an error, you can find it and correct it.

- Analog recording is like hiring an artist to copy a painting. It is going to come out a little different no matter how good they are.

What is oversampling?

CD audio reads 16 bit samples off of the disc at a rate of 44.1 K samples per second (for each channel). This is the 1X rate. It is possible to produce *perfectly* faithful sound reproduction at 1X. However, digital sampling theory and the Nyquist criterion then require an analog filter which has a flat frequency response in the audio passband - 20 Hz to 20 kHz, and 0 at 22.05 kHz (1/2 the sampling rate) and above. The filter is necessary to remove 'aliasing' artifacts which would produce frequencies in the output not present in the original recording. Such filters are are possible but very difficult to design and tend to have nasty phase response as you get near 20 kHz since the filter response needs to go from 1 to 0 within a very small frequency range (20-22.05 kHz). The phase response may have an effect on stereo imaging and instrument localization. Whether you can hear any of this depends on whether you have 'golden ears' or not.

Enter oversampling. Instead of putting out the original CD samples at 44.1 kHz, digitally interpolate intermediate samples so that the D/A converter can work at 2X, 4X, 8X or more. The digital filters can be designed with very good performance and are part of the VLSI chipset in the CD player. For example, with 4X oversampling, three interpolated samples will be inserted between each original 44.1 kHz sample and the D/A will run at 176.4 kHz. An analog antialiasing filter is still needed at the output but its response only needs to go from 1 to 0 over the range 20 kHz to 88.2 kHz - a much much easier filter to design.

Which will sound better? There is a lot of hype. It may depend more on the quality of either design rather than the basic technique. So many other factors enter into the ultimate listening experience that the difference in in frequency and phase response around 20 kHz can easily be overshadowed by errors introduced throughout the recording process as well as playback considerations such as speaker quality and placement, room acoustics, and listener location.

Most consumer grade CD players now use oversampling. The newest fad is the 1 bit D/A with 256X (or more) oversampling. This is largely cost driven as well: you don't even need a high quality 16 bit D/A anymore. The simplest way of describing this approach is that it is a combination of pulse width modulation and sophisticated interpolation. The net result is audibly the same as all the others.

For more information, see: Aspects of Sampling, Oversampling, Quantisation, Dither, and Noise Shaping, as Applied to Digital Audio by Christopher Hicks.

What is an anti-aliasing filter

Antialiasing filters are needed in a sampled data system (of which digital audio is one example) to guarantee that out-of-band signals do not confuse the digitization process or find their way into the output.

1. Prior to sampling and digitizing, an antialiasing filter is used to cut off all frequencies above Fmax where Fmax is the highest frequency that it is desirable to reproduce. Sampling per Nyquist must be at least at 2*Fmax but making it somewhat higher than this enables the antialiasing filter to be more easily designed.

   For example, CDs reproduce 20 kHz as Fmax and sample at 44.1 Ks/sec. The antialiasing filter must have a response which is substantially flat to 20 kHz and then rolls off to 0 before 22.05 kHz.

   If this is not done, frequencies between 22.05 kHz and 44.1 kHz (as well as any above) will be reflected back in the digitized samples resulting in aliasing noise which is mighty peculiar sounding!

   Thus, the signal flow for input is:

```
Mic or \|  +-----------+  +-------------+  +---------+  +-----+    Digital
other   +->+   Audio   +->+ Antialiasing +->+ Sample/ +->+ A/D +--> proc.,
source /|  | Amplifier |  |    Filter    |  |  Hold   |  +-----+    storage.
           +-----------+  +-------------+  +---------+
```

2. Following the D/A, an antialiasing filter with a similar roll off is used to remove all frequencies above Fmax introduced by the D/A process.

   Thus, the signal flow for output is:

```
                                                                      /
            +-----+  +--------------+  +-----------+    |/
   Digital o-->+ D/A +->+ Antialiasing +->+   Audio   +-->+  Loudspeaker
   Sample      |     |  |    Filter    |  | Amplifier |    |\
            +-----+  +--------------+  +-----------+      \
```

The output antialiasing filter is not for antialiasing in the same sense as the input filter (before digitization) but without it, similar audible effects can take place in subsequent amplification stages which respond in a non-linear fashion to any high frequency (out of band) sample or clock noise that gets through.

3. Oversampling techniques can be used on both input and output to simplify the filter design. Prior to the D/A, additional digital samples are interpolated between the original samples read off of the CD. Thus, the digital samples will typically already be at some multiple of 44.1 kHz. The D/A then runs at a much higher sample (clock) rate decreasing the demands on the analog filer. See the section: What is oversampling?.

How good are the digital filters in digital audio systems?

(From: Winfield Hill (hill@rowland.org).)

The digital filters within a typical CD-sound sampling system are very good indeed.

I'm looking at a few AES papers reprinted in the 1994 Crystal Semiconductor databook (so we're talking "old" technology!), and I see the amazing performance possible with the linear-phase finite-impulse-response (FIR) filters in the delta-sigma A/D chips.

For example, the Crystal CS5328 has a flat response to 22.5kHz and then drops like the proverbial rock to a first -105dB dip at 26kHz. Ditto for the filters in a high-quality D/A like the CS4328.

Also, the in-band frequency response is very good. Passband ripple within +0.00025 and -0.0004dB to 10kHz. Hmmm, deteriorating to -0.0006dB at 17.5kHz. And for the D/A chip, a flat line on the chart (I can't see under 0.01dB) to 20kHz with a slight 0.1 dB rise by 22kHz.

Strike that "very good," insert PERFECT.

The Crystal CS5328 A/D has a very low -105dB distortion with full-scale analog input, and -125dB with -10dB input. That works out to under 0.0005% at full scale and even less for typical signals. The CS4328 D/A is not quite as good, with under -92dB (0.0025%), but I'll not complain! Also, they and others (e.g. Analog Devices) make better parts for the purist.

Instant oversampling theory

(Mostly from: Lasse Langwadt Christensen (fuz@control.auc.dk).)

When you have a signal from a CD sampled at 44.1 kHz, the resulting frequency spectrum looks something like this after the D/A converter:

```
 Amplitude
    |
    |
 ___|______      ___________
```

```
   |     \     /           \
   |      \   /             \
 --+--------+--------+----------> Frequency
   0       Fs/2      Fs             Fs=44.1 kHz
```

After the D/A converter you then need a antialiasing filter to remove the frequencies around the sampling frequency (Fs). That filter has to pass the frequencies you need 0-20 kHz and remove (-96dB) the frequencies above Fs/2 (22.05 kHz). Thats a pretty sharp filter - which is a problem, since it has to be an analog filter.

This is where oversampling come in. If you insert one zero sample in between every real sample, you get a signal looking something like this:

where X = originally sampled values, 0 = inserted zeroes

Note: The analog signal would look like a line connecting the the X's, not ASCII friendly :-).

```
 Amplitude
   |
   |
   X         X
   |         |         X         X
   |         |         |         |
 --+----0----+----0----+----0----+---> Time
   0        1/Fs      2/Fs      3/Fs    Fs=44.1 kHz
```

The sampling frequency has now been increased to 88.2 Khz (2X oversampling) and in frequency it would look something like this:

```
 Amplitude
   |
   |
 __|_____      ___________     ____________
   |     \     /           \   /            \
   |      \   /             \ /              \
 --+--------+--------+----------------+-----------> Frequency
   0       Fs/2      Fs              Fs*2            Fs=44.1 kHz
                                                     new_Fs=88.2 kHz
```

If you now filter that signal with a digital filter (before the D/A), with the same specifications as the previous analog antialising filter, (it is a lot easier doing it digital than analog, you get a signal something like this in frequency:

```
 Amplitude
   |
   |
 __|_____                        ___________
   |     \                      /           \
   |      \                    /             \
```

```
 --+--------+--------+--------+--------+----------> Frequency
   0       Fs/2      Fs               Fs*2             Fs=44.1kHz
```

And in time domain would look something like this:

```
 Amplitude
   |
   |
   X    I    X
   |    |    |    I
   |    |    |    |    X    I    X
   |    |    |    |    |    |    |
 --+----+----+----+----+----+----+---> Time
   0        1/Fs      2/Fs     3/Fs     Fs=44.1kHz
```

As you can see from the signal in the frequency domain, the analog antialiasing does not need to be as sharp as before, it still has to pass the frequencies from 0-22.05 kHz but it only have to remove frequencies above 44.1kHz (the new Fs/2). This is much much easier.

If you look at the signal, in time domain, you can see that the original samples (X) are still where they where, but the I`s has been moved, so they are placed as if the signal had really been sampled twice as fast. Since the extra samples are interpolated from the original samples, are they only limited in accuracy, by how many bits that was used in the filter. So the signal after the digital filter could in theory be any number of bits, and thats why a 18, 20, or 22 bit D/A-converter is sometimes used.

Is there a difference between CDs for 1X, 2X, or 25X CDROM drives?

A CD may be recorded at a 1X, 2X, 4X, etc. rate but what is on the CD is supposed to be the same.

However, the location of the information on the disc may have been optimized for use readout at a 1X, 2X, 4X, etc. rate on a particular drive/computer combination but again what is on the CD is coded the same way and should be read properly regardless of the speed of the CDROM drive. However, actual performance including interactions with multimedia programs, and sound and video devices may be vary dramatically.

For CDROMs, the 8X specification is not related to the 8X oversampling of an audio player. An 8X CDROM drive can actually spin at up to 8 times the normal speed of an audio CD. It can transfer data at 8 times the 1X (audio) speed of 150 KB/second or about 1.2 MB/second. However, note that the actual access time for an 8X CDROM drive may not be dramatically better than that of a 1X drive once the seek time is taken into consideration.

A CDROM drive must get the data unaltered even with defects on the disc. An occasional unrecoverable error on an audio CD will never be detected. However, a dropped bit could render a program disc useless. Therefore, a CDROM disc is coded with additional levels of error correction and a CDROM drive has the required decoding logic to deal with this information. The interpolation used for oversampling and the interpolation and/or muting used for dealing with unrecoverable errors in audio players are not useful for data. How the CDROM drive actually deals with audio playback is a totally separate issue from its data readout performance.

For example, an 8X CDROM may actually use 4X oversampling for its audio playback but nothing else.

Conceivably, an 8X CD ROM could buffer and read ahead - and re-read a segment of the disc if errors are found (as some people think normal CD players do but generally do not - at least not in the context of oversampling).

Sophisticated programs reading audio data off the CD could certainly do this on a greater than 1X drive. I do not know whether any CDROM drives themselves would do this given that audio performance is not something that is generally considered that important on a CDROM drive.

An audio player using oversampling never need to spin the disc faster than the 1X speed but implement the interpolation to simplify the analog filter design. However, portable players with a 'bump immunity feature' have several seconds of audio sample memory and will read (prefetch) the audio information off of the disc at higher than 1X speed to assure that the buffer can be kept as full as possible even if the player is unable to track for a couple of seconds.

CDROM drive speed - where will it end?

CDROM drives advertised as 16X are now common. Taken literally, this would mean that at the inner track, this drive must spin the CD at 500*16 or 8,000 rpm. Geez, they must have a Kevlar shield around the perimeter to catch any shrapnel should the CD disintegrate! (Apparently, this isn't as rediculous as it sounds - see the description of an "event", below.) Have you ever seen the slow motion video of a jet engine exploding? Just about one year ago, I was 'proving' why such technology would never be practical. So much for predicting the future. Have I mentioned that my crystal ball has been in the shop for the last few years awaiting repair? :-)

However, most 16X drives really are not 16X CDROM drives.

Some drives do advertise '16X max' which might indicate a constant rotation apeed of a much more reasonable 3,200 rpm resulting in a transfer rate which approaches 16X only near the edge (outer tracks where 1X would be 200 rpm). The transfer rate could be as 'low' as 6.4X near the center.

Another possibility is a hybrid approach called Partial Constant Angular Velocity (PCAV) with a more modest 8X speed (around a constant 4240 rpm) for the inner tracks topping off at 16X near (5/6ths of the way radially to) the outer edge (at which point the rotation speed decreases to limit the peak transfer rate to 16X).

12X drives typically run at a true 12X rate with the CLV varying between 6360 and 2400 rpm across the disc. These will actually have a faster transfer rate than '16X max' drives since most discs are not full and the most frequently accessed data is near the center - where the '16X max' drives are only really operating at 8X.

One factor limiting the performance of present drives is the speed of the Digital Signal Processing (DSP) chipset which is used to perform the decoding and error handling (i.e., EFM and CIRC). This is one area where there will no doubt be rapid advances.

There is nothing to prohibit a fully Constant Angular Velocity (CAV as opposed to CLV or PCAV) approach from being used as long as the DSP can keep up. This would mean that the transfer rate varies continuously across the disc. An added bonus would be that CAV would actually greatly reduce stress on the spindle motor and its servo system allowing for much lower cost components and improved reliability.

There are other ways, at least in principle, of increasing the performance of CDROM drives without spinning the discs at hyperwarp speeds. These involve the use of multiple laser beams or entire laser pickups to read data from multiple tracks in parallel. However, the hardware and software for these schemes become extremely complex and expensive to implement due to the CLV encoding, CD tolerances, and other factors. Therefore, spinning the disc faster has become the solution of choice.

In addition, the seek time of the CDROM drive will dominate for short file transfers. Since this specification is not as hyped as the 'X' rating, these are often pathetic - 200 to 300 ms full stroke being typical even for high-X (e.g., 16X) CDROM drives.

Of course, ultimately, it is the speed of the computer interface, system bus, CPU, and software, which limits actual performance. Just because you have a high speed CDROM does not mean it will behave as expected on your system.

There is some question as to whether discs manufactured to current tolerances can be spun much above 6,000 rpm without vibrating themselves to pieces. Other than this slight 'problem', there really isn't any fundamental reason why faster drives could not be built. Perhaps, discs will simply need to be approved for high perfomance drives (sort of like grinding wheels: "Do not exceed 8,500 rpm") - "Do not use above 40X".

Therefore, a drive spun at a constant 8,000 rpm with an advanced DSP chipset could operate with '30X max' performance. Are you marketers listening?

Now (August 1997) some company is offering a 24X CDROM drive!

Stay tuned for "Safety precautions and recommended body armor when using or troubleshooting a 100X CDROM drive" :-).

Here are a couple of data points on ultimate CD speed limits:

For the following, if one assumes the worst case, 1X is equivalent to 500 rpm. You can do the heavy math. :-)

(From: Richard Griffin (rjgriffin@viewlogic.com).)

I just thought I would chip in with my 2 cents worth......

There have been studies into just how fast you can spin your average CD without structural problems occurring. I believe Philips (UK) conducted the study. They found that spinning a disc up to the equivalent of 45X caused the disc to stretch enough due to the centripetal forces to make it impossible for the laser to track the track (if you catch my drift). Just for the sheer hell of it, they wound the test discs up to 56X at which point they scattered themselves in a very artistic 'splinter' formation all over the test lab.

(From: Scott May (scottmay4@home.com).)

My wife was browsing a the contents of a CD-ROM on her computer when suddenly there was a loud noise, followed by shards of what was once her CD-ROM, now raining down on our heads. The door to the Memorex drive (model CD-482E) was blown off its hinges, and left dangling by a small spring.

About the room were fragments of the CD, mostly in splinters, and few larger than dime. Inside the CD-ROM drive were the remains of the disc. I was able to open the door using the manual release, but could not open more than halfway. Internal drive parts were blasted off and mixed with CD rubble.

We are both very lucky not to have suffered injuries, because of flying debris. But I'm dumb-founded as to the cause of this major malfunction. I've never heard of this happening to anyone before. And to be honest, I wouldn't believe it if it hadn't happened to me. The drive was about a year old, but we have no idea if the CD had any surface flaws or physical defects.

(From: Sam.)

There couldn't have been any major structural defects or it wouldn't have been usable. That's why I suggested Kevlar encased CDROM drives. With these high-X drives, a failure of the spindle motor servo control could easily put it over that 55X disintegration limit. I bet the manufacturer would be interested in knowing about this incident. Think of what a good slicky lawyer could do with it. :)

CDROM spins continuously even when not in use

The complaint may be that it sounds like a jet engine all the time and is annoying or just a matter of curiosity. I don't know whether it is normal or not for your combination of hardware and driver, but CDROM drives rated above about 12X are typically CAV (Constant Angular Velocity) - they run at a constant speed - not CLV (Constant Linear Velocity) like normal audio players (though they may drop into that mode when playing audio CDs). (The X speed rating is a MAX and you only get this performance for the outer tracks (which may be the later files in the directory unless they specifically placed them).

Thus, your 24X CDROM drive actually spins the disc at a constant 4,800 rpm or so and you only get the specified access times if it is already spinning. Therefore, by one argument, it makes sense to keep it spinning whenever a data disc is in place.

Also see the section: CDROM drive speed - where will it end?.

Golden ears and technohype

You have no doubt encountered various claims of how player A uses such-and-such a technology and therefore clearly has superior sound compared, no doubt, with all others in the explored universe. There may be people who can hear such differences in noise, frequency response smoothness, and such. Perhaps even you could hear a difference under ideal conditions. However, once all the variables that make *music* are included - the chain from artist and recording studio, microphones, recording, mixing, and resampling as well as your speakers and room acoustics - not just sinusoids played in anechoic or resonant chambers, the very slight differences between players are virtually undetectable to human ears. If you are interested in playing test discs all day, then worry about the last percentage point of noise floor or frequency response. If you really want to enjoy the music, this stuff should not bother you. There are more important things to worry about than an undetectable blip in your CD player's frequency response curve. Anyhow, with the introduction of the DVD technology pending, your carefully optimized ultimate stereo system will be as obsolete a year from now as a 78 turntable. Consider that! Only PC technology has a shorter lifespan. I bet you won't sleep tonight. :-)

I would be curious as to the results of any true double-blind listening tests comparing CD players implemented with differing technologies (analog vs. digital filters, 4X or 256X oversampling, 1 or 2 D/As, etc.) on actual music (not test tones) in realistic listening environmemts. Such tests should be with people who are interested in the overall musical experience and not just the nth decimal point of technological specsmanship. There must, of course, be no vested interests (financial or otherwise) in the outcome of such tests. I would bet that the results of such tests would make for some fascinating reading and surprises for some manufacturers of high-end audio equipment.

That last little decimal point

Someone was hyping his high-end CD player (with a stratospheric price tag no doubt as well) claiming that it uses **mechanical** relays instead of transistors to perform the muting function (between discs or tracks) in the final audio amplifier. These mechanical relays are supposed to have less capacitance and thus not affect the 'fluency' or some other equally meaningless non-measurable characteristic of the sound. According to the same article, "only cheap CD players costing less than $900 use transistors for muting. All more expensive players use relays". If this claim is true, then how can manufacturers claim a +/-0.3db response curve from 20Hz to 20kHz even for CD players costing a lot less than $900?

Well, my 10 year old Technics SLP-2 uses relays and it sure cost a lot less than $900. Shall we do a little calculation:

Parasitic capacitance, say 100 pF (much much larger than likely). Highest frequency of interest: 20 kHz.

The magnitude of the impedance of this parasitic capacitance will be:

|Z|=1/(2*pi*f*C) = 1/(2*3.14159*2E+4*1E-10) = 80 K ohms

Compare this to the output impedance of a typical final audio stage, say less than 1 K ohms (usually a lot less, but this will do for a back-of-the-envelope calculation). Yeh, right, I will loose a lot of sleep over that. There are better things to worry about than an immeasurable blip in your frequency response curve: Are the transistors at the very output? Oh my gosh, you better start investigating super ultra low capacitance audio cables costing at least $1000 each with water protected oxygen free tapered oriented strand conductors. But wait: you are connecting to an amplifier with non-infinite input impedance (perhaps, horrible as it may seem, non-uniform as well)? Your setup must sound like crap! How can you even have it in the same house with you? There are so many variables involved in the reproduction of high fidelity digital audio that this is about as significant as a pimple on an elephant.

Ask for a scientifically designed and implemented A-B comparison. You won't get one because the revelations might be too shocking for the audio industry should the 'Golden Ears' fail to reliably distinguish between players at the two ends of the price spectrum.

Totally worthless gadgets for CD enthusiasts

Here are descriptions of a few of the items sold to born-every-minute suckers to improve the performance and audio quality of their stereo systems with respect to CDs. (These are strictly CD or digital audio related. There are many many more for general audio 'enhancement'.)

Save your money. This stuff is total garbage:

- Sonic rings to put on your CDs to stabilize them. The argument goes that this reduces wow and flutter by helping the servo system. There is none to begin with since pitch is determined by a quartz crystal.

  Note: these may even make your performance worse due to the added inertia of the rings. In addition, any added thickness could cause mechanical problems with some players like Pioneer changers (cartridge type) - loading, unloading, or during play.

- Magic markers for used on the edge to reduce errors. The rational is that the colored edges will absorb any stray laser light and minimize interference with the main readout beam. Forget it. Such reflections are very minimal. Furthermore, the digital processing means that if there is a slight drop in the signal-to-noise ratio, there will be no - zero - audible effect.

- Special digital clock you sit near your stereo to improve sound. I have no idea of the basis for this but I heard about it on a supposedly serious audio show. To clarify, I am talking about a time-of-day clock as in 12:34:56 with LEDs that has no direct physical connection to the audio equipment, not some high precision atomic cesium beam time-base unit! Perhaps, the added digital noise floating around will add some dithering to the signals and improve linearity? Right.... :-).

- Special cleaning solutions. Soap and water just isn't good enough for Golden Ears. No doubt, CDs should be stored under pyramids as well for optimal longevity.

- Fiber optic patch cords to reduce phase distortion. No kidding, I am sure there is at least one biological life-form in the universe that could detect the nanosecond or so phase shift introduced by the ordinary copper variety used by the rest of us. You don't suppose all the electronics involved will introduce any distortion of its own, do you?

(From: Zev Berkovich (ah392@freenet.toronto.on.ca).)

I recently was sent one of those audiophile magazines, and out of all the really stupid things advertised there, these two I found the funniest:

- A demagnetizing CD. Play this on your system and it is supposed to demagnetize your equipment and make it sound better. The one I have seen the ad for claims: 10 times the effective demagnetization of other discs. Less than 1/100th the heat dissipation (!!!??) of other discs. Complete demagnetization of all frequency selective circuits.

  The fax I got was pretty funny. They claim on their fax that it also removes residual magnetism from the slight impurities present in the copper wires. (Maybe it will degauss my TV! --- sam)

  Of course, the disc is made with 99.999% pure 24 karat gold (for a higher reflected signal level, whatever that means). (This, too, is of course bogus. Gold will have the same or lower reflectance at the IR wavelength of the CD laser. It just looks way cool. --- sam).

- Special solder, which tells you to remove all the solder on your amplifier, and redo all of it with this "Wonder Solder UltraClear". "For mere pennies you can solder (or reflow) a whole amp or speaker, and make it sound like one twice as expensive". (Sure sounds like a fun project to me - solder reflow in your toaster oven! --- sam).

More on CD enhancers - magic markers and anti-vibration disks

(From: someone I will leave anonymous).

> "I just had to comment on what you said about CD enhancers. I had the opportunity to test both a special green magic marker and a plastic anti-vibration disc that you stick on top of the CD to improve sound. The magic marker didn't work but the anti-vibration plastic did work. What I heard it do was enhance the spatial quality of the music. The separation was better. It sounded like the various instruments were a good foot or two farther apart on each side. That said, the demo was conducted on a $20,000 stereo system and I felt that $50 for the plastic disc was a bit high and I wasn't convinced that I could hear a difference on my more modest system."

Sorry to be skeptical - go do an A/B comparison. Unless that player has an excessive error rate - and I doubt that to be the case with a $20,000 system - there is simply no way that any meaningful difference is possible. A CD is not like an LP - small variations in speed are irrelevant and thus improving the stability or whatever is also irrelevant. The data readout is fully buffered - meaning that even if there is wow and flutter or vibration in the CD rotation, it does not matter.

Show me a double blind A/B comparison and I will reconsider. For now, the physics doesn't make sense.

The guy doing the demo wasn't by any chance trying to sell $50 disks, now was he? :-)

And, no, I have not done a double blind test. But, I would not mind being proven wrong. Just that based on the physics and technology, unless the CD player had a high error rate to begin with due to an underdamped servo system - he could have jimmied it - then there simply is no basis for expecting such things to improve a digital datastream. If the error rate decreased due to his discs, then perhaps there would be some sonic improvement. But, it should not have been high to begin with. Error rate reduction is the only possible mechanism I can think of to explain any possible audible differences. However, virtually all errors due to disc imperfections and scratches are *fully* corrected and thus undetectable in the output by human or machine.

BTW, was he also selling $1000 speaker cables?

Why is speaker cable like spaghetti?

(From: Keith Mayes (Mayes@d-m-g.demon.co.uk).)

A survey was carried out in the 70's. People were given two bowls of spaghetti, one coloured blue and one coloured spaghetti colour. Most people claimed to prefer the taste of the spaghetti-coloured spaghetti.

This was a real effect, with real people who had nothing particularly to gain or lose either way. Naturally, there was no instrumentally measurable difference in flavour between the two types.

The same applies to speaker cables. People who have fancy cables will quite probably hear an improved sound, in their judgement. There is more to perceived sound quality than vibrating eardrums.

Someone who has already bought fancy cable will not appreciate this story. If they hear an improved sound, then that's their good fortune.

Someone who is considering buying fancy cables may well benefit from this story. It may save them a small fortune.

In reality, the Emperor's response to being told that he was naked was:

1. Deny it and prove it with signed affidavits.
2. Have the kid locked up under a section of the mental health act.

To believe in the power of a fancy cable surely pales into insignificance beside belief in a deity, and there are plenty of people who go for that.

Can a CDROM disc damage a CD player?

Some CDROMs include audio tracks that are entirely playable. However, data-only CDROMs may not even be recognized by newer CD players. With older ones - designed before the CDROM standards had been developed - the player may come up with a bogus track directory. Attempting to 'play' such a disc will probably not damage the CD player but will sound, shall we say, strange. I have done this and it really gets pretty boring pretty quickly. But, like pointing the camcorder at the video monitor, is something that is irresistible to try once. If you do this experiment, TURN DOWN THE VOLUME!!!. None of the rules which govern real-world audio frequencies and amplitudes are obeyed with data discs. You may blow out your speakers (or ear drums) if the volume is set too high or even at normal listening levels. I wonder what WIN.EXE or vmunix really sounds like!

Another less common possibility is that a CD-R or CD-R/W that was aborted during writing (or damaged CD or CDROM of any variety) could result in the reader to repeatedly attempt to access a non-existent tract causing excessive sled movement - possibly even into the stops. This *could* conceivably result in overheating of servo components and motors and permanent damage though I've never heard of this happening. More below.

Notes on Killer CDs and DVDs

I am not referring to popularity, but rather instances where a defective CD or DVD can either lock up a player or drive, or in the case of some DVD-R or DVD-RW drives, even destroy the drive.

The latter case has occurred (Fall, 2002) and involves certain DVD-R and DVD-RW drives using Pioneer pickups and electronics. See: New Scientist DVD Article. In short, a firmware bug in over 1 million Pioneer CD-R and CD-RW drives (Some Macs use these), and stand-alone players and recorders, may result in a burnt out laser when attempting and failing to recognize new high speed blank media. Apparently the firmware went in before the standard was fully developed (or at least fully debugged!). There is a firmware patch to fix the problem in existing equipment.

A normal CD player or CDROM drive could lock up but would probably not be damaged except by physically damaged media (e.g., a broken disc catching on something or disintegrating at high speed) but in principle, the same could happen to

CD-R or CD-RW drives. However, I am not aware of any such problems.

(From: Dave Platt (dplatt@radagast.org).)

I have seen situations in which these new "copy protected" discs have caused CD players to lock up quite seriously. These have been in cases where the CD player was based on a CD-ROM mechanism (i.e. an "internet appliance" type of device).

Some of the new copy-protection techniques work by creating an invalidly-formatted multisession disc. A standard Red Book audio CD player won't even try to look for the second session, so it'll play the disc just fine. A CD-ROM drive - or any appliance based on one - will see that the disc is multisession, try to read the second session header, and become badly confused by the misformatted disc.

In one case I witnessed, the CD-ROM drive's firmware became "stuck in a loop" trying to locate the malformed sessions. It never succeeded in accessing the disc, and it refused to respond to the "eject disc" button or the eject commands by the unit's control software. The only way to get the disc out of the drive was to shove an unfolded paper clip into the "emergency drawer open" hole in the front plate.

I've been told that many of the higher-tech car CD players actually use CD-ROM mechanisms and the "rip the data" method of playing, in order to allow the data to be spun at higher speeds than 1x and then buffered in RAM. This allows extremely good bump/shock protection.

If this is the case, then I expect that these types of car CD player will be unable to play these "copy protected" discs. Worse yet: imagine what will happen if such a disc locks-up the firmware in a slot-loading CD player which doesn't have an emergency-eject paper clip hole?! Put the disc in the player, it swallows it, the CD player freezes up and won't give the CD back, and you've got a useless CD player which requires a trip to the dealership for repair!

If this does, in fact, ever happen, I fully anticipate that some savvy lawyer will arrange to file a huge class-action lawsuit against the disc manufacturer, on the grounds of "strict liability". The disc manufacturer "knew that these discs were deliberately manufactured in a way which would 'freeze' certain types of CD player, and knew or should have known that this could result in expensive damage to certain types of CD players."

I'm heartened to note that Philips has put the disc vendors on notice that these discs *cannot* be caused by the "Compact Disc" name, or use the Compact Disc logo, or promise Compact Disc compatibility, since they do not meet the standards required by the license agreements.

Performance testing of CD players

The question arises: "How do I determine if my new, newly acquired, newly repaired or adjusted, or other CD player is actually performing up to specifications?".

Note that in this section I am not addressing questions like: "Is my THD less than .003% (or whatever)?" but rather general usability issues like immunity to disc defects. If the music sounds right, the audio circuits are working. Subtle problems with the audio circuitry are rare.

The best approach is to use the test disc(s) that most manufacturer have made available for their own CD players. However, this is probably an unacceptable expense unless your repair volume can justify it. No single test disc will be suitable for all brands. One problem is that CD players from different manufacturers (and even models from the same manufacturer) have varying amounts of tolerance to CD defects and varying levels of error correction (by design). Therefore, what plays on one may result in dropouts or skipping on another.

Without the test discs, no quantitative measurements can be made. However, general types of tests can be done.

My general recommendation would be to use a good quality music CD which is a full 74 minutes (e.g., Beethoven's 9th Symphony) to test basic seek and tracking capabilities. Exercise the player with track-track and full disc seeks in both directions to confirm stability and that none of these times are excessive. Evaluate bump immunity with your calibrated finger tap at the start, middle, and end of the disc.

Also see the sections: "Comments on test discs" and "Custom test CDs using CD-Rs".

Want to have fun?

Find a garbage CD - one you don't really care about - and add imperfections of your own to the non-label side - using it as a frisbee or hockey puck should qualify. I would also suggest smudges but these are not permanent and what we want is something that will not change over time. Maybe try some fine sandpaper or steel wool. Painting fine strips of black radially (up to a width of 2 mm or so) may also be instructive though in reality, although the error correction may be capable of dealing with these, there may still be skipping or other mistracking.

As long as the CD does not have any edges for the lens to catch on (it is not cracked or broken), there is little risk to your player.

Scratching through the label side to the pits (information) layer may also be intersting. In this case, the data and tracking will be affected directly since the benefits of the out-of-focus surface (the non-label side) are lost.

With this 'scientifically designed test CD' you should be able to gain a feel for how your unit-under-test compares to the CD player you normally use. However, don't be too disappointed if one or the other falls down in some respect. CD players are just not all designed alike. You may find that your $100 portable doesn't even hiccup on defects that send your $1000 audiophile model (which you thought was the ultimate in the state-of-the-art) straight to the showers.

Finally, if you take reasonable care of your CDs (and don't position the CD player in front of your Megablaster-1000 speaker systems, you won't be 'pushing the envelope' during normal use and your CD player will not have to deal with marginal discs and vibration that often.

For more fun, see the article: "Where is CD Date Physically?".

Comments on test discs

> "Is a special expensive test CD needed for typical servicing? Can anyone recommend a test CD disk. I want test tones more than recorded music, single note sinewaves rather than sweeps."

I ordered one from MCM Electronics called the "Diagnostic Test CD" for about $5. It has over 40 tracks mostly of pure tones (sinusoids) of various pitches (frequencies) and amplitudes.

However, as noted below, an appropriate test disc is more likely to be useful for evaluating tracking performance than for audio distortion problems. Any music CD will suffice for the latter - these faults are usually quite obvious even to your average chimpanzee (or someone who is tone deaf).

Test discs like the following will provide nice quantitative info and should be useful in comparing the defect tolerance of various CD players. However, you will need to know what the specifications are of the player-under-test to really be able to determine if it is performing properly.

(From: Dave A. Wreski (dawreski@nic.com>).)

We don't think that test tones are so important in real life. The few CD players that have audio distortion problems are usually so bad it does not take a trained ear to hear. What we found much more important is the ability to track through damaged or dirty sections on the disc. Although not the, final the test disc we use has been proven to provide us with a "standard" that we judge the overall performance of the servo's and the laser condition. Very rarely do we have to ask an owner for the disc that exhibits his problem. This disk is from Technics and is about $35.00. It is P/N SZZP1054C. It has the necessary test tones (17 tracks) but more important it has defects at calibrated levels. First it has missing pits at .4 to .9 mm in length and second it has calibrated black dots from .3 to .9 mm in size. These checks will give you a very fast and reliable way of seeing how good the system is working. We could not live without it. Try it once and you will like it forever.

(From: Armand (mondo@voicenet.com).)

Try the "Ultimate Test CD" on Wodford music. 32 different sine waves and more. Found it at Tower Records for $6.

(From: Dan Dugan (dan@dandugan.com).)

My favorite test discs are put out by the National Association of Broadcasters. More expensive but comprehensive. I use #1 (there are 2) almost every day for level setting.

(From: Brian Newman (b.newman@qcm.gu.edu.au).)

I normally use a Sony type 4 test disc, but if you are after tones, I would recommend the test disc put out by Dennon. It has standard tones as well as left/right sweeps.

Custom test CDs using CD-Rs

With the continuing decrease in the prices of CD-R recorders, this approach will likely become much more common. If you have access to one at work, then there is no problem - it is probably not being used for its intended purpose anyhow :-). The only caution is that since CD-Rs are not quite the same as CDs in terms of optical behavior, some adjustments may not be optimal and should be rechecked with a normal CD or test CD.

(From Kenneth Aaron (kennetha@geocities.com).)

I have created a test CD using a CD-R.

Using a program like Cool-Edit you can create perfect waves of different frequencies and amplitudes, silence tracks, and nearly anything else. With a program like Disc-at-Once delays can be added between tracks.

After you burn the CD, holes can be drilled in the disc as well. I left a 2 minute gap between adjacent tracks so I could see the spaces between tracks. Drilling holes from .2 mm to 2 mm with .2 mm increment is allright. The disc is fantastic and it was made to fit my needs.

Controlling the pitch of a CD player

While it is easy to vary the pitch of a turntable or tape deck by controlling motor speed, this will not work with a CD player.

Spindle motor speed is only loosely related to audio pitch. CD players use Constant Linear Velocity recording, meaning rotational speed varies from inner-most track to outside track. Reading a CD is more like transferring data from a hard drive under computer control - there is extensive buffering and the instantaneous spindle speed is not the main factor that determines pitch. For this reason, wow and flutter are generally so small as to be undetectable even with audio test instruments since readout is controlled by a very stable quartz crystal master clock, not anything electromechanical.

Digital audio data is read from the disc into a FIFO (First in First Out buffer). Various processing is performed including decoding and error checking/correction and it is then fed to the DACs at a constant rate (determined by a crystal). If the FIFO gets too low, the motor speeds up. If the FIFO gets too full, the motor slows down. Very simple. Change the rate that data is read and the motor follows right along (up to a point).

The actual frequency of the crystal varies from design to design but a typical value is 11.29 MHz (256 times the audio sampling rate of 44.1 kHz. If may be possible to substitute a variable frequency oscillator for the crystal to provide some amount of pitch control.

With care and possibly some tweaking of the PLL servo adjustments, a pitch range of +/- 6% (about 1 semitone) should be possible. Some commercial CD players may do +/-12% such as the Technics SLPD-967 and some people have apparently achieved as much as +/- 20% by substituting a variable oscillator. But beyond this, strange things will likely happen with the spindle servo and the anti-aliasing (analog) filter. However, a schematic is really needed - and possibly more like chip specifications - to determine if simply injecting an external oscillator signal will work.

Where a large change in pitch is desired, it may be easier to convert a CD player having an anti-shock memory since that capability means that the system inherently only calls for data when it needs it and actually reads the data off the disc at a much faster rate (e.g., 2X or 4X). This would also be the scheme used in players designed with a large range of pitch control. In any case, locating the clock that controls data readout (rather than the main microcontroller) would be the place to start. That may use a separate crystal. The more completely the player is based on digital processing, the less aliasing and other funny speed related effects will be present since everything will scale equally with readout rate. The only changes that may be needed to eliminate aliasing effects may be to the output antialiasing filters and may just be one or two capacitors in each channel. Needless to say, a schematic will be highly desirable.

All in all, transferring the audio to another medium that allows for easy pitch control would be a whole lot simpler! There are cassette decks that can provide a 2:1 change in pitch while maintaining reasonable audio quality. Or convert to MP3 and do whatever you want in software. :)

See Pitchman's Mixing Setup Page for a description and schematic of one approach that works for some CD players. It's just a simple variable speed clock that replaces the timing crystal of the CD player.

Converting a CD player into a CDROM drive

Why anyone would seriously consider this project other than for the curiosity value is not clear, but the question does seem to pop up from time to time.

If you mean audio making a CD player into a CDROM drive. Forget it. Don't waste any neural bandwidth on such considerations. While the optics and front end electronics are similar, the CD player is missing the circuitry needed to decode the CD data, CDROMs used more involved error correction, the control inputs are not there, and it is virtually impossible to obtain detailed schematics or firmware listings.

And, in the end, it would be a state-of-the-art 1X drive since the servo systems and motors in an audio CD player are not capable of operation at more than 1X speed. Unless, that is, you are willing to butcher a CD player with an anti-skip buffer! :) You can probably pick up a 1X CDROM drive for $5 or less probably much less, like free. They practically come in cereal boxes these days (or was that 1G hard drives? Technology moves so quickly).

Similar comments also apply to the nth degree with respect to converting a CD player or CDROM drive into an MPEG video device or something more exotic.

Using a CDROM drive as a stand-alone CD player

Since nearly all CDROM drives are capable of playing audio CDs, a natural question is whether it is possible to just supply power and be able to use an old 1X (or 2X or 10X) CDROM drive as a CD player without attaching it to a computer.

For many types, the answer is yes. These provide some way of starting play and moving between tracks on the front panel. Usually, this is a pair of push buttons which combine play, eject, and next track functions or a volume control that can be pushed to start play and move to the next track. All these CDROM drives usually need is power to operate as audioCD players. For headphone listening, just use the front panel jack. A suitable adapter will permit the line outputs in the rear to be connected to the CD or AUX inputs of your stereo system.

Some will automatically play CDs upon powering up or closing the drawer if a jumper is set properly. The Eject button will then control play, track selection, stopping, ejecting, depending on how long it is held down.

Where the drive does not have these features, this may be more difficult.

- It is probably not worth it for SCSI or IDE drives as special commands will need to be set up.

- I don't know how difficult it is with the custom interfaces like Sony and Mitsumi. These may have a simpler command set but I doubt that it is just jumpering a signal to ground somewhere.

- For the once popular Panasonic CDROM drives with the custom interface (e.g., CR562, CR563), the interface specifications are available at:

  - Interfacing details of Panasonic SLCD CD-Roms

  Some logic will likely be needed to allow the drive to play music CDs but it should not be that complex. Here is an example of one solution that works:

  - Gary Tait's Home Built (almost) Panasonic/MKE/CR56x CD-ROM Interface

Note that the audio performance of CDROM drives is usually a notch below that of the typical audio-only CD player. The audio circuits are basically an afterthought for a CDROM drive. Therefore, don't expect quite the same level of frequency response, dynamic range, and lack of noise as your are used to with your stereo system or even your portable CD player. Of course, in a Jeep, this may not matter much.

In addition, the bump immunity is probably not spectacular - PCs are usually not expected to deal with pot holes. Therefore, unacceptable rates of skipping and repeating may result if a converted CDROM drive is used in your car or back pack.

However, some people claim to have used retired CDROM drives in vehicles with great success (see below). Therefore, it is worth a try if your model doesn't require a PC to be dragged along to play music CDs!

CAUTION: Since the interface (if unused) will be disconnected, some people have expressed concern that leaving the inputs floating may be bad for the circuitry and/or that they will pick up spurious signals resulting in erratic behavior even if just using the front panel buttons. Therefore, it may be worth identifying the inputs and tying them inactive (pullup or pulldown as appropriate). I don't really know if this is ever a problem - just something to consider. Well designed systems *should* already have this built-in to handle the case where the cable becomes disconnected accidentally.

(From: Dougie (blair@irnbru.enet.dec.com).)

I use a 2X CDROM Drive in my car and have done so since a local shop sold off all their drives for a fiver each!! I used a 5 volt regulator to make an in-line adapter to give me 12 and 5 volts to run the drive. You don't need any front panel controls since the eject button is used on most drives as FF/skip button. As far as bouncing and skipping is concerned. I originally put the drive inside my glove compartment and it jumped like crazy. But I now have it on the passenger's side floor under the seat and I can't remember the last time it jumped. You'll find a good spot in your car that works best.

I've even thought of putting on one of these flexible goose neck platforms that are used for portable cd players, but since it works fine where it is I haven't bothered.

I'm always interested in what other 'experts' tell you about the differences in internal electronics between PC CDROM drives and in-car CD players, but I work in a lab and spend every day carrying out failure analysis on CDROM drives of all types and I've always had the opinion that the only way to find something out for certain is to try it your self....

I have collected 6 of these drives now and am in the process of making them into a multi-CD player to be housed in my boot/trunk. All CDs will run continuously and only the audio will be selected and digitally switched. It should be fun and cheap.

SP/DIF digital audio interface

(From: Arny Kruger" (arnyk@flash.net).)

SP/DIF is common on most newer ATAPI CD and DVD drives, and specifically very rare on SCSI drives.

Toshiba, Teac, Panasonic, etc, have SP/DIF. I think the long term idea is to eventually drop the headphone output and DAC in the CDROM and route SP/DIF to the sound card which will, or is being put on the motherboard. I have a number of new motherboards with SP/DIF inputs but I have not yet tested them in this mode. I know that the digital performance of the sound chip used on these particular boards (the HT1869) is horrible. Hopefully, somebody will do it 'right', as this is technology with promise.

I've tested some CDROM's SP/DIF output with external audio DACs and good quality sound cards with digital inputs and they work, pure and simple. The performance of a $80 CD ROM and a $200-300 DAC (specifically the Technics SH-AC-300) can eclipse more expensive equipment, in technical terms.

Can I use the pickup from a CD player or CDROM drive for optical experiments?

With the nice precision optics, electromechanical actuators, laser diode, and photodiode array present in the mass produced pickup of a CD player, CDROM drive, or other optical disc/k drive, one would think that alternative uses could be found for this assembly after it has served for many years performing its intended functions - or perhaps, much earlier, depending on your relative priorities :-).

People sometimes ask about using the focused laser beam for for scanning or interferometry. This requires among other things convincing the logic in the CD player or CDROM drive to turn the laser on and leave it on despite the possible inability to focus, track, or read data. The alternative is to remove the optical pickup entirely and drive it externally.

If you keep the pickup installed in the CD player (or other equipment), what you want to do isn't going to be easy since the microcontroller will probably abort operation and turn off the laser based on a failure of the focus as well as inability to return valid data after some period of time.

However, you may be able to cheat:

- If the unit has a 'Test Mode', it may be possible to force the laser to remain on despite a total lack of return signal - or even without the focus and tracking actuators even being connected, for that matter. Many models have a Test switch, jumper, or pair of solder pads on the mainboard (enable before powering up). Then, there may be a key sequence to enable the laser, move the sled, etc. See, for example, the section: Pioneer PD/M series test mode.

Where such a feature is not provided:

- First, whatever is used to detect a disc must be defeated. Usually, this is a reflection of the laser (most common).)but may be a separate sensor.

- Then, the 'focus ok' signal must be provided even if you are not attempting to focus the laser beam. It may be possible to tie this signal to the appropriate logic level to do this.

- Even if it is not possible to access these signals, depending on design, you may be able to locate the logic signal to turn on the laser and enable it there. However, some systems bury this inside a chip based on the controller to activate it. Getting a schematic will probably be essential - but this may be difficult (especially for a CDROM).

It may be easier to just remove the pickup entirely and drive it directly. Of course you need to provide a proper laser diode power supply to avoid damaging it. See Sam's Laser FAQ in the chapter: "Diode Laser Power Supplies" for details. You will then have to provide the focus and/or tracking servo front-end electronics (if you need to process their signals or drive their actuators) but these should not be that complex.

CAUTION: Take care around the lens since the laser will be on even when there is no disc in place and its beam is essentially invisible. See the section: SAFETY.

Some people have used intact CD player, CDROM, and other optical disc/k drive pickup assemblies to construct short range interferometers. While they have had some success, the 'instruments' constructed in this manner have proven to be noisy and finicky. I suspect this is due more to the construction of the optical block which doesn't usually take great care in suppressing stray and unwanted reflections (which may not matter that much for the original optical pickup application but can be very significant for interferometry) rather than a fundamental limitation with the coherence length or other properties of the diode laser light source itself as is generally assumed.

In any case, some of the components from the optical block of that dead CD player may be useful even if you will be substituting a nice HeNe laser for the original laser diode in your experiments. Although optimized for the IR wavelength (generally 780 nm), parts like lenses, diffraction grating (if present and should you need it), and the photodiode array, will work fine for visible light. However, the mirrors and beam splitter (if present) may not be much better than pieces of clear glass!

Unfortunately, everything in a modern pickup is quite small and may be a bit a challenge to extract from the optical block should this be required since they are usually glued in place.

Taking a CD player overseas (or vice-versa)

Fortunately, the standard for the CDs themselves is the same everywhere in the explored universe. Yes, even Australia :-). Thus, there should be no issues of incompatibility. The differences will relate only to the power supply needed for your player.

First, check your user's manual (which you of course have saved in a known location, right?). It may provide specific instructions and/or restrictions.

Most component type CD players use a simple power supply - a power transformer followed by rectification, filter capacitors, and linear regulators. These will usually only require a small step up or step down transformer to operate on a different voltage. Since power requirements are minimal, even a 50 VA transformers should be fine. WARNING: never attempt to use one of those cheap lightweight power adapters that are not true transformers to go from 220 V to 110 V as they are designed only for heating appliances. They will smoke your CD player (or other equipment not designed to handle 220 V to 240 V input).

Some CD players may have dual voltage power transformers which can be easily rewired for the required voltage change or may even have a selector switch on the rear panel or internally.

The frequency difference - 50 or 60 Hz should not be a problem as nothing in a CD player uses this as a timing reference. The only slight concern would be using a CD player specified for 60 Hz on 50 Hz power - the transformer core may saturate and overheat - possibly blowing the internal fuse. However, I believe this to be a rather remote possibility.

For portable CD players, if your wall adapter does not have a voltage selector switch, obtain one that is rated for your local line voltage or use a suitable transformer with the one you have. As with power transformers, a frequency difference may cause a problem but this is not likely.

Sony portable service mode

This applies to the D33 - don't know about other Sonys. At least only a single jumper is involved. On the D88, it was necessary to both remove one jumper and add another. After several of these cycles, the circuit board tracks started to disintegrate :-(How about pads for a microswitch which would be part of the standard Sony service kit?

(From: Jxrn-E. Ernes (joern-ea@online.no).)

Remove the power supply (batteries or whatever you have) and the bottom cover. Now make a soldered interconnection between the two jumper TEST terminals and apply power again). Pressing the PLAY button should cause the spindle to spin continuously.

That would make it easier to determine whether the motor is OK or not.

Portable CD player Q & A

The following questions and comments may give you a better feel for the considerations on attempting to repair a portable CD player (or CDROM drive for that matter).

> "I've read the relevant sections in the FAQ already. My problem concerns a Sony D-99 discman, it started skipping, etc., but within a matter of days degenerated to the point that it won't even read the TOC any more and is essentially dead. All the motors work fine.
>
> I'm assuming that the problem has to be something to do with the laser optical subsystem or its setup. The fact that it sort of worked for a while but rapidly degenerated suggested nothing has died totally but something has a terminal disease. I'm guessing either that the calibration has drifted to (and now beyond) the limits it can accept, or that the laser's power output is deteriorating.
>
> 1. Do lasers age significantly assuming they aren't abused as noted in the FAQ (i.e. turn into DEDS)?"

They really should not 'wear out'. Certainly not in the span of a few days after having been faithful servants for several years. The quoted life of a typical laser diode is 5,000 to 10,000 hours. But that assumes proper drive There is no way of knowing for sure. FWIW, there is a disc player that I repaired for a mechanical problem that is used something like 8 to 10 hours a day, 6 days a week for the last 5 years or so. It is still going strong.

> "2. Since it is a small Discman, I worry a little that it will either go 'pling' when I take the back off (not that that ever stopped me opening things before) but more seriously there will be little I can do when I get in

there."

Portable CD players tend to be fairly well behaved when the covers are removed. However, I am not optimistic about your chances of repair. Some careful exploration should not harm anything (not that it is likely to matter). I have found from my experience with portables that working on those things is a pain. This is especially true of older Sonys where the mainboard is connected to the optical pickup with many fine soldered wires in addition to soldered in flexible cables.

> "3. Sony have *not* been helpful. They will likely charge me the same as it costs to buy a new one, which is a shame because this old girl is actually made of metal and I hate the horrid plastic feel of the new toys, even if the batteries last longer and it sounds as good. The Sony man himself said that the new ones are built down to a lower price."

Forget Sony. If I interpret the model correctly, that one is fairly old. You would be lucky to get their attention for something 1 day out of warranty.

> "4. Should I pay the man?"

The temptation of some repair places is to blame the optics without even doing any testing - which alone will set you back more than the price of a new basic player (well, it will do everything yours will do but weigh half as much!).

> "5. Should I throw it away?"

That would be a shame but it depends on how much you value your time versus the cost of a new one. I really do respect the look and feel of those old Sonys.

Needing to reseat internal connectors, dirty controls, mechanical problems, are still possibilities.

Also, if you are using an AC adapter, make sure *it* is not the one that is terminal!

However, adjustments may not even be marked and if it is now totally unresponsive, there is no way to really tweak them without a service manual.

> "6. Should I take the back off, nothing to loose, then most likely throw it away?"

First, clean the lens and check the mechanics, and the AC adapter.

Next, see the chapter: "Startup Problems".

Then try to identify how far it is getting. This can probably be done without taking the back off.

You can pretty much forget attempting to repair the circuitry - most components are surface mount - both very tiny discrete parts and large multilegged ICs. It is difficult to obtain data sheets for many of these. The service manual is not always complete enough to be much help. Even probing test points without shorting anything out or having the whole mess fall on the floor while balancing the guts of the player and pushing buttons typically requires a minimum of 4 hands.

> "7. Do I stand a chance to find someone who will give me a better likelihood of success at a reasonable price than the local sony man (who to be honest looks like his idea of repair is to replace it in any case, certainly on a module level)?"

IMO, unlikely. It takes more time to get into one of those than a full size. Time is money, etc. They would probably have to order the manual which is an added expense that may never be useful for a future customer.

> "Sorry if 'throw it away' isn't in the spirit of things, but hey."

Sometimes it is. :(

> "P.S., one improvement to the FAQ would be to outline the likelihood that things actually have worn/died with age, rather than simply how to adjust or repair something that just doesn't work for some reason. This one has had a lot of use over five years."

Unfortunately, aside from things like grease gumming up or mechanical parts collecting dirt, optics getting coated with dust, tobacco smoke or cooking grease residue, motor bearings wearing out, the electronics and optics really should not age. Of course, there are all kinds of ways that this could happen through use and abuse (e.g., large dogs, toilets, and salt air) or bad design.

CD players in vehicles

Although a CD player mounted in an automobile or ATV is subject to much greater levels of vibration and shock than a home stereo (though perhaps not more than a well used portable), this may not be the primary factor affecting the long term survival of these devices. Other considerations are cycles of heat, cold, and humidity; dust and tobacco smoke; and the harsh environment of the vehicle's electrical system.

Temperatures under the dash or in the trunk can easily vary from below 0 F to more than 110 F during the year. Humid and salt air are particularly nasty. The confines of the passenger compartment concentrate tobacco smoke products so the lens and optics may suffer more in this environment.

While these must perform the same basic functions as their more stationary counterparts, there are some additional considerations:

- Environmental - hot, cold, humidity, exhaust fumes, tobacco smoke. All of these can result in more wear and tear on the mechanism, temporary or long term problems.

- Vibration - Unless you live in an earthquake zone, your home stereo system doesn't get bounced around much. However, in a car or truck, constant bouncing is to be expected. CD players designed to be used in mobile situations should have more robust and compliant shock mounts. This is one reason why using a surplus CDROM drive as a mobile CD player may not work well (but some will be fine).

- Power - The quality of the power to the accessories is often pretty poor compared to a stereo system or PC. High voltage spikes may result in permanent damage if there is inadequate protection. Ignition noise may feed through to the audio and require special line filters or other means to reduce the whine or buzz to acceptable levels. Either of these may also result in erratic behavior.

- Accessibility for repair - Finally, these systems are generally difficult to work on when repairs are needed. This includes removing the unit(s) from the dash/trunk, providing proper power and possibly control, and simulating the conditions that are causing the problems in the first place!

Here is one example illustrating the additional uncertainties of these units:

> "I have recently install a Panasonic in-dash CD, My problem is the CD player does read and play but it will stop suddenly and eject itself, few of my friends have told me it could be due to dirty lens and I have seek a second opinion from a pro car audio installer and they told me is my lens is damaged and needs repair."

The "pro car audio installer" probably doesn't have a clue but mentioning the lens is sure to impress - NOT!

(From: Filip M. Gieszczykiewicz (filipg@repairfaq.org).)

If you installed a *new* player, I doubt that this is the problem. Most likely, alas, is a wiring mistake or a bad connection. Did you follow the instructions and use the recommended wire harness adapter? Did you provide a good, solid ground? What wire-splicing method did you use? Did you tape/heat- shrink all connections? Did you mount the radio securely in the dash?

Most car CD-players will spit out the disk when power is interrupted to them. Does it happen when you hit a bump or are going over rough road?

Check over the wiring, then check the ground, but first check *when* exactly the problem appears!

Take it for a test-drive over a bumpy road: does the light flicker before the disk comes out? Any noise from the speakers?

(From: Steve Loboyko (sloboyko@mindspring.com).)

Automotive CD players are more susceptible to smoke on lens. Also, highly variable temperatures make servo "center" adjustments tougher and critical on a car in-dash CD player. For example, I am starting to have problems reading gold/green CD-R's in my car if the interior of the car is hot. Gold/blue CD-Rs won't work at all. All work 100% fine in home audio or CD mechanisms. It will be a pain in the butt to fix, with a hair drier simulating the "normal operating temperature" on a 90 degree day.

Who says CDROM drives are fragile?

The average person thinks that a CD player or CDROM drive is a delicate piece of precision equipment that will die given the least excuse. Well, chalk at least one up for the good guys!

(From: Joseph E. Fealkovich (jef812@ix.netcom.com).)

My best friend calls me up, he works at a computer outlet in Cleveland, OH (figure it had to be Cleveland! :-) --- sam), to tell me he has a Teac CDROM he 'accidentally' ran over with a pallet truck loaded with about 850 pounds of DOS and Windows (who says software isn't a tangible asset! :-) --- sam).

The CDROM drive is crushed a little bit in the rear, the faceplate popped off and skittered across the floor. Upon obtaining this CDROM drive, I look at it and yes, the back part is pretty well damaged. Me and my good friend Timmy take this poor unit apart to look at the insides. I'll be damned, there is no internal damage whatsoever. All that has to be done is straighten the main chassis of this CDROM and straighten out the outer case. While I was at work straightening out the CDROM, I hit Teac's website to get the drivers for this CDROM, and I'll be double damned, IT IS A 16X CDROM DRIVE!! COOL! The model number is CD-516E, cool, if I get this gem working, I can put it on my secondary port on my 32-Bit IDE interface. Sure enough, I straightened out the crushed case on this unit and I install it with the drivers I downloaded from Teac's website. This CDROM works like it was brand new!:-) WOW, is this damn thing fast! COOL, I got a free 16X CDROM, all I had to do is fix the damaged case and chassis!:)

Most expensive replacement part of the century award

This is right up there with $400 hammers and $20,000 toilet seats :-)

MCM Catalog #38, page 500: Original Aiwa/Sony Spindle Assembly: $94.50(ea). It is part number 32-7275 if you are eager to order one ;-).

From the picture, this is the type of spindle assembly used in the typical $70 portable CD player or cheap (by now obsolete) CDROM drive - a $1.99 Mabuchi style motor (two pin connector included!) and plastic self locking spindle platter glued or pressed to the shaft.

Do people actual pay this???? Why would anyone spend almost $100 for one of these replacements?

Yes, I know most of the answers. The question is to stimulate discussion.

Comments on Sony KSS pickup suspension problems

There seems to be some debate as to what extent weak suspension contribute to uncorrectable (by the internal adjustments) skipping and other erratic behavior. However, it is generally agreed among those who actually have to repair CD players and CDROM drives using Sony KSS pickups that such deteriorated suspensions can indeed be a cause of a variety of problems.

(From Mark Z. (zmachar780@aol.com).)

Anyone who has worked much with these units knows that the suspension can be a factor, especially where a player is somewhat finicky about which discs it likes or doesn't. This is particularly true of the D- series portables. I call attention also to the Denon DN2000 type dual players which use the KSS240A optic. Replacing the pickup seems to *always* fix these type of erratic skipping problems.

There is no way I know of to tell for sure that the focus bias or other adjustment won't get it back into nominal area of operation, other than just trying it. In fact, adjusting the focus bias (focus offset) is often done to get the player into a better operating area, and to save the expense of a new optic. With a player say, 4 to 5 years old, the actual deterioration may be quite minor, and the adjustment may be all that is needed. Of course, if if it is really that minor, why was it acting up in the first place? I disagree with Sony on the issue of deterioration. I've seen too many examples, particularly when the objective lens is 'bottomed out'. If the focus servo is really able to overcome this physical problem:

- The focus drive electronics, transistors, IC, whatever will run unnecessarily hot. These circuits are designed to have a zero average offset to lower average power dissipation.
- Why then does the RF signal look so bad on players where the disc table is installed at the wrong height by as little as 1/2 mm?

However, most skipping, sticking, repeating, and similar symptoms are still caused by feed problems and spindle motors. Sony is correct to state that many pickups get replaced unnecessarily. I attribute this to inadequate technician training, and also that CD players work by FM.... (F***ing Magic). tech humor. Ha. Ha :-).

Enhancing the sound quality of an inexpensive CD player

OK, this isn't for everyone. But, if you have the electronics experience and desire, it may be possible:

(From: Michael Widlok (widlok@uci.agh.edu.pl).)

As we all know, reading errors are NOT main problem in CDs (as I know it is not a problem at all. I checked this in my old Technics). What really making some of them sounds so bad are awful output states and analogue filters. Sound of some cheaper players can quite easily be improved by changing these crappy output states and filters. When I recognize this I went to the market and I bought old second- hand Technics (or Matsushita) SL-P550 for a rather low price. I chose this one because it had the good optical deck (linear motor and three points spring suspension) and generally was in good condition. Then, it was extremely easy to find all signals on electronics board, as most of them are marked (what an idea!) and most important ICs are "typical" and easy to find in catalogues (it does not mean that they are good). Finally I decided to change everything from digital filter to the output. I bought NPC 8x oversampling filter, Burr-Brown DACs and designed my own analogue lowpass filters and output states. I still don't know much of a problem jitter is, but I wanted to make a really HiFi CD, so I throw away the 16.9344 MHz crystal and connected XTI pin of main laser receiver/decoder to the separate low jitter oscillator. For connections from main board I used short wires soldered directly to electrical paths, and then connected to my own circuits. It is funny how a few signals were needed (Data In, Bit CLK, L/R CLK, and System Clock - all can be found directly on Yamaha digital filter on main board). I also change (upgrade) the power supply and add a display on/ off switch. I think that almost every CD (maybe not small portable units) can be upgraded in this way, but be careful - CDs are usually NOT the limiting components in stereo system. You need a really good one to hear the difference in between them.

Impress your friends with the power of your CD player

The laser output of the typical CD player optics is less than 1 mW but since the beam is focussed to a diffraction limited spot of less than 2 um the resulting power density is truly impressive:

(Portions of the following from: James Carter (jcarter@photon-sys.com).)

Intensity is related to power by the 'area' of the beam. For a Gaussian laser (as most semiconductor lasers are), the 'area' of the beam is related to the area of the intensity contour (usually an ellipse for these guys) representing 1/e^2 or approx. 13.5% of peak intensity (at the centroid).

Thus the peak intensity occurs at the centroid and equals

```
            2 * Po
   Io  =  ------------
          pi * Wx * Wy
```

Wx and Wy are the beam semi-diameters for the 1/e^2 contour.

The beam size at the facet of a semiconductor laser can be as small as 1.5 by 3.5 microns. The high power density at the facet represents the cause for most common failure modes in laser diodes. For a 5 mW laser diode, the resulting power sensity on this facet can be in excess of 600 MW (that is Megawatts) per square meter! Sounds impressive, doesn't it?

At the CD, the spot is even smaller which for the same power would result in even higher densities. However, this is more than offset by the fact that a significant fraction of the original power is lost in the optics so the the power density might be only - 300 MW per square meter. I still would not recommend hanging out at the focal point!

Note that while these numbers are impressive, conduction and other losses generally prevent any actual damage from occurring to most common materials. However, in a CD-R recorder using a laser diode with a power output of similar magnitude, the temperature rise at the disc even while spinning at 4X or greater speed is sufficient to blast holes in the intermediate (green) information layer. Watch out!

CD to VCD converter?

(From: Allen Bong (sfbong@tm.net.my).)

In Malaysia, many people convert their cd player to be able to play vcd. The whole conversion by a skilled technician including parts is only US$60.

They can convert cheap CD players selling at RM200-300. The converter just took the signal coming from the amplifier after the CD head. And the output is RF signal for the TV. I once saw one of these cards to have a 8051 uC on it and I don't really know how the thing works. They also do mods on LD players and it works well with the remote control on the LD player.

Modifying CD player to get at data stream?

(From: Bill Den Beste (billd@reprise.com).)

A couple of years ago Elector electronics magazine published several articles about add-on items for digital audio. They also published a construction article for making a CD player.

The data stream is called SPDIF (Sony Philips Digital Interchange Format). This is the same data stream format that you'll see at an internal node on every Sound Blaster card. It is not just audio waveforms encoded as numbers. It also can contain the copy bits, and perhaps other stuff. I believe that it is a 24 bit data format, even though the data on the CD itself is only 16 bits.

Philips and SGS Thomson make neat consumer IC's that process this data stream in various ways. Again see the back issues of Elector for more information. If you cannot find them, let me know by email and I'll search my archive.

Designing CDROM reader to recover data from damaged CDs, CD-Rs, or CD-RWs

A disc/k which has been cracked or some of the coating has peeled off, may be totally unreadable, especially if any of the damage is in the directory area.

In principle, you could design a CD reader that would get most of the data in the areas that are not damaged. It would have to read slowly so that focus and tracking lock could be reacquired after skipping the damaged area. Whether a normal CD reader could be modified I don't know, it might take custom circuitry to rotate the disc at a programmable slow rate and pick off the raw data. Decoding and reconstruction could be done in software. It could be a big project with questionable returns. There would still be major gaps and with data, that could be bad news. This is worse than attempting to recover data from a magnetic disk (diskette or hard drive).

- Back to CD Repair FAQ Table of Contents.

Exploration and Tinkering

Interesting CD player signals

Poking around inside a working CD player makes an excellent exercise for the student. Component CD players very often have clearly marked test points for RF, focus, tracking, and audio data. With care, there is little risk of damaging anything as long as you are not tempted to try your hand at tweaking any of the internal adjustments.

If you have nothing better to do and you have your CD player open, try to locate the test points for data, fine tracking, and focus. They may be labeled something like TP.DTA (or TP.RF), TP.FO, TP.TR.

TP.DTA or TP.RF is the data coming off of the disc having gone through only the photodiode segment combiner and preamp (probably). Using a 10:1 probe set the scope for a horizontal sweep of around .5 us/div. Try a vertical sensitivity of .2 V per division to start and adjust for a full screen display. Use internal positive triggering. While playing a disc, you should see the classic 'eye' pattern used in the communication world to characterize channel quality.

The CD player 'eye' pattern

The 'eye pattern' depicted below results from the characteristics of the run length limited 8-14 modulation coding used on the CD where there are no fewer than 3 and no more than 11 clock cycles per symbol. You should be able to make out the fact that the minimum distance between channel bits is 3 with the smallest distance between bit transitions of about 3*232 ns. The readout clock is 1/(232 ns) or about 4.321 MHz.

A 'good' eye pattern will be clean, symmetric, and stable with clear visibility in the cross hatched areas. Its amplitude is typically in the .75 to 2 V range p-p when measured at the RF test point. This waveform may be viewed using an oscilloscope of at least 5 MHz bandwidth.

Some typical RF amplitude specifications:

- Aiwa: 1.3 to 1.4 V p-p.
- Sony full size: 1.2 V p-p, auto and portable: 0.85 V p-p.

This diagram shows the general form of the eye pattern present while playing a musical track or reading data from a CDROM. An actual scope trace from a typical CD player RF testpoint is shown in: CD Player Eye Pattern.

```
        ______________________________________________________
       /      \   \   \   \    \/  \/  \/  \/  \/  \/  \/  \/
      /        \   \   \   \   /\  /\  /\  /\  /\  /\  /\  /\
     /          \   \   \    \/  \/  \/  \/  \/  \/  \/  \/  \/
                 \   \   \   /\  /\  /\  /\  /\  /\  /\  /\  /\
                  \   \    \/  \/  \/  \/  \/  \/  \/  \/  \/
                   \___\__/\__/\__/\__/\__/\__/\__/\__/\__/\__

                        |<---- 1 us ---->| (approximately)
```

Examination of the eye pattern would be the first measurement that would be performed to determine the condition of the CD player optics and electronics. A good eye pattern eliminates most of the parts of the optical pickup from suspicion.

Note that the eye pattern observed while the player is accessing the following areas of the disc may not be well formed as in the diagram above:

- Disc directory (Table of Contents or TOC).
- Before the start of the first track (Track 1, time less than -0:01).
- Between tracks of distinct selections (where there is silence).
- After the end of the last track.

This is because there is no musical data at these locations on the disc (but probably a constant value like 0) and the TOC and/or time display is obtained from the Q bit. The Q bit is part of the Control and Display byte that is present once per frame (14 EFM coded bits out of 588 total bits per frame). See the section: CD (disc) construction. This funny looking eye pattern has much more low frequency content and thus does not exhibit the nice cross hatched area as will be present with the highly variable audio data.

Focus and tracking drive or error signals

TP.FO or TP.FE is the focus voice coil error signal. Monitoring this with a disc in good condition will show what looks like noise - the more or less random fluctuations in actuator current necessary to maintain proper focus within +/- .5 um of the disc surface. On a warped disc you will see the DC level of this signal varying at the disc rotation rate. On a damaged disc, you will see higher frequency variations in the level depending on what kind of defects are present. Gently tapping the optical deck should evoke a visible effect on this signal as well as the servos correct for your mischief.

TP.TR or TP.TE is the fine tracking voice coil error signal. As with TP.FE, this will show a noise waveform with a good disc. On a disc with runout, you will see a periodic level variation at the spindle rotation frequency. Note how the DC value of this signal gradually changes as the voice coil actuator maintains lock on the track while the track spirals outward.

Eventually, this error becomes great enough to trigger the coarse tracking motor to jog the pickup a fraction of a mm and recenter it on the track at which point the signal you are watching will suddenly shift its DC level.

On a disc with scratches, there will be higher frequency deviations which will be readily visible on a scope trace. Gently tap the optical deck from various points and observe the effects on this signal.

For both focus and tracking, you can actually hear the voice coil actuators as they compensate for minute defects or just the normal data pattern. This is the 'gritty' sound one hears from the CD audio or CDROM transport when it is operating correctly and is an indication that the laser and focus (at least) are most likely functioning properly. If you listen carefully, you can actually hear various defects by the effect they have on this gritty sound but there will be no corresponding effect in the audio outputs as there would be with an LP.

Focus, tracking, and error correction performance

If you have a test CD (or use your regular CD), put your scope on one of audio outputs. Put some thin pieces of tape or mark with a (water soluble) felt tipped pen radially on the bottom surface of the disc to create some 'defects'. Play some tracks which have constant pure tones or silence. For widths less than the error correcting capability of your CD's LSI chipset, there should be no detectable signal degradation. See what happens as you increase the width of your 'defects'. Put your finger on the spindle or even gently touch the disc as it is rotating. Note that unless you really press hard, the disc will continue to play normally without any change in pitch. This is due to the servo control and extensive buffering of the data - unlike an LP turntable where the instantaneous speed is what determines pitch.

Other experiments are left as exercises for the student.

IR detector circuit

This IR Detector may be used for testing of IR remote controls, CD player laser diodes, and other low level near IR emitters.

Component values are not critical. Purchase photodiode sensitive to near IR - 750-900 um or salvage from optocoupler or photosensor. Dead computer mice, not the furry kind, usually contain IR sensitive photodiodes. For convenience, use a 9V battery for power. Even a weak one will work fine. Construct so that LED does not illuminate the photodiode!

The detected signal may be monitored across the transistor with an oscilloscope.

```
 Vcc (+9 V) >-------+---------+
                    |         |
                    |         \
                    /         /  R3
                    \ R1      \  500
                    / 3.3K    /
                    \       __|__
                    |       _\_/_  LED1 Visible LED
```

```
                 __|__        |
        IR ---->  _/_\_ PD1   +--------> Scope monitor point
          Sensor   |          |
        Photodiode |     B |/ C
                   +-------|    Q1 2N3904
                   |       |\ E
                   \          |
                   / R2       +--------> GND
                   \ 27K      |
                   /          |
                   |          |
       GND >-------+----------+
                  _|_
                   -
```

Inexpensive laser power meter

In principle, a reverse biased photodiode and mA meter can be used to measure laser power. A silicon solar cell could also be used in zero bias current source (photovoltaic) mode. However, this is sort of difficult for CD and similar equipment which don't produce a nice compact collimated beam that can be directed at the photodiode without losing too much. The beam from the objective lens of CD, DVD, or other similar optical storage equipment is highly divergent.

The conversion factor of current to laser beam power also depends on wavelength and the way the photodiode was processed. A typical silicon photodiode has a sensitivity of 0.4 to 0.45 mA per mW at 632.8 (HeNe laser wavelength, close enough for DVD). At 780 nm, it will increase to 0.5 to 0.55 mA per mW.

More information on laser power meters can be found in Sam's Laser FAQ in the chapter: "Items of Interest".

Laser diode fundamentals

Note: This is a summary. For additional information on using laser diodes, see Sam's Laser FAQ in the chapter: "Diode Lasers".

Typical CD laser optics put out about 0.1 to 1 mW at the objective lens though the diodes themselves may be capable of up to 4 or 5 mW depending on type. The laser diodes for CD players are infra red - IR - usually at around 780 nm. Visible laser diodes are also readily available from many sources. The most common wavelength is 670 nm which is deep red but 630 nm diodes are also available - red orange and appear much brighter (and more expensive at the present time). Inexpensive (well relatively) laser pointers use visible laser diodes with power outputs up to about 5 mW. This is enough power to risk permanent retinal damage if you look into the beam especially when well collimated as is required for a pointer. Don't.

Typical currents are in the 30-100 mA range at 1.7-2.5 V. However, the power curve is extremely non-linear. There is a lasing threshold below which there will be no output. For a diode rated at a threshold of 80 mA, the maximum operating current may be as low as 85 mA. This is one reason why all actual applications of laser diodes include optical sensing (there is a built in photodiode in the same case as the laser emitter) to regulate beam power. You can easily destroy a laser diode by exceeding the safe current even for an instant. It is critical to the life of the laser diode that under no circumstances do you exceed the safe current limit even for a microsecond!

Laser diodes are also extremely sensitive to electrostatic discharge, so use appropriate precautions. Also, do not try to test them with a VOM which could on the low ohms scale exceed their safe current rating.

While only a few hundred mW at most is dissipated by the laser diode, a good heat sink is also important for long life and stability. The optical pickup is usually a metal casting partially for this reason. Remember that the active diode chip is only about .1 mm on a side. However, some optical blocks are now made of plastic so this must not be as important as in the past.

It is possible to drive laser diodes with a DC supply and resistor, but unless you know the precise value needed, you can easily exceed the ratings.

One approach that works for testing is to use a 0-10 VDC supply (preferably a linear supply - a switching supply may put out laser diode destroying pulses) with say, a 100 ohm resistor in series with the diode. Slowly bring the current up until you get a beam. Use an IR detector for this! If you get the polarity backwards or are actually measuring across the internal photodiode, the voltage across the diode will go above 3 volts or will be less than 1 V. Then, turn power off and reverse the leads. Note: some laser diodes will be destroyed by reverse voltage greater than 3 V - a spec sheet will list the reverse voltage rating. The ones I have tried out of CD players were fine to at least 5 V in the reverse direction.

Without a laser power meter, however, you will have no way of knowing when the limit on safe beam power (safe for the laser diode, that is) is reached. If you have the data sheet for your laser diode, then the best you can do is limit the current to specified maximum rating. Also, there is usually a weakly visible emission which appears red (for IR laser diodes) present when powered. Do not be fooled into thinking that the laser diode is weak as a result of this dim red light. The main beam is IR and invisible - and up to 10,000 times more intense than it appears.

The beam from the raw laser diode is emitted in a broad wedge typically 10 x 30 degrees. A convex lens is needed to collimate the beam (make it parallel). For optimal results, this needs to be anamorphic - unequal horizontal and vertical focal lengths - to correct the astigmatism of the beam. The mass produced optical pickups used in CD players include this as well as other sophisticated optics.

For an actual application, you should use the optical feedback to regulate beam power. This usually takes the form of a simple current controlled power supply with extensive capacitive filtering and a regulated reference. It is possible to modulate the beam power by tapping into the feedback circuits - as long as you guarantee that the maximum current specification will never be exceeded. Laser diodes do not behave like LEDs and cannot be pulsed for higher peak power - they turn into DEDs - Dark Emitting Diodes.

Single chips are available from a number of manufacturers for driving laser diodes in both CW and modulated modes.

For additional information, see the document: Sam's Laser FAQ.

Laser diode life

For all intents and purposes, laser diodes in properly designed circuits do not degrade significantly during use or when powered on or off. However, it doesn't take much to blow them (see the section: Laser diode fundamentals). I have seen CD players go more than 10,000 hours with no noticeable change in performance. This doesn't necessarily mean that the laser diode itself isn't gradually degrading in some way - just that the automatic power control is still able to compensate fully. However, this is a lower bound on possible laser diode life span.

Laser diodes that fail or weaken prematurely were either defective to begin with or, their driver circuitry was inadequate, or they experience some 'event' such as a power-on transient resulting in momentary overcurrent, possibly as short as a few nanoseconds in length!

As noted elsewhere, a weak laser diode is well down on the list of likely causes for CD player problems.

Of course, in the grand scheme of things, even LEDs gradually lose brightness with use.

However, this is another area where manufacturers can cut corners - see the next section.

Comments on CD player/laser life

(From: David Kuhajda (dkuhajda@locl.net).)

I did a check on several manufactures expected laser output life. Note this does not relate to the life of the mechanical parts of the optical pickup assembly itself.

The usable laser output light level is that which the electronics and light sensors can still reliably detect the rf pattern returning off the disc. A new laser in most units optimally will give 1.5 V p-p RF level, while the threshold for failure is around .95 V p-p. (This is why many CD players cannot reliably play CD-R's as they have between 60% and 80% reflectivity of a normal CD).

Non-officially acknowledged hours rating from a MAJOR CD/LD player manufacture:

A few years ago most manufactures of consumer grade cd players reduced the quality of the laser to around 7,000 hours usable output. This is a light bulb in a sense and all light sources will eventually degrade. The laser has an auto power circuit to maintain the proper calibrated light output and the laser power should NEVER be increased may already be operating near the point at which the laser is damaged. The temperature of the laser diode also increase and as the laser gets warm the light output will decrease. I have seen this many times by monitoring the RF level while playing a reference disc and heating up the unit with a hair dryer in those old units that come in saying skips and stops playing after an hour or so.

Today many el-cheapo units has rated laser light output life of between 700 and 3000 hours. Yes, really that low. Even 7,000 hours comes out to 9.5 months if the unit is playing 24 hours a day. I cannot tell you how many of these consumer grade units I have had businesses bring in that was playing music on hold all the time, then having to tell them it is not a warranty failure due to excessive use and using a consumer product in a commercial application (all warranties on consumer goods specifically exclude this type of use)

It is very possible that due to the large air vents required on boomboxes due to the heat generated by the audio output IC, that a lot of dirt gets into the inside of the optical assembly. For example, 99% of the Aiwa units we get in for repair wind up needing new optics to make the play reliably again as the dirt has caused too much internal damage to the delicate optical pickup mechanism.

Sony acknowledges that over 90% of the optics they test come out good on tests, but still replacing them fixed the 'skipping' problem in any given cd player.

The number one failure I was seeing with optics was not the laser diode output, but from the internal grating lens shifting inside the optics (usually from the glue holding the internal grating lens in place had cracked and come loose).

The second failure I would see would be an open focus coil. This was due to poor design where the combo unit would spike the focus coil with full dc b+ on power on of the unit, causing it to exceed its mechanical limits and heat up the windings.

The only case of actual worn out lasers I have seen was in a big box RCA marketed made in China combo stereo. Whenever the unit was plugged in, the laser was on, when the amplifier was turned on the laser would get spiked with large DC voltage. The unit was suppose to have been an exchange in warranty unit, but they had to make it a repair item and supply the modification entire cd mechanisms with circuit board and an auxiliary circuit board as well.

LD players due to the larger optical pickup assembly used and the higher cost design of the unit are made to last MUCH longer than the normal el-cheapo cd player.

DVD players on the other hand are currently being made so cheaply that we are commonly seeing them in for repair JUST out of warranty with weak lasers (even from major manufactures). Just look at this Oritron super junk DVD brand that is currently on the market right now. Get real: $125 for a DVD player, what kind of junk is it really. I have a friend that works at the local Best Buy service desk and asked him after seeing a pile of these units that have been returned about them, most of them actually have problems within the first week that need to be sent back to the manufacturer for repair. No actual parts or service literature is available for these units.

CW Laser Light (reverse engineered from commercial unit)

This circuit was traced from a commercial CW laser light. Errors may have been made in the transcription. The type and specifications for the laser diode assembly (LD and PD) are unknown. The available output power is unknown but the circuit should be suitable for the typical 3-5 mW visible or IR laser diode (assuming the same polarity of LD and PD or with suitable modifications for different polarity units.)

If you do build this or any other circuit for driving a laser diode, I suggest testing it first with an LED and discrete photodiode to verify current limited operation. Them with the laser diode in place, start with a low voltage supply rather than 9V until you have determined optimal settings and work up gradually. Laser diodes are very unforgiving.

Note the heavy capacitive filtering. Changes would be needed to enable this circuit to be modulated at any reasonable rate.

```
           D1
 +9 >------|>|-------+------------+-----------------+-----+--------+
         1N4001      |            |                 |     |        |
         Reverse     |            |      Pwr Adj    |    _|_     __|__
        Protectio n  |            /      R3 10K (2) | PD /_\  LD _\_/_
                     |        R2  \     +----+      |     |        |
                     |       560  /     |    V      +-----|---||---+
                     |            \     +---/\/\--+-------+   C4   |
                     |            |     |         |          .1 uF |
                     |+           |     |         +----||----+     |
                   __|__          |     |       __|__  C2 (1)|     /
                C1 -----          |     |     E /   \  100 pF|     \
               10 uF | -          +-----|------' Q1  '-------+     / R4
                     |            |     |    BC328-25 (5)    |     \ 3.9
                     |            |     |       (PNP)        |     |
                     |            |     |                    |     |
                     |        +---+     |                    |   |/ Q2
                     |        |_ _|_i   |                    +---|  BD139 (NPN)
                     |     VR1  _/_\_   |                   +|   |\ (5)
                     |    LM431   |     |              C3  __|__  E|
                     |    2.5 V   |     |           10 uF  -----   |
                     |    (3)     |     |                   -|     |
          R1 3.9     |            |     |                    |     |
 GND >----/\/\/\-----+------------+-----+--------------------+-----+
```

Notes:

1. Capacitor C4 value estimated.
2. Potentiometer R3 measured at 6K.
3. LM431 shunt regulator set up as 2.5 V zener.
4. Supply current measured at 150 mA (includes power on LED not shown).

5. Transistor types do not appear to be critical.

Use of a CD, CDROM, CD-R, or DVD disc as diffraction grating

You have no doubt been impressed by the neat and nifty rainbow patterns seen in the reflection off of a compact disc. This is due to the effect of the closely spaced rows of pits acting like a diffraction grating.

How good is it?

I tried an informal experiment with both a normal music CD and a partly recorded CD-R (using the label side of the CD-R as the green layer on the back is a great filter for 632.8 nm HeNe laser light!).

Both types worked quite well as reflection gratings with very sharply defined 1st and 2nd order beams from a collimated HeNe laser. There was a slight amount of spread in the direction parallel to the tracks of the CD and this was more pronounced with the music CD, presumably caused by the effectively random data pits.

If you can figure out a non-destructive way of removing the label, top lacquer layer, and aluminum coating, the result should be a decent transmission type grating.

Note that there is usually no truly blank area on a normal CD - the area beyond the music is usually recorded with 0s which with the coding used, are neither blank nor a nice repeating pattern. The CD-R starts out pregrooved so that the CD-writer servo systems can follow the tracks while recording. There is no noticeable change to the label-side as a result of recording on a CD-R.

The track pitch on a CD is about 1.6 um or about 625 grooves/mm, quite comparable to some of the commercial gratings from Edmund Scientific or elsewhere. (Note that this is the nominal specification but may vary somewhat and will be less on those CDs that contain more than 74 minutes if music or 650 MB of data but it is probably constant for any give CD.) For a 1 mm HeNe spot, the curvature of the tracks is totally inconsequential. However, for larger area beams, this will have to be taken into account - using outer tracks will be better.

The 'tracks' on a DVD are much closer together - .74 um compared to 1.6 um for a CD. Since this spacing is very close to the 632.8 nm wavelength of a HeNe laser, only the 0th and first order spots will be present and the first order spots will be at a large angle - 59 degrees *within* the polycarbonate substrate. This becomes an even larger angle when they exit due to the refraction from the surface. At this extreme angle, the spots are weak and distorted. The typically longer wavelength of a laser pointer (up to 670 nm or more) would be even worse. Shorter wavelengths (like that of a green HeNe laser at 543.5 nm) would result in a smaller angle and cleaner spots.

Interestingly, on my DVD demo disc (I don't even own a DVD player), the reflection from the label-side also shows a rainbow pattern but it has a track spacing consistent with the CD rather than DVD format. (The DVD is a sandwich of two .6 mm thick polycarbonate substrates with the information on their inner surfaces allowing for either a single or double-sided disc. In the case the pattern for the label-side is just there for decoration!)

Most other optical media can be used as diffraction gratings as well. DVDs (Digital Versatile Discs) in particular should be even better at this as their tracks are much closer together than those on CDs :-).

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Service Information

Advanced CD troubleshooting

If the solutions to your problems have not been covered in this document, you still have some options other than surrendering your CD player to the local service center or the dumpster.

When tackling electronic faults, a service manual with schematics will prove essential. Many manufacturers will happily supply this for a modest cost - $10 to $50 typical. However, some manufacturers are not providing schematics - only mechanical and alignment info. Confirm that a schematic (not just a block diagram) is included if you need one before purchasing the manual.

Sams Technical Publishing (formerly Howard Sams) publishes Sams Photofacts service data for almost every model TV that has ever been sold but their selection of CDfacts is nearly if not totally nonexistent.

Test point locations, important signals, and power supply voltages are often clearly labeled on the electronics board. In this case, quite a bit of troubleshooting can be done without the schematic. There is a good chance that the problem can be isolated to a particular subsystem by just following the signals using this information.

Whatever the ultimate outcome, you will have learned a great deal. Have fun - don't think of this as a chore. Electronic troubleshooting represents a detective's challenge of the type hat Sherlock Holmes could not have resisted. You at least have the advantage that the electronics do not lie or attempt to deceive you (though you may beg to differ at times). So, what are you waiting for?

Web resources

Tandy (Radio Shack) has a nice web resource and fax-back service. This is mostly for their equipment but some of it applies to other brands and there are diagrams which may be useful for other manufacturers' VCRs, TVs, CD players, camcorders, remote controls, and other devices.

- Radio Shack Product Support

Since Radio Shack does not manufacture its own equipment (I can tell this doesn't particularly surprise you!) - they are other brands with Realistic, Optimus, or other Radio Shack logos - your model may actually be covered. It may just take a little searching to find it.

Suggested references

There are a variety of books dealing with all aspects of CD player repair. While not as common as books on VCR repair, there are more of these than you might think. Your local public library may have some in the electronics section - around 621.38 if your library is numbered that way. Technical bookstores, electronics distributors, and the mail order parts sources listed in this document carry a variety of these texts.

1. Troubleshooting and Repairing Compact Disc Players
   Homer L. Davidson
   TAB Books, A Division of McGraw Hill, Inc., 1989
   Blue Ridge Summit, PA 17294, USA
   ISBN 0-8306-9107-3 (hardcover), ISBN 0-8306-3107-0 (paperback)

   Includes several complete CD player schematic diagrams which are quite interesting in their own right.) There is now at least a third edition (1996).

2. Compact Disc Troubleshooting and Repair

Neil Heller and Thomas Bentz
Howard W. Sams & Company, A Division of Macmillan, Inc., 1988
4300 West 62nd Street
Indianapolis, Indiana 46268, USA
ISBN 0-672-22521-2

3. The Compact Disc Book - A Complete Guide to the Digital Sound of the Future
   Bryan Brewer and Edd Key
   Harcourt Brace Jovanovich, Publishers, 1987
   Orlando, FL 32887
   ISBN 0-15-620050-3 (paperback)

   Includes a variety of high level information but no details.

4. The Complete Guide to Digital Audio Tape Recorders including Troubleshooting TIps
   Erik S. Schetina
   P.T.R. Prentice Hall
   Englewood Cliffs, NJ 07632
   ISBN 0-13-213448-9

   Mostly directed to digital audio tape recording but also includes some information on digital sampling and CIRC coding.

5. DAT - The Complete Guide to Digital Audio Tape
   Delton T. Horn
   TAB Books, Inc., 1991
   Blue Ridge Summit, PA 17294-0214
   ISBN 0-8306-7670-8 (hardcover), ISBN 0-8306-3670-6 (paperback)

   Includes a chapter on the compact disc.

6. The Compact Disk
   Ken C. Pohlmann

7. All Thumbs Guide to Compact Disc Players
   Gene B. Williams
   TAB Books, Inc., 1993
   Blue Ridge Summit, PA 17294-0214
   ISBN 0-8306-4179-3 (paperback)

   This one is very basic but does cover the most common problems and has illustrated instructions for hookup, cleaning the lens, cleaning and lubricating the mechanism, simple electronic problems, etc.

Rubber belts in CD players

The type of belts used in CD players for drawer loading and sometimes elsewhere is nearly always a type with a square cross section. Obtaining an exact replacement belt may be difficult and not really necessary.

Measure the old belt and select one from a parts supplier like MCM Electronics which is as close as possible - equal or slightly greater thickness and an inside circumference (this is how they are measured) such that it will be tight but not so tight as to slow the motor or cause damage to the bearings. This usually means about 5 to 10 percent less than the old (stretched) belt.

Interchangeability of electronic and mechanical components

The question often arises: If I cannot obtain an exact replacement or if I have a CD, VCR, or other equipment carcass gathering dust, can I substitute a part that is not a precise match? Sometimes, this is simply desired to confirm a diagnosis and avoid the risk of ordering an expensive replacement and/or having to wait until it arrives.

For safety related items, the answer is generally NO - an exact replacement part is needed to maintain the specifications within acceptable limits with respect to line isolation, X-ray protection and to minimize fire hazards. However, these components are rare in CD players.

Although only a few manufacturers produce most of the components in CD players and CDROM drives, don't expect a lot of readily interchangeable parts other than the common electronic ones listed below. In their never ending search for cost reductions and technology improvements, manufacturers are constantly tweaking their designs. More and more circuitry is finding its way into custom VLSI chips. Fortunately, these do not fail too often.

The only parts that are fairly standardized aside from the electronic components are motors. Often, if the motor is physically interchangeable, then it will work as a replacement. Electronic components and entire circuit boards (if identical models and production run) can often be substituted without difficulty though servo alignment will probably be needed due to slight unavoidable differences between apparently identical pickups or electronic components.

For common components, whether a not quite identical substitute will work reliably or at all depends on many factors. Except for the optical pickup, non-custom components in CD players are fairly standard.

Here are some guidelines:

1. Fuses - exact same current rating and at least equal voltage rating. I have often soldered a normal 3AG size fuse onto a smaller blown 20 mm long fuse as a substitute.

2. Resistors, capacitors, inductors, diodes, switches, potentiometers, LEDs, and other common parts - except for those specifically marked as safety-critical - substitution as long as the replacement part fits and specifications should be fine. It is best to use the same type - metal film resistor, for example. But for testing, even this is not a hard and fast rule and a carbon resistor should work just fine.

3. Rectifiers - replacements should have at equal or better PRV and Imax specifications. For power supply rectifiers, 1N400x types can usually be used.

4. Transistors - substitutes will generally work as long as their specifications meet or exceed those of the original. For testing, it is usually ok to use types that do not quite meet all of these as long as the BVceo and Ic specifications are not exceeded. However, performance may not be quite as good. For power types, make sure to use a heatsink.

5. Motors - small PM motors may be substituted if they fit physically and their winding resistance are reasonably similar (say, within 25 percent of one-another).

   Brushless DC spindle motors are not usually interchangeable.

6. Sensors - many are sufficiently similar to permit substitution.

7. Power transformers - in some cases, these may be sufficiently similar that a substitute will work. However, make sure you test for compatible output voltages to avoid damage to the regulator(s) and rest of the circuitry.

8. Belts - a close match should be good enough at least to confirm a problem or to use until the replacements arrives.

9. Mechanical parts like screws, flat and split washers, C- and E-clips, and springs - these can often be salvaged from another unit.

10. Optical pickups - see the section below: "Interchangeability of components in the optical pickup".

The following are usually custom parts and substitution of something from your junk box is unlikely to be successful even for testing: microcontrollers, other custom programmed chips, display modules; and entire optical pickups, optical decks, or power supplies unless identical.

Interchangeability of components in the optical pickup

Once you have located a problem in the optical pickup, what should you do? The quick answer is: probably nothing. In the end any such attempts may simply prove too time consuming and frustrating.

For parts like laser diodes and photodiode arrays, there are probably too many variables to consider and the labor and risks involved - even for the do-it-yourselfer - would likely be unacceptably high. As an example, the laser diode, which is an expensive component you might be tempted to attempt replacing with one from another pickup (1) may not fit physically, (2) may have different polarity laser diode and photodiode inside the case, (3) may have a very different threshold current and safe operating current, and (4) may have a different optical alignment with respect to any index marks. Any of these would likely make the interchange virtually impossible. The only possibility like to have any chance of success would be to replace the laser diode with a known working device from another *identical* pickup. This is known to work for at least some models but I wouldn't guarantee its success in general.

The only breakdown below the pickup level that I would consider as having a reasonable chance of success would be to swap the lens assembly including focus and tracking coils between identical pickups. The optical alignment is not supercritical at this point. However, servo alignment might be needed after this exchange. See the section: Aligning the lens assembly after replacement.

One style of lens assembly found in many (Sony) pickups is mounted with two tiny Torx style screws from the top of the optical block. Pop the black plastic cover and you will see these at the end opposite the lens. A small straight blade screwdriver or .7 mm hex wrench may work in place of the Torx. Unsolder the four connections for the focus and tracking coils and the entire lens assembly can be removed without disturbing anything else. (Yeh, right, like anyone would actually go to all this trouble!). The lens assembly may be mounted on a platform that is fastened with three screws - two which affect optical alignment from the bottom and a spring loaded screw from the top. Once the alignment is set at the factory, the lens assembly is fixed in place with adhesive. It should not need to be touched.

Thus, interchange of these lens assemblies is possible but expect to spend a lazy afternoon or more :-(. However, you will probably wish you had that friendly unemployed Swiss Watchmaker for your assistant.

If you have narrowed the problem down to the pickup and you have an identical pickup which you believe to be functional, the best bet is to exchange the entire pickup as a unit. Only minimal servo system alignment would likely be needed after such a replacement. The only optical adjustment needed might be the setting making the beam perpendicular to the disc surface - possibly a hexagonal nut on the bottom of the deck. Be careful with respect to static discharge which could destroy the laser diode. Sometimes, the cable carrying the laser drive voltage has a pair of solder pads to short while handling the pickup not connected to the electronics board. Take care not to rip any of the fine ribbon or other electrical cables and avoid damaging the delicate lens assembly. One other risk is that the laser power adjustment may be set too high for your new pickup - especially if you had turned it up in an effort to revive a weak laser diode.

Better yet is to replace the entire optical deck as a unit. This is a lot less work and there is no risk of optical alignment problems at all. Then, only (probably minor) servo alignment may be needed.

If you are lucky, the design of your player will even permit you to twiddle the servo adjustment screws while attempting to play a disc (with all the wiring in place) - which is really handy. Also see the section: Test CDs.

Aligning the lens assembly after replacement

Should you need to remove the lens assembly from a Sony or other optical pickup, it will need to be replaced in *precisely* the same position, accurate to .1 mm or better. Unless it is keyed in place to begin with, this will require monitoring of the return beam and maximizing the amplitude of the sum of the photodiodes A,B,C,D from a mirror or disc.

First of all, hope you never have to deal with this!

Second, it may be fundamentally impossible to accomplish with a disc in place unless you are the size of a dust mite and can fit between the CD and the pickup!

Finally, a minor miracle may also be required and it is best to arrange for this ahead of time :-).

If you get mostly one type of pickup, then you can build a test device which would power the laser and and provide a test point to monitor the combined photodiode current. In principle, it is simple. In practice you will most likely need a custom device for each type of pickup.

With some CD players, you can do this in test mode and monitor the RF while adjusting the alignment.

Recommended parts suppliers

For general electronic components like resistors and capacitors, most electronics distributors will have a sufficient variety at reasonable cost. Even Radio Shack can be considered in a pinch.

However, for consumer electronic equipment repairs, places like Digikey, Allied, and Newark do not have the a variety of Japanese semiconductors like ICs and transistor or any components like flyback transformers or even degauss Posistors.

See the document: Major Service Parts Suppliers for some companies that I have used in the past and others that have been recommended. Also see the document: Troubleshooting and Repair of Consumer Electronic Equipment for additional parts sources.

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-- end V3.47 --

Notes on the Troubleshooting and Repair of Optical Disc Players and Optical Data Storage Drives

including

LaserDisc, MiniDisc, DVD, WORM, CD-R, MO
Version 1.28

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Working on optical storage equipment entails a number of personal risks: electrical, laser, mechanical, as well as the possibility of irreversible damage to the equipment and loss or corruption of data due to improper repair or adjustment.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Introduction

Scope of this document

While compact disc (CD) players and CDROM drives account for the vast majority of optical disc platforms in the known universe, there are other types in use for both entertainment and data storage applications. These include:

- LD - LaserDisc - various forms of storage of feature length movies, instructional programs, and interactive video games on (usually) 12 inch single or double sided discs.

- MD - MiniDisc - Sony's attempt at converting everyone from analog cassette tape to optical digital record/play technology. Data storage versions also available.

- DVD - Digital Versatile (or Video) Disc - Super hyped next generation in video and data storage. This *will* replace CDROM but how much further it goes remains to be seen.

- WORM - Write Once Read Many drives - Older optical data storage storage technology using a media that may be written but which may not be erased and rewritten.

- CD-R - Recordable CD. A special case of WORM technology using the CD format which may be played or read in normal CD equipment. The CD-R writers are coming down in price and becoming much more common.

- MO - Magneto optical disk drives - various incompatible or marginally compatible forms of high capacity read/write storage on optical platters, usually in either 3-1/2" or 5-1/4" form factors, single and double sided.

These all use optical technology very similar to that of the compact disc and CDROM. Thus, most problems with these cousins of the CD will be similar. See the document: "Notes on the Troubleshooting and Repair of Compact Disc Players and CDROM Drives" for an introduction to the basic technology, general maintenance procedures, and diagnosis of most common problems. This document addresses those aspects of the technology and repair that are unique to each of these other formats. Problems with Sony PlayStation PSX (and similar) CDROM-like game machines are covered there as well.

Once CD (and DVD) rewritable technology becomes more popular (and lower in price), these will be added. I currenty have little information on this equipment.

Contributions are always welcome as you will note that there really isn't that much specific information at the present time on anything other than LaserDisk players and even this is sparse. I don't expect that much interest in or offers of CD-R, WORM, or MO repair information. However, MiniDisc has some sort of a following and we are destined to be inundated with DVD problems in the near future as they replace CDs as the equipment of choice. I am still waiting to see the inside of a DVD player - working or otherwise :-).

SAFETY

In addition to the usual safety precautions outlined in the document: "Safety Guidelines for High Voltage and/or Line Powered Equipment", some of this equipment has the added risk of vision damage from the higher power lasers that may be used for disk writers or recorders.

This isn't that much of a problem with LaserDisk players since the laser power is likely (but not guaranteed!) to be similar to that of a CD player where relatively minimal precautions are adequate.

However, for the technologies which can record or write on an optical disk, the laser power may be much higher and instant irreversible damage to vision is quite possible. Furthermore, these are almost always IR (infra-red) lasers which are for all intents and purposes, invisible. Proper precautions are essential and laser-blocking goggles are definitely recommended whenever the unit is powered without a laser shield in place. Once you damage both of your original equipment eyesballs, you don't receive any replacements (even if they are still under warranty - read the fine print of your contract)!

General safety precautions:

While there are fewer potential dangers involved in servicing an LD player or MO drive compared to a TV, monitor, or microwave oven, precautions are still required when working with the cover removed. These relate to electrical connections to the AC line, getting caught in the mechanisms, and exposure to the laser beam:

- Electrical: There may be a few exposed electrically live parts from the power line, usually around the power cord entrance, power transformer, and on/off switch. If there are, tape them over or cover them somehow so you need not be concerned with a low tech shock! Unless you are troubleshooting a primary side power supply problem, there will be no need to go near the AC line.

  Some equipment such as LaserDisc players may use switching power supplies with their own set of problems. Internal drives may include their own DC-DC converters as well (which are not particularly dangerous but can be easily damaged through the careless slip of a probe). In these case, see the document: "Notes on the Troubleshooting and Repair of Switchmode Power Supplies" for more information.

  Where an older LaserDisc player uses a Helium-Neon (HeNe) laser, there will be a high voltage power supply for the HeNe laser tube. While this is probably not powerful enough to kill you, a reflex action from touching the wrong terminal can result in collateral damage like ripped flesh from sharp sheet metal parts. These terminals are usually clearly marked and insulated but make a note of their location to be safe and add several layers of plastic electrical tape if they are exposed.

- Mechanical: Some of this equipment including LaserDisc players and higher performance optical drives spin relatively heavy (at least compared to a CD) platters at 3,600 RPM or more. The motors are larger and you really do not want to catch your tie in one of these (yes, I know, you don't wear a tie!).

- Laser: A variety of types of lasers are used in this equipment. It may be a diode type - either visible or IR, or in older LaserDisc equipment, a low power helium neon tube.

  - Low power (Class II, less than 1 mW at the lens) - This power level is typically used for the play-only or read-only equipment (CD, LD) or when in play or read mode for equipment that can write or record (MD, CD-R, WORM, MO).

  - Medium power (Class IIIa, 1 to 5 mW at the lens) - This power level may be used for recording or writing in a CD-R, MD, or MO device.

  - Medium power (Class IIIb, 5 to 30 mW or more at the lens) - This power level may be found in a CD-R or WORM drive in write mode. A typical CD-R drive sets the laser power at 3 to 5 mW for read and 25 to 30 mW for write.

  ALL THE HIGHER POWER LASERS ARE LIKELY TO BE IR AND INVISIBLE! You won't be able to see a bright beam you can avoid! The laser in all these devices is infra red, near IR - around 780 nm - border of visible range but for all intents and purposes invisible. While the laser is supposed to be set to low power for playing or reading POWER CIRCUITS CAN FAIL! Don't take any chances.

  With a visible beam, it is easier to avoid exposure and LD and DVD players use low power lasers anyhow. Reflections at these power levels are not strong enough to be a serious hazard. This will change eventually as DVD recorders and writers using higher power visible lasers are introduced. As a comparison, these will likely be similar in power level (5 mW) to the brightest laser pointers currently on the market and are a definite risk to vision at close range. Still, being visible, it is easy to avoid direct exposure.

However, for an IR laser producing an invisible beam, there is no way to reliably avoid the beam visually. With the optics intact (no damage to the pickup and none of the covers on the pickup removed) and a disk in place on the spindle or the lens covered with black tape (no holes!), it should be safe to work at a reasonable distance. Don't put one of your eyeballs up to the optical block - there could always be a light leak! Proper IR blocking goggles would definitely be a good idea where exposure to these higher power lasers is possible.

CAUTION: There is usually a very low intensity (in appearance) emission from an IR laser which appears deep red. It will be visible as a spot the size of the period at the end of this sentence when the lens is viewed from an oblique angle. This is just your eye's response to the near IR energy of the main beam. (Some people apparently cannot see this at all.) Do not be mislead into thinking that the laser is weak as a result of how dim this is. The main beam is up to 10,000 times more intense than it appears! It's power output is generally around 1 mW - comparable to a laser pointer. Take care. However, the red dot is an indication that the laser is being powered and probably functional, though it is no guarantee of the later. You really need a laser power meter or at least an IR detector to confirm the existence of an IR laser beam.

For more information on CD and optical disc technology

Philips/Magnavox used to have a very nice on-line introduction to a variety of consumer electronics technologies. Although their site has disappeared - and even people who work for them have no clue - I have now recovered several of the articles including those on TVs, VCRs, camcorders, satellite reception, and connections. See the Introductory Consumer Electronics Technology Series.

Also check out:

- A Fundamental Introduction to the Compact Disc Player is a somewhat more theoretical discussion of compact disc audio technology with diagrams and even some equations. If it doesn't put you to sleep, you will find quite a bit of interesting information in this article. In either case, it may prove of value.

- Andy Poggio's relatively short article: From Plastic Pits to "Fantasia" provides a nice overview of CD technology.

- The University of Washington has a couple of on-line tutorials which both appear to be excellent resources providing easy to understand discussions with many diagrams:

  - Compact Disc Technology.
  - Audio Compact Disc - An Introduction. This is part of their Consumer Electronics Education Project.

- The How Stuff Works Web site has some really nice introductory material (with graphics) on a variety of topics relating to technology in the modern world. Of relevance to this document are articles on CD technology, motors, remote controls, power adapters, etc.

- The Cimram International, Inc Web site provides information and links on CD and DVD technology, formats, mastering, and manufacturing.

The following sites have a variety of information on CD and DVD technology:

- CD Page
- MediaWorld

A couple of sites with CD-R specific information including some repair tips is:

- Rictee's CD-R Page.
- Andy McFadden's CD-R FAQ.

An extensive amount of information on other optical disc/k technologies with many useful links can be found at:

- Leopold's LaserDisc Page.
- The MiniDisc Page.
- The DVD Page.
- DVD Central at E/Town.
- DVD Demystified (Includes the DVD FAQ).

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Technology Specific Principles of Operation

LaserDisc (LD) Players

This is actually the oldest of the optical disc technologies to be introduced to the consumer market. In fact, most of its applications are for analog video storage - feature length movies and interactive learning tools and video games.

In terms of performance, video quality from the Laserdisc medium can be far superior to even SVHS and SuperBeta when viewed on a correspondingly high quality TV/monitor. Like a CD and unlike tape, access to any scene or even frame is nearly instantaneous. This is definitely a significant advantage for the casual viewer. However, it is the enabling technology for interactive learning and games. With over 65,000 individual frames on a side, this is a potentially very powerful way to present information as combinations of stills and moving segments and permit context dependent control of access or video action.

High-end video enthusiasts swear by Laserdisc technology but this medium never caught on due to its relatively high cost of both the equipment and the software (movies), limited rental availability, and because it is a play-only media. In addition, the capacity (NTSC) of a single LaserDisc is around 1 hour total on both sides requiring frequent disc changes even if the player has dual laser pickups.

The basic eletro-optical mechanism is similar to that of a CD including the techniques used for beam generation, focusing, and tracking. However:

- Older units may use a helium neon laser instead of laser diode for the light source. All newer LD players use laser diodes similar to those found in CD players.

- There will likely be an additional servo for pickup tilt to assure that the laser beam is perfectly perpendicular to the disc surface. Since the information is analog, this is needed to minimize crosstalk between tracks.

- Most mechanical components will be larger and much more robust since spindle speeds can reach 3,600 RPM with the large mass of a 12 inch platter.

- Both CLV (Constant Linear Velocity) and CAV (Constant Angular Velocity) encoding has been used and both may be supported on one player.

- Most LD players also will play audio CDs so testing with this less demanding medium is a good way to determine if the basic optics and electronics are in working order.

(From: Mark Zenier (mzenier@netcom.com).)

The original version is covered in The "Television Engineering Handbook" edited by Benson from McGraw-Hill, 1986. Don't know about the newer version with digital sound. (Or what the newer edition of the book covers, either).

It's an analog FM system at 8 MHz that records the composite signal, with two FM audio carriers at 2.3 and 2.8 MHz.

So what about the RCA "CED" video player?

CED stood for something like "Capacitive Electronic Disc" probably with a "Selectavision" label.

It is NOT related to LaserDisc technology and does not use an optical pickup.

If you found one of these, you have a classic dinosaur! The CED system was something RCA spent $200-300 million to develop about the same time that LaserDisc technology was being perfected. Guess which won!

And, this was shortly after the same company spent a similar vast amount of money on another consumer electronics dud. It was also named Selectavision if I recall correctly and used optical scanning of 4 mm (??) movie film.

CED uses a capacitive contact sensor 'sled' running in a grooved disc.

The pickup actually rides on the disc like the stylus on a phonograph record. The sensor detects minute changes in the capacitance between the tip of the pickup and the metallized surface of the disc embossed with millions of tiny bumps and valleys.

This really isn't that bad - the system DID work but suffered from some of the same problems as records - wear, critical tracking requirements, etc.

If you are trying to resurrect a CED player, you better have the discs you want because they will not be available at your neighborhood video store!

Since it is more than 15 years old, there can be any number of problems with the equipment just from age and non-use. These are likely to be both mechanical (gummed up grease, dirt), and electronic (dried up electrolytic capacitors in the power supply, bad connections, etc.).

However, chances are good that it wasn't actually broken to begin with since consumers likely gave up on this technology before it actually failed - there just wasn't enough movies/programming available.

Start by checking the obvious, reseating all connectors, testing power supply voltages and for ripple, etc.

It certainly would be cool to get working.

MiniDisc (MD) recorders/players

The MiniDisc cartridge looks somewhat like a small (2-1/2") version of a 3-1/2" computer diskette. Both players (around) $400 and player/recorders (around $700) have been introduced with disappointing sales. Not enough prerecorded material was available and the prices were too high to lure people away from the convenience, low cost, and limitless variety of the audio cassette medium.

MDs may be pressed like CDs with the information encoded in pits and lands. This is the way prerecorded play-only MiniDiscs are made.

For recording, the MiniDisc technology uses a higher power laser beam (upped to 5 mW at the disc surface) to heat a magneto-optically active coating to above its cure point (where magnetization is lost). A writing coil in close proximity to the back of the Minidisc is used to switch the magnetic field polarity (N or S) of the coating as it cools. Thus, the laser beam may be thought of as 'softening up' the magnetic material but the actual writing is by the coil. This is not the same way most other writable magneto optical drives are implemented. See the sections: "WORM drives" and "Magneto optical drives" for more details on these other media.

For playback of this magneto-optical (MO) recording, the pickup uses what is known as the 'magneto-optic Kerr effect'. When a polarized laser beam is reflected from the disc coating, its polarization orientation is rotated slightly depending on the magnetic field polarity (N or S). This rotation is small (about 1%) but enough to permit detection. However, since it is so small, it isn't surprising that there can be problems with the optics and front-end electronics for MO readback.

Thus, the MiniDisc pickup and front-end operates in three modes: spatial (pits and lands) read, MO read, and MO write.

The basic mechanism and optical pickup is similar to that of a CD including the techniques used for beam generation, focusing, and tracking. However:

- Additional components will be present to detect the magneto-optic Kerr effect for playback of MO recordings.

- The laser can be switched between low and high power (as well as off). However, this is not a particularly high speed change as the modulation is done by the external magnetic field coil. WARNING: IR, invisible, 5 mW at the lens is enough power to be a significant risk to vision.

- The magnetic field coil will be found directly opposite the lens (and thus it may block any access to the lens unless it is removed for servicing.

- Extensive information compression techniques are used to enable roughly the same amount of audio to be stored on a MiniDisc with about 1/5th the surface area of a CD. For data storage, this is not usually possible so an MD may hold 'only' 125 MB or so of computer information.

Digital Versatile (or Video) Disc (DVD)

The DVD is destined to replace the CD as *the* optical medium of choice in the near future. This will happen if for no other reason than manufacturers will stop producing CD players (since DVD players will be able to read CDs).

The basic components are very similar and thus cost of manufacture will be similar. So, why produce old fashioned equipment?

The DVD permits storage of up to 4.5 GB per information layer with up to 2 of these on each side (one under the other) for a total of 18 GB if fully implemented. This means (per layer):

- 8 hours of CD quality audio.

- 2 hours of MPEG-II compressed LaserDisc equivalent video (Note: there is much debate as to the actual level of quality but we won't get into that here).

- Multilingual sound tracks.

- Any mixture of these.

The 8-fold increase in storage capacity per layer is accomplished through a number of incremental enhancements to the basic CD technology including:

- Use of a 635 to 650 nm red-orange laser diode instead of a 780 nm IR laser diode.

- A higher quality (actually higher NA) optical system permitting a smaller spot on the disc.

This permits:

- Closer track spacing on the disc (.8 um instead of 1.6 um).

- Higher CLV bit density.

For readout on both sides of a dual-sided DVD, dual optical pickups can be used where the user is willing to pay for this significant added expense!

From a marketing perspective, it is essential for DVD equipment to support the CD format. However, since DVDs and CDs differ in terms of feature size, track spacing, thickness, and so forth, it would not be very effective to simply shine the DVD pickup at a CD! Either of two approaches may be taken:

- Include dual optical pickups. This is probably the best way to assure total compatibility but is obviously an expensive solution.

- Provide optics that may be switched into the beam path to 'simulate' a CD pickup. The shorter 635 to 650 wavelength light is still used in both cases but the beam width and focus are adjusted with an intermediate lens or holographically generated compensator.

Are blue lasers used in DVDs?

The readout laser for DVDs is red, around 650 nm. This is similar in color to a typical red LED.

Some people seem to think blue lasers are used for DVDs. One reason may be that manufacturers are putting blue illumination on the front panels and maybe even inside the disc compartment of DVD players - solely for marketing reasons.

However, blue or UV lasers (e.g., argon or krypton ion) may be used to write the glass master for DVD (as well as CDs) where the shorter wavelength results in crisper more accurate rendition of the pits and lands of the information layer. Of course, these machines cost $250,000.

Converting to a shorter wavelength laser for readout won't help anything except the manufacturer's bottom line assuming they could charge much more for the hype than the additional cost of the laser. Currently, the only viable option is the Nichia 400 nm violet laser diode which go for about $2K each! To take advantage of a shorter wavelength laser, the entire standard would need to be revamped. I have already named the new standard: the "Digital Ultra Disc" or DUD. :) Once those violet lasers (or alternatives) come down in price, there is little doubt that the World will be treated to yet another advance in technology whether anyone wants it or not.

Will DVD be the killer format?

There has been and will continue to be a lot of hype with respect to the incredible advantages of the Digital Video (Versatile) Disc for everything from computer multimedia to HDTV.

Here is my take. My track record isn't great on predicting the future as my crystal ball has been broken for a long time, so don't buy or sell shares in any company based on these comments!

DVD will do very well for data storage since due to its much higher capacity compared to CDROMs (5 to 20 GB versus .64 GB), it will serve an important purpose in the increasingly interactive applications and games to come.

Full size DVD will be overkill for many audio applications. At the normal CD audio sampling rate of 44.1 K/second, the smaller DVD format will hold over 8 hours of music. Whether people will be willing to pay the expected price for a DVD with several hours of music is questionable. There certainly will be many good reasons to do this - full concerts or operas on a single disc, for example. I would expect the average total length of normal musical DVDs to increase beyond what is typical of CDs as well.

However, mini-DVDs are possible. A 3-1/2" format would hold about 1/3 as much as a full size DVD or over 2 hours of music. This or an even smaller format would be ideal for discman applications.

What about multilinqual sound tracks? Sure, this capability may save money by requiring pressing of only one disc to support multiple markets. But, few people will have a need to pay for this.

There are no doubt all sorts of applications that have not been identified yet for which the DVD is ideal. However, the hopes of the industry are pegged to DVD's success for video - in part, to replace the consumer (VHS) VCR. Unfortunately, It is here where I believe DVD has its greatest weaknesses.

Many of the specifications have been developed tailored to today's video standards, not HDTV. The DVD is supposed to be superior to both VHS VCR and laserdisc formats. However, this is in comparison to standards (NTSC and PAL) that are close to celebrating their 50th birthday. Even the quality advantages are questionable as so much depends on the MPEG-2 encoding used to compress the vast amount of video information onto the DVD.

Video tape and laserdiscs do not care what is recorded on them - they are equally good or equally poor for static scenes as well as explosive action shots. This is not true of DVDs. Complex images and rapid scene chances require more bits to minimize artifacts. And, the types of artifacts that are introduced are not those one expects from poor reception or bad tapes. It will take a great deal of effort on the part of the companies who will be converting original movies and other source material to the DVD to do justice to the format. It may simply be impossible for certain action sequences. The result may be 'pixelation' or momentary blockiness, erratic motion, momentary freezes, and so forth - not just slight fuzziness or snow. It is not known how the general viewer will accept these. Developers of source material will not be free to put in whatever they desire. The medium may break down when presented with too much fast complex action or rapid scene changes.

The situation gets even murkier for HDTV where the required amounts of data and data transfer rates increase dramatically. Depending on HDTV format, this could be anywhere from 2:1 or 8:1 - or more. If the DVD is marginal now, what does this say for HDTV?

Initially, DVD will not have record capability. Thus, there will be no compelling reason to switch over and throw out your VCR especially if the quality isn't dramatically better. The majority of consumers don't care that much about picture quality anyhow. Beta, S-VHS, and laserdisc, all have substantially better picture quality than normal VHS and NTSC broadcasts. It has not mattered due to various usability issues and marketing stupidity. The critical mass was never reached with respect to availability of source or rental tapes or discs. Thus, these have been relegated to niche markets and niche markets don't drive the industry.

Will DVDs turn into yet another Edsel, Selectavision, or Betamax? Only time will tell but the industry must make a deliberate effort to assure the quality of the initial releases or else DVD's future as a video media will be sealed before it gets off the ground even if the technology there.

DVD FAQ?

Well one, at least:

- alt.video.dvd FAQ

WORM drives

A large number of technologies have been introduced to provide storage of large amounts of information on optical platters with varying degrees of flexibility.

The earliest were called WORM (Write Once Read Many) drives. Writing resulted in an irreversible change in an information layer. Thus, data could be written but not erased and rewritten (though just erasing a block might be possible). Heating with the writing laser beam resulted in damage (ablating) of a coating. Reading is similar to that used for CDs and other optical technologies.

Typical capacity was 650 MB per side. Disks could be one sided or two sided.

This is somewhat similar to the technology used in CD-R drives though many variations have been developed which vary mostly in the details.

Unlike CDs, MDs, and LDs, these optical discs are formatted more like hard drives or diskettes with circular (not spiral) tracks and fixed sectors - some of which are visible to the naked eye since they are physically etched on the disk itself.

The laser power for WORM drives is typically higher than for read-only drives when in writing mode - likely in the 10s of mW range. 30 mW is one number I have heard. Modern drives all use IR emitting laser diodes.

The basic mechanism and optical pickup is similar to that of a CD including the techniques used for beam generation, focusing, and tracking. However:

- These usually spin at high speed - 3,600 RPM typical - so spindle motors and other mechanical components are more robust.
- Laser power can be switched between a fraction of a mW for reading and high power for writing (in addition to off). WARNING: IR, invisible, Class IIIB, dangerous!

Magneto-optical drives

Most modern optical drives use magneto-optical techniques in some ways similar to the MiniDisc. However, unlike the MD, the laser beam is switched at high speed to alter the magnetic properties of the coating and a write cycle is usually a two step process:

1. Energize the bias coil with the '0' polarity (e.g., N).
2. Erase a block by turning on the laser as that area of the disk passes under the pickup.
3. Reverse the polarity of the bias field to that of a '1' (e.g., S).
4. On the next revolution, write the information by selectively heating only those regions destined to become '1's in the stored pattern.

The laser power for MO drives is typically higher than for read-only drives and likely in the 10s of mW range. Modern drives all use IR emitting laser diodes.

The media is usually enclosed in a cartridge for protection with a door that opens automatically when inserted into the drive. Capacity is typically 650 MB per side for a 5-1/4" disk.

- Additional components will be present to detect the magneto-optic Kerr effect for playback of MO recordings.

- These usually spin at high speed - 3,600 RPM typical - so spindle motors and other mechanical components are more robust.

- Laser power can be switched between a fraction of a mW for reading and high power for writing (in addition to off). WARNING: IR, invisible, Class IIIB, dangerous!

- The bias coil is opposite the lens and may block access for servicing unless removed.

CD-R Recorders/Players

These use media that is the same size as the CD but can be written once and is then read-only like the WORM disk. In many ways, this technology is similar to WORM except that the format is a spiral track like that of a CD rather than circular tracks and sectors like other optical disk formats or hard and diskette drives.

Although CD-R started out being quite expensive (greater than $10,000 for a recorder), it really was designed as an inexpensive technology and to have total compatibility for reading with CDs and CDROMs. Current prices for multispin (2X, 4X) CD-R recorders are under $500 and dropping. The capacity of a CD-R is the same as a CD - about 650 MB.

Like the WORM drive, a higher power laser ablates a coating inside the CD-R media. With most, this is a blue-green polymer dye backed by a gold coating. Otherwise, construction of the CD and CD-R media are similar.

However, since the pits and lands are not as precisely formed as those of a pressed CD whose master was made on a $250,000 laser cutting lath, some CD players or CDROM drives may have tracking or other problems with CD-Rs.

CD-R recorders and high performance CDROM drives are very similar except:

- The laser in a CD-R recorder can be switched to higher power mode and modulated for writing. WARNING: IR, invisible, enough power to be a significant risk to vision.

- Tracking may need to be more robust as before the disk is recorded, there is only a guide groove rather than the pits and lands of a normal CD.

- Servo electronics must be more complex to control disk speed for recording.

- Back to Optical Drive Repair FAQ Table of Contents.

LaserDisc Players

Considerations when troubleshooting LaserDisc (LD) players

CD and LD players share much of the same optical technology. Many models will play normal audio CDs as well as LDs. If this is the case, start by determining if a CD will play properly. If it does, then you can be fairly sure that most of the optics and front-end electronics are functional.

Modern LD players use the same 780 nm laser diodes as CD players. Really old players used Helium-Neon (HeNe) gas lasers resulting in a visible beam at 632.8 nm (orange-red). CAUTION: these use a high voltage power supply. Contact with this probably won't hurt you but will not be pleasant. The high voltage terminals are probably well insulated but it is a good idea to locate them and double check.

Since most LD players also play CDs (and possibly multiple size LDs as well), there will be optical sensors - LED-photodiode pairs aimed at the disc from one or more locations beneath the drawer assembly. If you have the top off for servicing, room lighting may confuse these sensors resulting in all sorts of strange behavior such as attempting to play a CD using the LD spindle! Cover the entire unit with a piece of cardboard or just the holes in the drawer with matt black paper to eliminate the possibility of both electronic and human confusion!

LD players will generally have one additional servo system compared to CD players - tilt. This adjusts the angle of the pickup with respect to the disc to minimize interference between adjacent tracks. This would result in degradation of the analog video signal. The tilt servo is usually pretty simple using an IR LED emitter and a pair of IR photodiodes detecting the reflection from the laserdisc. If after manually rotating the tilt motor away from the balanced position, the tilt readjusts itself, there is a good chance this it is operating correctly. There is probably a tilt balance adjustment as well but don't touch it unless you have the service manual if possible.

Spindle motors in LD players are of much higher quality than typical CD players since the spindle must spin continuously at thousands of rpm with the greater mass of the LD as well. Other motors may be similar to those in CD players. Some LD players have two spindles that are selected and moved into position depending on the type of disk being played.

Due to the mass of LDs, the clamper is even more critical to proper behavior than for CDs. Any slippage and LDs may fail to be recognized.

There may still be rubber belts that degrade :-).

Naturally, a video monitor makes an excellent diagnostic tool once it is possible to obtain some output from the LD player. A service manual is almost a must for serious troubleshooting.

LaserDisc optical alignment?

As noted elsewhere, optics don't generally drift except from abuse.

The following is a further confirmation that optical alignment should not be needed under normal conditions:

(From: Dave A. Wreski (dawreski@nic.com).)

I have been servicing these since they came out. The *only* time I had to do any optical alignments is when some fool decided to mess with the alignments. They do not misalign themselves. In the past the only adjustment we had to do (on Pioneer Laserdisc players) is the 1/4 wave plate which can be done with a scope. All other alignments must be done with a Laser power meter and a polarization adjustment jig from Pioneer. Many dollars!

If the optics are clean and haven't been maladjusted, your unit is suppose to work. If not, look elsewhere in the electrical alignments or motor problems.

Replacement for Helium-Neon laser tube and power supply components

Older LaserDisc equipment used a Helium-Neon (HeNe) laser instead of a laser diode. These use a HeNe laser tube and require a high voltage power supply for operation. The tube can wear out or get broken and the power supply can fail. Obtaining an exact replacement of either is probably virtually impossible today and too costly in any case.

However, it should be possible to substitute a surplus HeNe tube and/or HeNe laser power supply. The tube will have to be of a similar power output (usually around .5 to 1 mW) and physical size. It probably also needs to produce a polarized beam (which eliminates a lot of the common barcode scanner tubes as replacements). If the beam diameter and divergence are similar, it may be possible to get by without any optical alignment as long as the tube is carefully mounted with its output in the same position and orientation as the original. However, since these parameters are probably not known, there could be problems with a swap. In that case, another tube can probably be made to work but some amount of optical alignment (possibly just resetting the position of one lens) will be needed. A service manual will be essential.

HeNe laser tubes with power supplies can be had for as little as $25 from various mail order sources but you need to confirm compatibility. It may be possible to compensate for a different beam diameter and/or divergence by adjusting the external optics. However, you can't easily get a non-polarized tube to produce a polarized beam. (It can be done with powerful magnets but this is probably not a viable option inside a cramped LaserDisc player.) I don't know if LaserDisc players do anything special with optical feedback or anything like that but if it is just a power supply, this may be an easy and inexpensive alternative.

If a suitable HeNe laser replacement is unavailable, too expensive, or just too mundane, it may be possible to use a diode laser - even a laser pointer - in its place. The beam characteristics would need to be similar with respect to divergence and polarization. A unit with adjustable focus will probably be best to match up divergence. Since, all diode lasers are polarized, that at least, shouldn't be an issue. Apparently, some people have successfully done such a transplant without major problems. The most difficulty may arise from devising a suitable mounting arrangement and providing the stable low voltage power needed for the diode laser or pointer. I'd still recommend staying with an HeNe laser if possible but at least, there is an alternative that will keep your prized 1979 LaserDisc player going strong. :)

Kenwood LaserDisc clamping problems

With the larger mass of a LaserDisc compared to a CD, clamping is even more critical. Slipping belts are a common cause of clamping problems.

(From: dwb@rell.com).

I had a problem with my Kenwood machine not locking the disc in place correctly. The drive belt was slipping to bad (couldn't hear it though). The replacement was a NEW mechanism that regeared the assembly for slower feed but more more clamping force.

Philips Laser disk problems and discussion

> "A friend of mine has a Phillips Laserdisc player that is acting up. What it does is the player will just stop playing in the middle of the movie, usually in the same spot."

(From: Douglas W. Jefferys (dougj@freenet.hamilton.on.ca).)

How old is the player? I've worked on the Philips 22VP931 and seen similar things. This is an ancient (ca. 1982) industrial player with a tendency for the radial and tangential mirrors to jam in their servos. (The glue that holds the magnets behind the mirrors weakens with age. If a magnet detaches, the mirror jams solid, but the magnets can also migrate outwards and cause sticky behavior).

If it's an older player, it's *possible* that it's in the early stages of the same failure mode. (That said, all the 22VP931s I've seen that have this failure have had *solid* jams on at least one of the mirrors, so I think it's an all-or-nothing thing.)

Anyways, after fixing the servos (a nightmare - it's a good thing I had help from a knowledgeable source about what to expect when I went into the guts of the thing :-), I did an eyeball alignment (power *OFF*, machine unplugged, a double-check that the power is off and the machine unplugged, and look down through the objective and see if you can see down the entire beam path) and got the same results you did. Worked fine on the early portion of the disk, but slowly screws up later on. High-speed seeks worked marginally early on, and not at all on later portions of the disk.

An examination of the player while playing showed that one of the mirrors was near the limit of its range of movement at the point when the video started freezing up.

NOTE: I'd strongly recommend *against* looking at the mirrors in operation unless it's either a visible-beam system or you have goggles opaque to the laser's frequency. I was willing to be somewhat stupid because it was a visible-beam system, and I still used a piece of paper to ensure my head was nowhere near the areas where bits of beam were leaking from the player. I wouldn't have even fantasized about attempting this with an IR beam.

About three hours and umpteen incremental adjustments of the optical head's alignment screws (which I had to remove and thereby misalign when fixing the servos), and the thing was working fine.

Summary:

1. Check to ensure the tangential/radial mirrors move freely.

2. Check optical alignment on early portion of disk and 'stuck' portion of disk. Preferably with an optical alignment tool, but if you've got goggles or a visible-beam system and more balls than brains, you can *carefully* look at the mirrors when the disk is playing and use that as a guess as to which way to tweak the mirrors.

One final note: Some of the alignment things can be "one-way" adjustments, and anything on the optical path is vulnerable to scratches. I'd strongly advise trying to find the service manual before attempting any modifications.

If you have contacts with professional fixers, I'd also suggest you bounce your ideas off of them before proceeding. When hacking LD players, you're always one mistake away from owning a very expensive pile of spare parts.

Pioneer Laserdisc RS-232 commands

(From: Jim Jackson (jim@aviendha.demon.co.uk).)

Here is a list of commands I have for controlling Pioneer players via the RS-232C jack. Hope it helps. I have also heard that there is supposedly a MCI driver for Windows but I haven't personally seen it. I tried these codes on a Pioneer machine I have at work using the Windows terminal program and was able to control the player. This file is from a public domain file for the amiga. I think I also have a C program (also for the amiga) somewhere if you need it.

Communication protocol:

- Computer activates CTS (pin 5) of RS232 port, (amiga 7-line handshake).
- Then sends a command sequence and expects 'R' and carriage return (CR).
- ASCII digits used for addresses, etc. Returns frame# as ASCII digits.
- Player is string oriented and reverse-polish (arg then verb).

COMMANDS	CHARS	HEX	DECIMAL	COMMENT
Door Open	OP			open the door
Reject	RJ			stop disc rotation
Start	SA			start disc rotation
Play	PL			(address)PL
Pause	PA			
Still	ST			still frame
Step Forward	SF			
Step Reverse	SR			
Scan Forward	NF			
Scan Reverse	NR			
MultiSpeed FWD	MF			(address)MF
MultiSpeed REV	MR			(address)MR
Speed	SP			integer SP
Search	SE			address SE
Stop Marker	SM			address SM
Frame	FR			set frame mode
Time	TM			set time code mode
Chapter	CH			set chapter mode
Audio Control	AD			integer AD 0=off,1=Ch1,2=Ch2,3=stereo
Video Control	VD			integer VD 0=off,1=on
Display Control	DS			integer DS 0=off,1=on
Clear	CL			clear entry or mode
Frame #	?F			get frame number
Time code #	?T			get time code number

```
Chapter #        ?C                                        get chapter number
Player active?   ?P                                        P00=door
open,P01=park,P05=still
Disc status      ?D                                        5 bytes and CR returned
(and a few others....)

SERIAL PORT CONNECTION:

  Computer      Player
 ----------    --------
   TxD 2        3 RxD
   RxD 3        2 TxD
   CTS 5        4 DTR
   GND 7        1 GND
```

```
For more info on your type of Pioneer player:

    Pioneer Communications of America, Inc.
    Engineering and Technical Support Deptment
    Sherbrooke Office Center
    600 East Crescent Avenue
    Upper Saddle River, NJ 07458-1827
```

Pioneer LaserDisc player test program

From: Colin Kraft (ckraft@airmail.net).)

I have just found a RS-232 test program for all Pioneer LaserDisc players on Pioneer's web page. The URL is:

- Pioneer Drivers

It's called testprog.exe and it's quite impressive and handles just about every Pioneer player that has the RS-232 port. It also comes with a nice doc file that cover dip settings for various players and more.

I tried it with my newly acquired LDV4200 and found that it did not work. Right now I am fearing that my player has a problem with the control port. The data seems to be coming through the cable as I get a flashing logic probe when I hook it up but the player does not respond.

I'm not sure about the codes as they are not covered in the otherwise excellent doc file (they always leave something out it seems). However, I think you can get codes for your player through Pioneer.

Comments on Pioneer 8210

(Portions from: Dave A. Wreski (dawreski@nic.com).)

The 8210 service manual is 120 pages long. This is not an easy unit to work on. It is the very first industrial video disk player that Pioneer made. All of the GM dealers had them when they first came out and I have seen them for sale in most flee markets for around $50.00.

These are built like a tank and use a HeNe laser tube and a bunch of discrete optics that are very hard to align properly without the manual.

Pioneer '90' series LaserDisc player doesn't play older LDs

> "Check those discs you are playing. My 1090 won't play some older Image Discs including my (BOO HOO!) Bride Of Re-Animator disc."

(From: Steven B (lasers@netrus.net).)

The 90 series of laser player had a fault that was fixed by Pioneer at no cost. It also caused a whole new series designation. Call Pioneer!

Pioneer CD/LD Player Model CLD-S104 with shorted power supply

(From Mark Z. (zmachar780@aol.com).)

Your Pioneer LD has a shorted protective device, a V1B24 or similar. Looks like a diode and is located near the main AC input to the board. Clip it out, replace the fuse, and normal operation will resume. You STILL NEED to replace it; it protects some very expensive chips. Get the reference number off the board and call Pioneer at 800-457-2881.

Pioneer 503 LD player sled slews to one end after service

(From: illusion@pqc.com).

I have seen that before. The Sled runs on a differential op-amp. This uses +15V and -15V. One of these supplies is out. There are two fuses in power supply for this. Most likely u blew one when changing spindle motor. This will throw loading motor and sled motor, and maybe even the tilt motor (if it isn't also the loading motor) into overdrive in 1 direction. Loss of either supply will shift the differential one way.

Pioneer CLD-D701 tray locking problem?

> "I've owned a Pioneer 701 laserdisc player for many years. Other than its tendency to drift out of alignment slowly and steadily over the years, it has been a good LD player. However, within the last year the tray has developed a strange problem. Each time I turn the 701 on and press the eject button to load a LD it takes about 6 seconds of gear grinding before the tray finally decides to come out. Just a couple of years ago the response was almost immediate.
>
> Once the tray has finally opened, thereafter it behaves normally and responds immediately for as long as the player is left on. Even if it's turned off briefly and back on, the tray behaves OK. However, if I wait to the next day the tray goes back to its nearly 6 second wait again.

There appear to be several opinions as to the cause

First suggests it is a sticky rubber problem:

(From: Jeff Boettler (boettler@us.ibm.com).)

Eject the LD drawer and disconnect from the mains. Then remove the cover. On the 2950 there is a mechanism that clamps the disc that is suspended by metal bars running over the top of the drawer. Remove this, around four screws and locate the motor. There will be a rubber mat that grabs the disc. Clean this with meths and nothing else. Allow to dry and reassemble.

Apparently this problem is accelerated by dirty labels on the LD and BBFC logos that have been removed, which leave a nasty deposit that rubs off on the mat.

(From: Bruce Esquibel (bje@ripco.com).)

I somewhat have a clue - but haven't came up with a 100% fix yet.

The trouble appears to be the upper 'track' that hub/laser assembly uses when it returns from the side 2 position.

This track floats within the metal sleeve on the upper left hand side as you look at the player from the rear (front away from you). It appears the last inch or so is warped or slightly deformed, probably because of age.

If you examine the construction the track is pulled upward via a pair of springs and held in by a couple L-tabs or ears from the track. When the laser is returning from side 2 to stop you can see the track slightly move as the motor on the hub assembly runs on it.

When it just about hits the end, that is when the grinding noise is heard, the gear on the shaft of the motor is spinning, but not meshing with that part of the track. It appears that after so much time the player detects the error and starts 'slapping' the hub around and eventually it grabs and does its flip.

Odd part about this is that even the slightest pressure on either the track or hub will allow it to cycle without missing a beat.

What I did, which reduced the grinding, but did not fix the trouble completely was to modify the rear spring to be tighter by carefully cutting the loop off and unwinding one turn, making into another loop. I suppose you can find another similar spring which has less turns also. The other bit that helped was kind of cheesy, the rear L-tab from the track seemed to have too much play when the motor ran near it. All I did was stick a small piece of electrical tape under it, on the metal housing which also tightened the track.

I'm pretty sure the track itself is the problem, but it looks like a son-of-a-bitch to replace, even if it is a replaceable part. Another possibility is the gear on the motor shaft getting worn down but being the problem is only at that one end, I really don't think so.

If you aren't into repair (just a joe consumer), I really don't recommend trying either the spring mod or tape bit, the spring can be easily malformed or the L-tab can break off, which either happening will put you in a world of hurt.

All I can add is don't bother greasing the track, was the first thing I tried and it didn't help a bit. Also there was no indication of it needing lubrication anyway. This is a tolerance issue between the gear and track.

The grinding noise, although sounding nasty, isn't really. It's not chewing up anything and I didn't even notice nylon dust around the area where the teeth are grinding. It's more of an annoyance problem than a major malfunction.

Pioneer LD-3090 turn over problem

(From: Kurtis Bahr (kbahr@erols.com).)

I once fixed a 3090 that had a problem when stopping the LD and the pickup tried to turn back over to side A. It actually made a grinding sound for awhile then finally grabbed into the turning assembly and turned over.

The fix was to lubricate the metal guide shaft where it transfers from the playing shaft to the shaft on the turn mechanism. After this was done it has worked flawlessly.

Sony LDP-1450 problems and discussion

> "I'm the proud owner of a very confused LDP-1450 from a Mad Dog McRee machine. It's got six option DIP switches, all are "off" (down), and>it's set for 1200 baud."

(From: Ruben Panossian (malcor@ozemail.com.au).)

The Extended Function dip switches are for just that, extended functions, which change certain characteristics of the player's operation. There are only three extended functions, using switches 1, 2, and 4 only. The other DIP switches are not used. Factory default is for all of the DIP switches to be set in the "off" position.

The baud rate setting would not matter if you have nothing connected to the interface. BTW, it should be set for 9600 for ALG games.

> "Power-Up: Disc rotates 10-30 degrees in random directions, changing directions erratically every half-second or so, and the head makes a weird squeaking sound periodically as it tries to seek (maybe it's making physical contact with the disc??)"

The objective is unable to find focus when this occurs. (usually) The disc will not spin-up to speed, rather, a slower turn and often in reverse. To determine if the player is finding focus you will need to get access to the lower PCB's. Turn the player on its *side* and remove the bottom cover. (Do *not* try to eject the disc in this position!) This is the servicing position.

The large board you will see, behind the lower cover, is called MB-40. You will need to pull this board out a bit so you can work on it. Locate IC313, it is an HA11529. This IC controls the focus (coils), tracking (coils) and communicates to the main system control.

Looking at the schematics, you can see that pin 36 of IC313 drives the focus coils. Pin 26 of IC313 is an output to the system control, which signals when focus is locked. By using a CRO, connect one channel to pin 26 and the other to pin 36. Adjust the display so that you can see the two signal but not on top of each other. You will need a CRO (or DSO, whatever) as the signals are about 3Vpp.

Turn on the LD player (with a disc already loaded) and watch the signals. (the disc should be moving and sounds from the player) You should get a ramping (triangular) signal on pin 36 for a moment then a steady line (0V), indicating that focus has occurred. The signal on pin 26 (focus lock) is high, when focus is not locked, and low when locked. When the focus is locked the player should spin-up and go in to playback mode.

Now, if you are finding that focus locks then searches then locks, in a peculiar way then you will have to do some more checking to determine the problem. This can be caused by many things.

If focus is not locking and the signal on pin 36 is a constant triangular wave then the problem is more than likely in the optical block or the laser not turning on.

Check to see if the objective is free. Next, check the continuity of the focus coils from the connector on the MB-40 board.

You can check if the laser diode is turning on by checking the test point TP302 on the MB-40 board. It is located near IC312 which is a three pin -5V voltage regulator. When there is -5V on this test point the laser should be on. If there is no -5V there then check for -8 to -10V on R334 (any side) If there is no voltage there then there is a voltage rail supply problem. (like you hadn't guessed)

If there is around -10V, then check the base on Q314. This is the right pin if the flat side is facing you, the right way around. It should have 0V on it to turn the laser on. Hmm... I will try again. One pin is connected to the +5V rail (collector), another pin, the emitter, drives the base of Q313 (which then supplies -10V to IC312) which should have +5V on it when the remaining pin (base) is at 0V. The base is connected to the LD "ON" or LD "OFF" signal. It is an active low signal, so a low signal will turn "on" transistor Q314 and in turn eventually turn on the laser diode. The laser diode also has an APC which complicates things, but don't worry about that at the moment.

If the of base of Q314 is 0V and the collector is +5V then the emitter should have almost +5V on it. If not then the transistor must be real hot or dead. If it is hot, Q313 would be faulty. BTW, this transistor, Q314, is a pre-biased "digital" transistor. It is either fully on or off.

I had a laser power problem like this, on a player out of a TT, which I had previously repaired. This time it turned out that the laser was not turning on all the time. Some times it would be ok for a couple of hours then it wouldn't work properly. By the time I had taken the covers off it was OK again. (Grrrr)

To make a long and frustrating story short, I found that the laser wasn't being turned on when it should all the time. Turned out to be a bad connection on IC902, which is a 80 pin quad flat pack (SMD) and *only* pin 31 had a poor connection. This pin controls the laser diode "on" and "off" signal. I think I may have caused this poor connection when I was poking around previously.

Also be careful when probing around a SMD like IC902. If you inadvertently short out a couple of pins, the slide motor may move (turbo) the optical block towards the spindle and not stop, causing a nice gear jumping noise that brings on a sudden panic attack. Which may cause you to knock over your LD player while trying to find the "OFF" button while still holding a cro probe. Although, I wouldn't admit to doing such a stupid thing, especially publicly. :-)

Now, back to IC 313 on the M-40 PCB.

If you are not getting a triangular wave or steady line on pin 36, but a wavy (sinus) signal then check the soldered joints on pins 38, 41 on IC313 and on R384, R382, R381, C337, C338. These are for phase compensation for the focus coil. If the signal looks strange on pin 36 of IC313 or the laser is turned on and IC313 is not working then IC313 or the serial control input signals may be your problem. I have only seen a couple of poor soldered connections on these, otherwise A+, players but you never know...

If you find that focus is locking in say 10ms intervals (on and off) then the problem may be in the focus loop, which is initiated right when focus is locked. This loop controls the current supplied to the focus coil to maintain a constant current which is proportional to the focus error, so the focal point is maintained as the disc turns. Keep in mind that the focal length is not constant, as the disc is rotating.

Or the problem could get interesting. In other words, *could* end-up being a "dog" of a problem, unless you have a manual. Either way a manual is essential. If you can read and understand the circuit diagrams then you shouldn't have any problems, other than the faults that were devised in hell.

> "Self Test: Removing the front cover revealed a "self test" jumper. Shorting the two pins together forced the player to spin up. The player correctly displays video for a few seconds (overlaid on the video is a frame number of approximately 7000), but quality, which starts off great, deteriorates rapidly, and the player then jumps back 100 frames or so and repeats the cycle. The words "NTSC 12" appear underneath the frame number whenever the self test jumper is shorted.
>
> The frames played are identical for any given disc. Mad Dog McRee gave me 7000ish, and Star Rider gave me 6900ish.
>
> When the player is in this mode, pressing the eject button causes the video to mute and the player to spin down. When the disc has stopped rotating, a further press of the eject button will eject the disc correctly, and a further pressing will reload the player."

Yes, this is normal. Even if the focus error is greater than it's cut-off point the player will spin-up and try to display video. How good the video is will depend on how great the focus error is, I guess. I have done this myself, however, have found the video to be very jumpy and poor if any at all. When the focus error gets to it's cut-off point it re-initiates focus search..

If the video is clear and stable then your problem sounds like it is not with the optical block, focus, etc. (with the test jumper closed)

The test jumper you found is *only* meant for adjusting the "inner" and "outer" frame limits for the disc sizes, hence the displayed frame numbers.

> "Theories:
>
> 1. The player works but is still configured for a video game; it has to have something useful coming in on the RS-232 port in order for it to work."

No. There were different LDP1450 software revisions though.

With the Extended Function Dip switches all set to the "off" position the player will "spin-up" a disc and go to playback mode, when a disc is loaded.

> "2. This might be changeable (or I might get a different set of diagnostic information) if I knew what to do with the six option DIP switches."

Yes and no. This is not your problem, though,.

> "3. The player is malfunctioning, probably something to do with alignment of the slide on which the optical head moves, and this accounts for the weird looping behavior I get in the self-test mode."

Possible and no.

> "Questions:
>
> 1. Am I doing something boneheaded?

No, considering the lack of information you have for this player. You could have done worse...by poking around IC902. I don't think that you will get very far without a service manual. The Sony service manual is relatively expensive, however, it is essential, It is also well detailed and clear, unlike some early player manuals.

> "2. Anyone know where I can get a service manual?"

Yes, from Sony :-). Because it is not a real old LD player, they will have the manual.

> "3. I have yet to hook it up to a computer. I have a utility that purports to be able to talk to an LD player; would this help, or should I concentrate on getting it to work correctly in stand-alone mode before trying to talk to it?"

This wouldn't help you with repairing the player, rather the opposite.

Also, I forgot to mention one of the first things you should check for. Check the power supply voltages. Obviously +5V is ok. You should have an idea of which voltages are ok by what is working in the player as a start, anyway. There are around 10 voltage supplies or more including at least 5 different voltage rails.

Disclaimer:

If anyone goes blind, destroys their LD player, decapitates their dog Fluffy, etc, by following my suggestions , it is not my fault. Only work on a LD player if you have an idea of what you are doing and understand what the dangers are. i.e., take blame for your own actions.

Replacing a laserdisc player spindle motor

With a CD player, all you have to get correct is the spindle height.

Unfortunately, for a typical LD player, this is just the beginning.

(From: Jack (jackh35785@aol.com).)

Replacing a spindle motor is a "can of worms". I used to build these things!! You have a VERY critical height that is adjustable by three pylons with screws, etc. You need a special disc which had a "constant pitch" from inside to outside. There is also a method of doing this using a mirror disc (as the CD folks know about). You absolutely must have the LD player service manual!

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MinDisc Equipment

MiniDisc record/write problems

(From: David Vlack (cptvdeo@ainil.com).)

To write a MD, a magnetic head is brought in contact with the top of the disk with the writing laser below. Without the magnetic head in place, no recording takes place. I have seen a few of these (mostly SHARP) where the actuator motor binds up. Taking it apart and freeing it up usually fixes the problem.

Sony MiniDisk player/recorder considerations

The Sony MiniDisk system was supposed to replace cassette tape as the preferred medium for portable music (and data). Yeh, well, I am not holding my breath but it may yet come to pass. The disks are about 2-1/2 inches in diameter and enclosed in a protective case like a 1.44 MB diskette. Thus, dirty disks, at least, should not be much of a problem. A MiniDisk (MD) holds approximately 1/5th as much raw data as a full size CD. Compression techniques are used to achieve the same maximum time for audio - about 74 minutes - supposedly with negligible loss in audio quality. (I won't get into that argument either).

For playback of prerecorded discs, the optics and servo systems are operating in modes which are very similar to those in CD players and thus suffer from most of the afflictions and remedies described elsewhere in this document. The digital decoding and error correction including an advanced form of the CIRC may be substantially more sophisticated for MD players and MD data drives (if you can imagine that being possible) but the circuitry involved should be very reliable.

However, for playback of MiniDisks recorded on MO (magneto-optical) media, there can be many other problems as the optics/electronics are sensing the different polarization of reflected light from the N and S magnetized spots rather than pits and lands. The signal-to-noise ratio of the MO effect may be lower than that of a stamped disc. Thus, prerecorded media with the normal pits and lands on the information layer may work fine but MO media may suffer from tracking, audio noise, or uncorrectable data errors. Servo adjustments for tracking and CLV spindle control may be even more critical than for CD players.

Note that some MDs may include both prerecorded (stamped) and MO sections so that it is possible that only certain portions of these disks will play reliably.

MiniDisk recording requires that the laser diode be operated at higher power (around 4.5 mW optical output compared with less than 1 mW for reading) and that an electromagnetic head in contact with the back of the MD is driven with the EFM coded data pattern. This is not really a write head such as that used in a computer disk drive - the laser beam does the actual writing by heating the MO layer but the magnetic field determines the polarity (e.g., 1 or 0, N or S) of the written spots. Therefore, the actual position of the head is not critical - there is no servo for it! Note that this approach contrasts with that used in many other MO drives where the laser power is modulated to write 1s and 0s. The 'Magnetic Field Modulation' approach used with the MiniDisk claims many advantages in terms of robustness when confronted with less than perfect optical alignment and control of laser power, among others.

CLV servo lock during recording is determined by a signal derived be impressing a reference modulation (wiggle) on the premastered groove wall position - yet another possible area for failure or need for servo adjustments!

CAUTION: the higher power laser output required for recording is substantially more hazardous than that of CD players. However, since under normal conditions even with the case disassembled, the disk and electromagnet will be blocking the lens, there is little danger. However, if you remove the electromagnet and there is no disk in place, this optical power must be treated with respect.

Sony MDS 302 Minidisc optical blocks

This likely pertains to other Sony models as well.

(From: Shawn (slin01@mail.orion.org).)

These is a very common problem with Sony MD/CD players. I'll bet it is skipping and/or ruining your recordable MD's, right? It causes far more "disasters" with MD because an MD deck that has trouble reading a recordable MD will think it is corrupt and try to write a new TOC, which can ruin the contents of the disc! When this occurs, press the STOP button until the "TOC" indicator disappears (may take up to 10 seconds) and eject your disc, it will come out unharmed.

Anyhow, on to the optical block problems. I will bet your MDS302 will work fine if turned on its side or upside-down. I have seen this problem many times with Sony MD/CD equipment. I have MD players from Sharp which are much older and have suffered great abuses (like being run over by a car) which don't suffer this problem.

My only guess is that it's either a problem with the lens suspension or the focusing coil. It is definitely a problem with the focusing system in the optical block because: A) replacing the block fixes the problem B) sometimes adjusting Focus Bias on the deck will compensate and reduce or eliminate the problem. C) I have fooled around under the cover of the optical block and have experimented using pieces of tape to suspend the lens suspension. I suspect this compensates for either a poorly functioning suspension or a screwy focus coil. I have been able to regain 100% perfect operation using this fudge-fix method!

Unfortunately, to fix this problem properly, you will need the new optical block. We can only hope that Sony will correct this problem! BTW, you could always use your deck upside-down or sideways. :(

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DVD Equipment

CD and DVD support on same drive

Digital Versatile (or Video) Disc players should be hitting the streets by now or at least very soon. What this means is that DVD players will need repair just like CD players.

While much of the basic construction of CD and DVD players is similar, in order for a single player to work with both CDs and DVDs requires some fancy footwork to avoid the costs of dual laser pickups. This comes about from the change in the laser wavelength (780 nm for CDs, 632 nm for DVDs) and thickness of the disc (1.2 mm for CDs, .6 mm for DVDs). This requires differences in the optics to produce the proper spot size and readback image on the photodiode array.

(From: Bill Studenmund (wrstuden@macro.stanford.edu).)

I saw an overview in a journal on what they're doing, and it's pretty cool. They have a variable aperture in the beam (maybe it's on a hinge and snaps into the beam path?). In one setting, the beam is the right diameter to fill an inner area of the objective, and focuses to a spot the right diameter for reading normal CD's. The spot has correction for the spherical aberration from 1.2 mm of disk.

When the aperture is not in the beam, it fills the full aperture of the lens. There's a holographic grating on the lens so the the combination of the inner and outer areas is diffraction limited for 635 and compensates for 0.6 mm of disk.

Though the signal to noise ratio will be lower as the 1/4 wavelength's a bit off, I doubt it'll be a problem. The electronics have gotten so good that they can read a disk w/o metal backing! That's how the Sony dual-layer disk technique works. There are two surfaces with data, and the one in the disk has no aluminum backing. They get enough S/N to read that layer. It's about 50 um above the "normal" layer, so not much of a defocus.

Could DVD discs be made with compatible CD tracks?

CDs are 1.2 mm thick. DVDs consist of two bonded .6 mm substrates. In principle, the DVD layer could be made partially transparent permitting a CD player's laser beam to focus through it to some tracks of CD information pressed in their normal position 1.2 mm from the bottom surface.

As a practical matter, it is very unlikely that any existing CD player could be made to work with such a scheme. It would be like viewing the pits through a frosted plastic screen - theoretically possible but substantially reducing the signal to noise ratio. Furthermore, the CD focus servo would very likely lock onto the DVD rather than the CD layer as it goes through its focus search routine.

It might be possible to design such a CD player but why would anyone want one? By the time this matters, DVD players will either be mainstream (CD-only players may not even be available any more) or will have been superseded by something even more wonderful. Why would you pay a premium for a DVD pressing and then only want to play portions of it on a CD player anyhow?

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WORM Drives

WORM drive Laser Diodes

(From: Alan Shinn (alshinn@sirius.com).)

Well, I bought a few of those WORM drives I wrote about. The LD puts out at 30mW at 110mA, As measured by using it to heat up a surface mount transistor hooked up as a thermometer with a surface mount resistor glued onto it for calibration.. I wish I had gotten more. Not that I know what I will do with them (the LDs) The drives also have several rare earth magnets so they were quite a fun deal.

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CD-R Equipment

Differences between CD and CD-R media

(From: Michael Portmann (mikep@adelaide.on.net).)

I have a flyer on Mitsui CD-R media. I quote from this:

The difference between a CD-R and a CD-ROM lies in the structural layers between the polycarbonate substrate and the protective lacquer surface that both discs possess.

The CD-R has one long groove stamped in the polycarbonate substrate to guide the laser. This groove is covered with an organic dye lyer, which, when written upon by the heat of a higher powered laser light from the recorder, will deform to produce the 'pits' and 'lands' of information. The dye is protected by a non-corrosive, highly reflective thin layer of gold. One the CD-R layer is recorded, the deformations in the dye become permanent.

The Mitsui gold CD uses a patented Phthalocyanine Dye & Data shield surface.

They then go on to mention how unlike Cyanine based CD-R, theirs shows less degeneration from continuous exposure to light and heat.

HP 4020i/Philips CDD2000 Spring Fix for Write Append Errors

(From: Rick Richardson (rick@dgii.com).)

Here is the fix I applied to my two year old HP 4020i CD-R recorder when I started to get Write Append errors when writing CD's larger than about 550 MBs.

I got a tip that this problem was due to a "spring" wearing out or of insufficient strength from David Neal on the cdwrite@pixar.com mailing list (Unix CD-R software mailing list).

Armed with this clue, I searched DejaNews on the subject of CDD2000 & Spring. Here I found basically two theories for the problem - the spring theory and another one that said it is dust on the laser lens that needs to be blown off with compressed air (*not* wiped).

Since my HP 4020i drive is over two years old, I figured I had nothing to lose by opening it up and seeing if I couldn't apply the "spring fix". Also, at the same time I blew off the laser lens with compressed air.

After applying the "spring fix" and blowing the lens with air, the drive now works 100% again. I cannot say with confidence which of the these actually fixed the drive.

I attach the approximate procedure I used for applying the "spring fix" below. I disclaim any responsibility for the correctness or incorrectness of this fix. Apply the fix will void your warranty. You should not attempt the fix unless you have the proper tools and ability.

Tools Needed:

- Torx T-10 screwdriver
- Torx T-? screwdriver (even smaller than above). I did not have this small a Torx screwdriver, so I used a regular slotted screwdriver with about a 1/8" blade from a jewelers screwdriver kit. I was able to wedge the slotted screwdriver into two of the Torx slots and get enough friction to remove the screws
- Very very small philips screwdriver. Again, I did not have this size screwdriver, but was able to use another of the slotted screwdrivers from a jewelers kit. (A jeweler's screwdriver set with Philips types will probably have the correct size. --- sam)
- Two pair of small needle nosed pliers.
- Pair of dikes (cutters) used for electronic work

Parts Needed:

- About 1.25" long straight but springy wire. I found a suitable wire in an old 5.25" floppy drive that was used to apply pressure to the spindle.

Skills Needed:

- Good eye-hand coordination.
- Good eyesight.
- Steady hands.
- Patience.

The first step is to remove the case. Remove two screws with the T-10 screwdriver and four screws with the T-? screwdriver. Remove metal case. Gently release the top circuit board from two plastic alignment posts -- this may require gradual rocking of the circuit board but do not stress the circuit board as it is very thin.

The next step is to remove the main circuit board by disconnecting three ribbon cables and two sets of two pin connectors. The larger ribbon cables are released by moving two pieces of plastic at each end of the cable connector away from the connector body by about 1/8". The cables should then easily slide out of the connector. The smaller cable has a slightly different release mechanism, but again just move it about 1/8" away from the connector body. Slowly rock the two pin cables from their sockets.

You should now be able to see 4 more T-10 screws. Remove these to free the drive mechanism from the other part of the metal case.

The next step is to remove the smaller circuit board on the laser transport assembly. Remove 4 philips head screws. Pull the board up and lay it over - you will not be able to fully remove the board because two wires are soldered to the motor.

If you look at the transport now, you will see a worm gear which drives a regular gear which drives a rack gear. The rack gear is spring loaded to press up against the regular gear. According to theory, the spring which causes this pressure is worn out and/or not designed to be strong enough.

The spring itself is a straight length of springy wire, about 1" in length and rumored to be about .012" in diameter. Since I don't own calipers, I couldn't verify this.

The spring is held in place only by its springiness. Each end fits into a slot and the middle is bowed down an under a notch in the plastic rack gear.

What you want to do is add a *second* spring wire. You should not need to remove the original spring wire. I found a suitable wire in a 5.25" floppy drive I had laying around. I removed the wire from the floppy drive and straightened out a couple of bends that were in it and ended up with a straight piece of springy wire about 1.25" long, which is longer than the spring in the CD-R drive. You want it longer for now because it is easier to install it that way. It will be cut to length later. Use the two pairs of needle nose pliers to straighten the spring wire.

With your finger, rotate the worm gear on the shaft of the motor to move the transport carriage so that the center of the spring is under the center of the regular gear. You should be able to see the notches that hold both end of the spring now.

Lay your new spring on top of these notches. Using the blade of a small screwdriver perpendicular to the length of the spring, press the spring down in the middle until it is underneath the slot in the black rack gear. This bows the spring about 1/8" in the middle. The spring should now be in place.

Using your smallest dikes, cut the ends of the spring wire off so that they are the proper length. Wear eye protection when doing this, and if possible grasp the end being cut off with needle nose pliers so that the wire won't fly around the room or worse into the drive mechanism.

With the drive still opened up, use a can of compressed air to blow off the dust on the laser lens. DO NOT touch the laser lens as it is magnetically floating in its holder.

Now, reassemble the drive by reversing the disassembly instructions.

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-- end V1.28 --

Sam's CD FAQ Components

HTML, Diagrams, Photos, and Schematics

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

Introduction

This is a complete list of the files which constitute Sam's CD FAQ (Official name: Notes on the Troubleshooting and Repair of CD Players and CDROM Drives).

Note: There are additional diagrams and schematics included within the HTML file itself. Those that are listed here are only the ones that are in .ps, .gif, .jpg, or other graphics or compressed format.

Sam's CD FAQ Components

- Sam's CD FAQ Components (This file, cdfil.htm).

- Sam's CD FAQ (cdfaq.htm).

  - General Three-Beam Optical Pickup Organization (cdt3bp.pdf).
  - Sony KSS361A Optical Pickup Organization (cdkssp.pdf).
  - Simple Three-Beam Optical Pickup Organization (cds3bp.pdf).

  - Optical Path of CD/DVDROM from Sony F390 Laptop (dvdop1.jpg).
  - DVD Laser Holographic Optical Element (3bhoe.jpg).

  - RCA RP-7903A Portable CD Player (Cover Removed) (rp7903a.gif).

  - Sony KSS361A Optical Pickup (kss361a.gif).
  - Sony KSS110C Optical Pickup (kss110c.gif).
  - Sanyo K38N Optical Pickup (k38n.gif).
  - CMKS-81X Optical Pickup (cmks81x.gif).
  - Optical Pickup from Philips PCA80SC CDROM (pcap.gif).
  - Optical Pickup from Philips CR-206 CDROM (crp.gif).

  - Pioneer CD Player Optical Deck (pd5100.gif).
  - Sony D-2 CD Player Optical Deck (d2.gif).
  - Sony D-14 CD Player Optical Deck (d14.gif).
  - Philips CD Player Optical Deck (philcdp.gif).

  - Sony CDU-31/33A CDROM Optical Deck (cdu31a.gif).
  - Sony CDU-8001 CDROM Optical Deck (cdu8001.gif).
  - Philips CR-206 CDROM Optical Deck (cr206.gif).

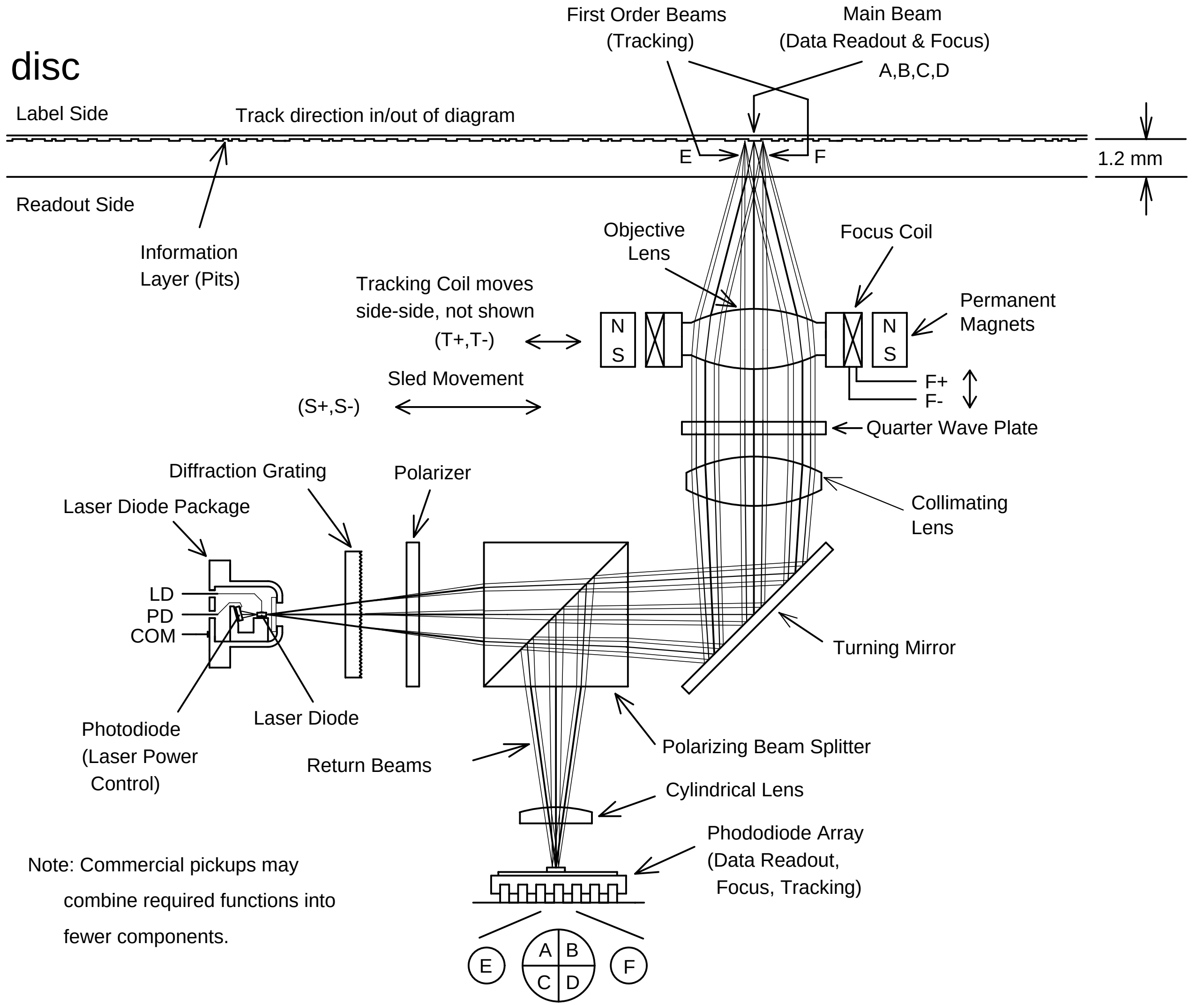
  - Philips PCA80SC CDROM Optical Deck (pca80sc.gif).
  - Teac CD-532S CDROM Drive (cd532s.gif).

  - Toshiba SD-M1212 DVDROM Drive (sdm1212.gif).

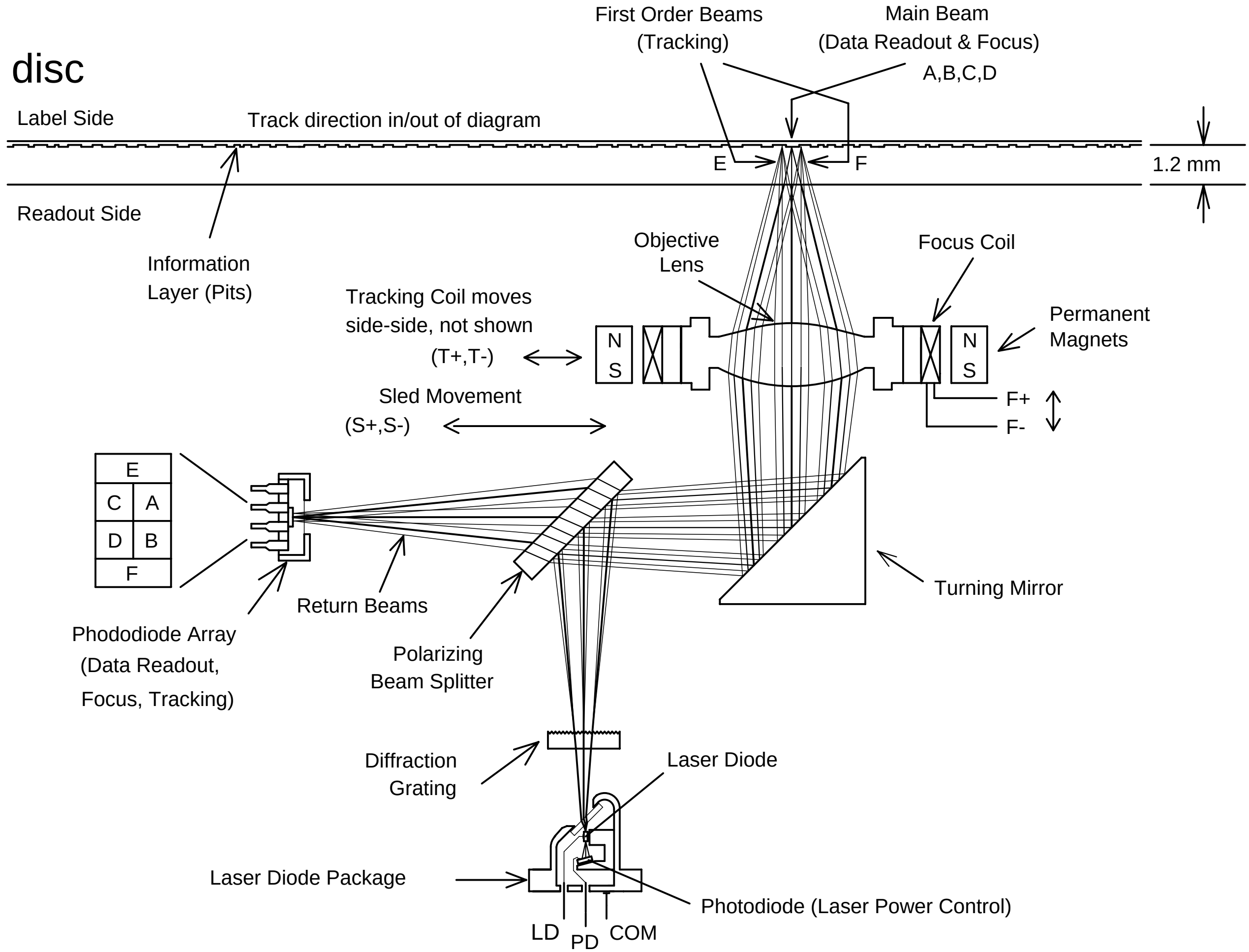
  - A Variety of Small Laser Diodes (lds.gif).
  - Closeup of Typical Laser Diode (ldclose.gif).

    - Closeup of Laser Diode from Sony KSS361A Optical Pickup (kssld.gif).
    - CD Player Front-End (cdfrend.gif).
    - CD Player Eye Pattern (cdeye.gif).

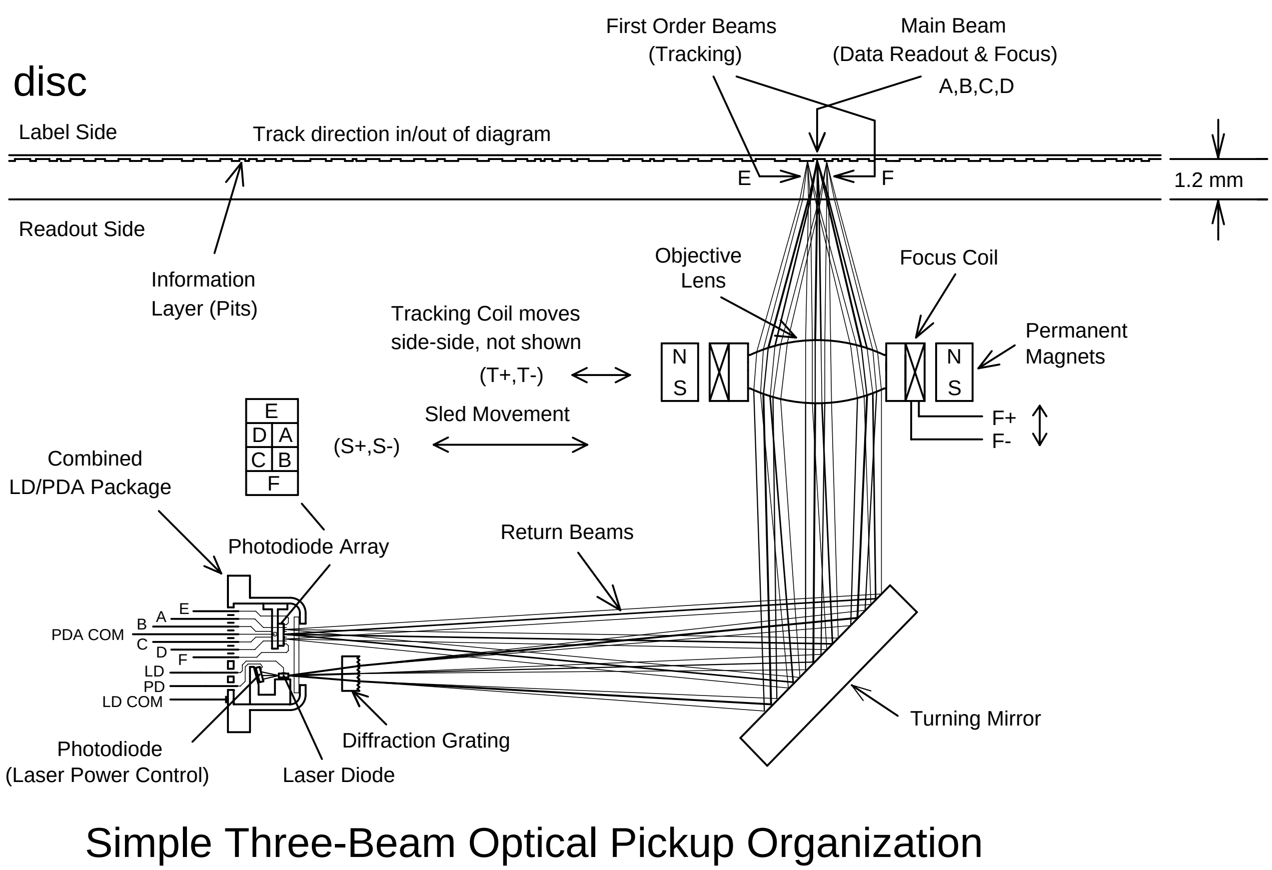
- Go to Sam's CD FAQ.



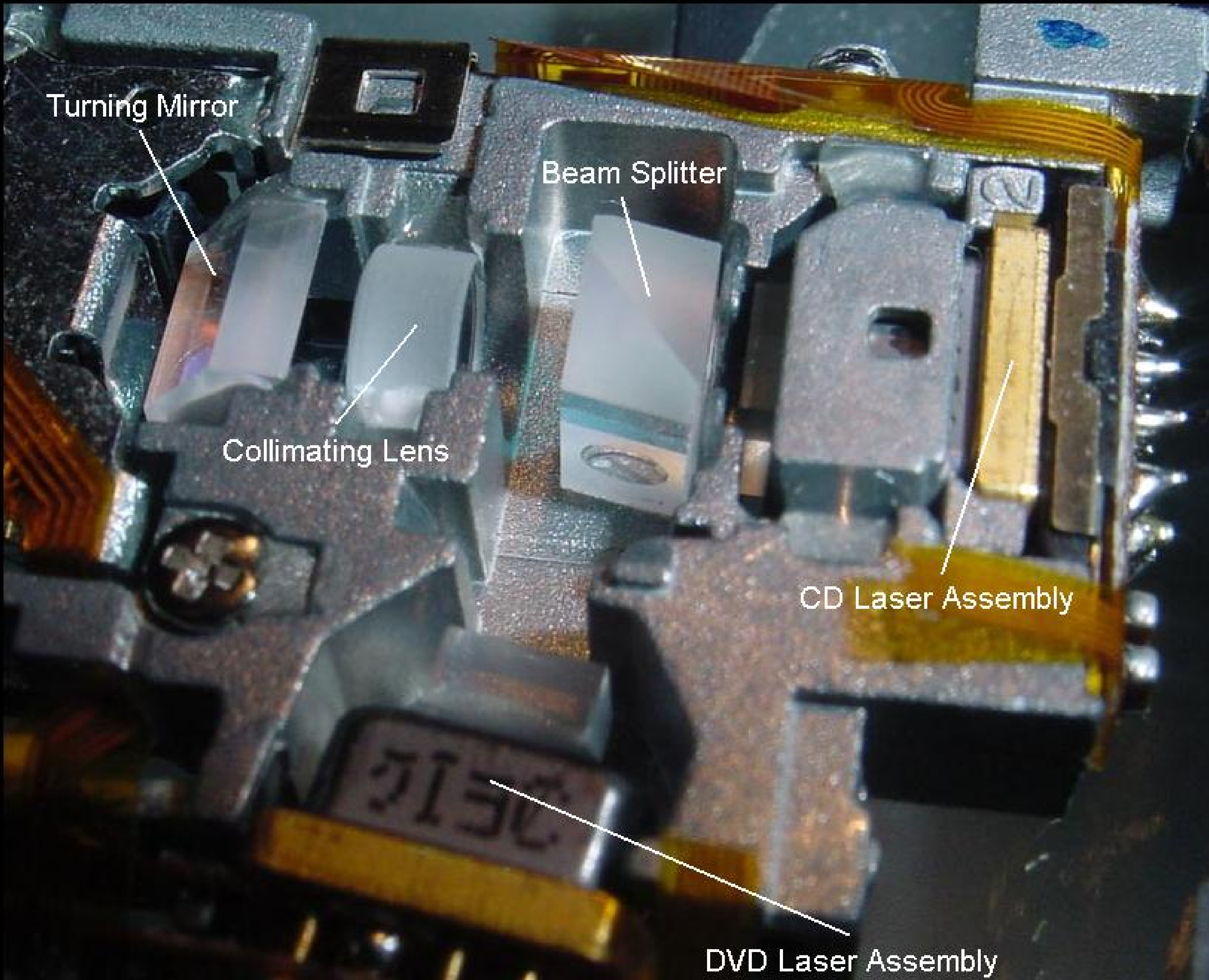
General Three-Beam Optical Pickup Organization

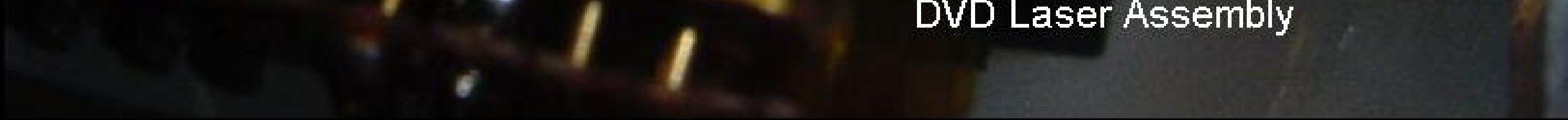


Sony KSS361A Optical Pickup Organization

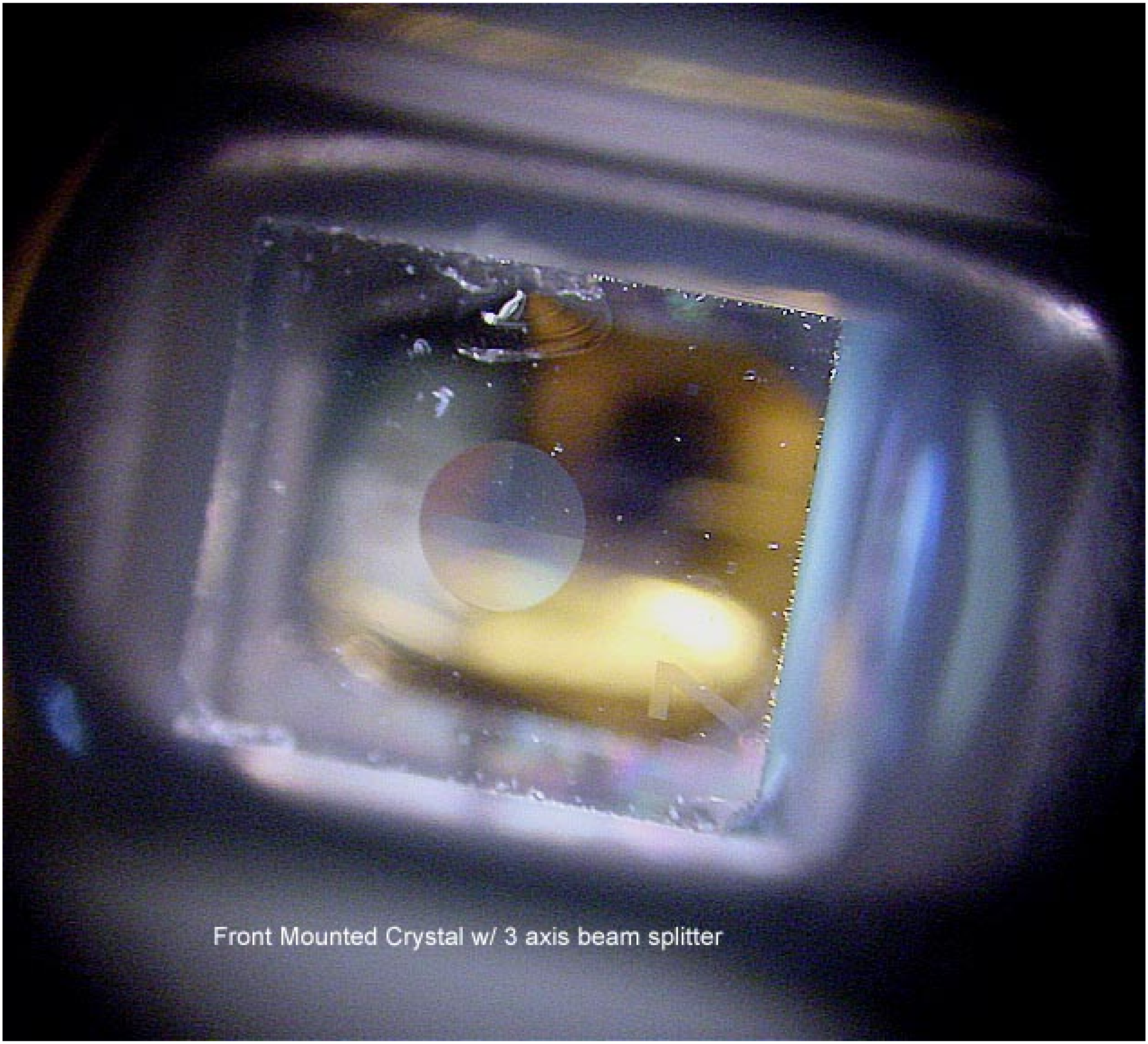


Simple Three-Beam Optical Pickup Organization

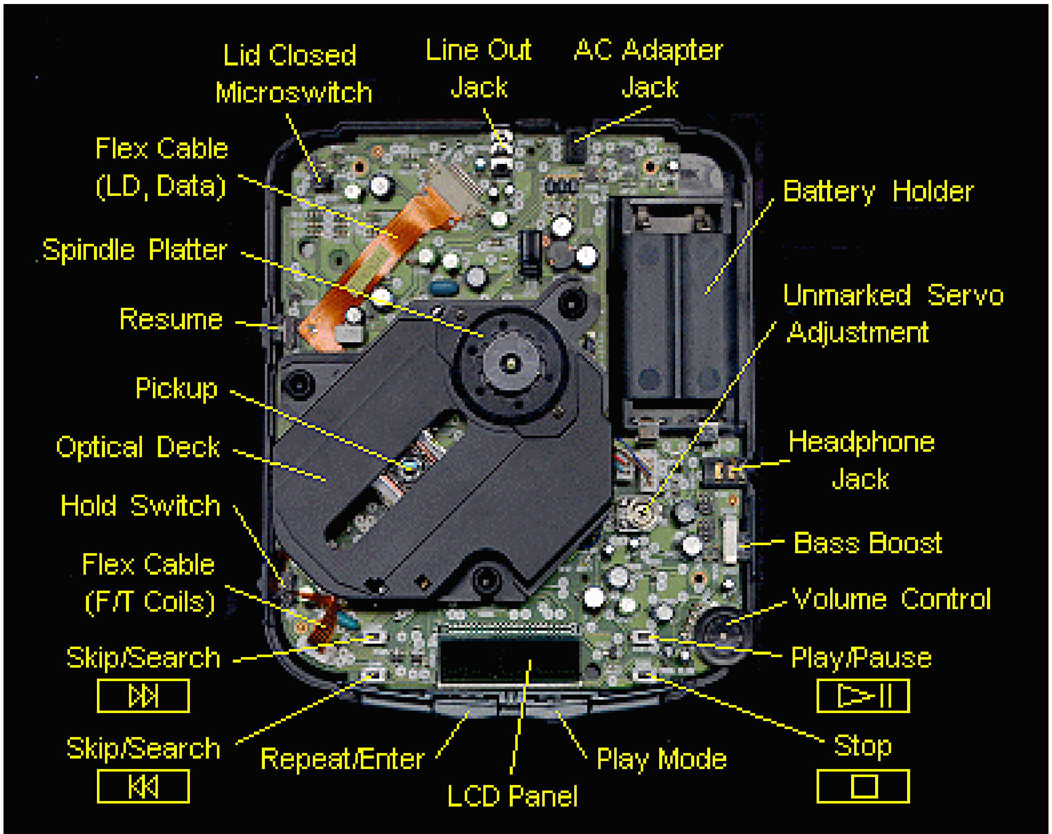

Turning Mirror
Beam Splitter
Collimating Lens
CD Laser Assembly
DVD Laser Assembly



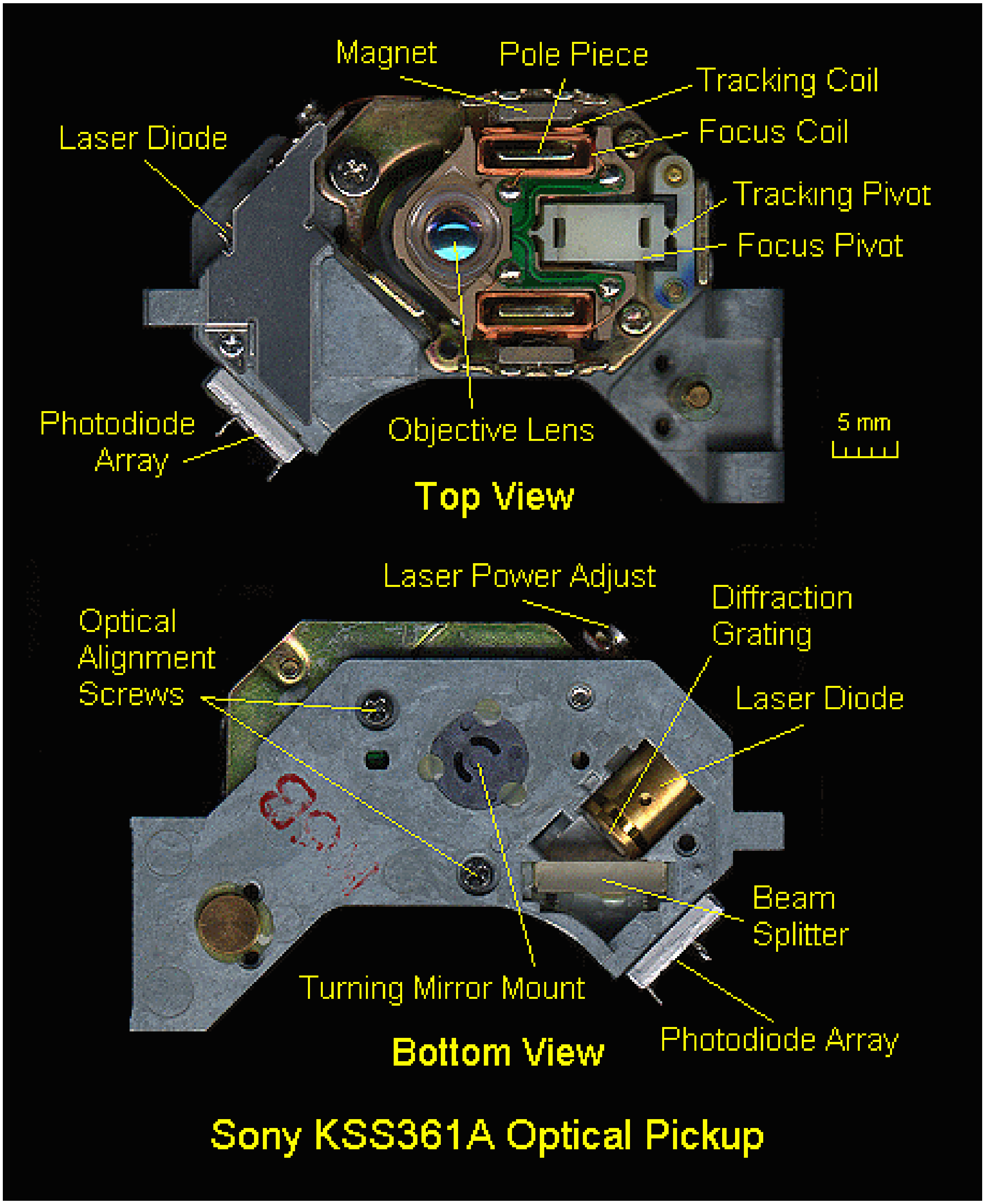
Optical Path of CD/DVDROM from Sony F390 Laptop

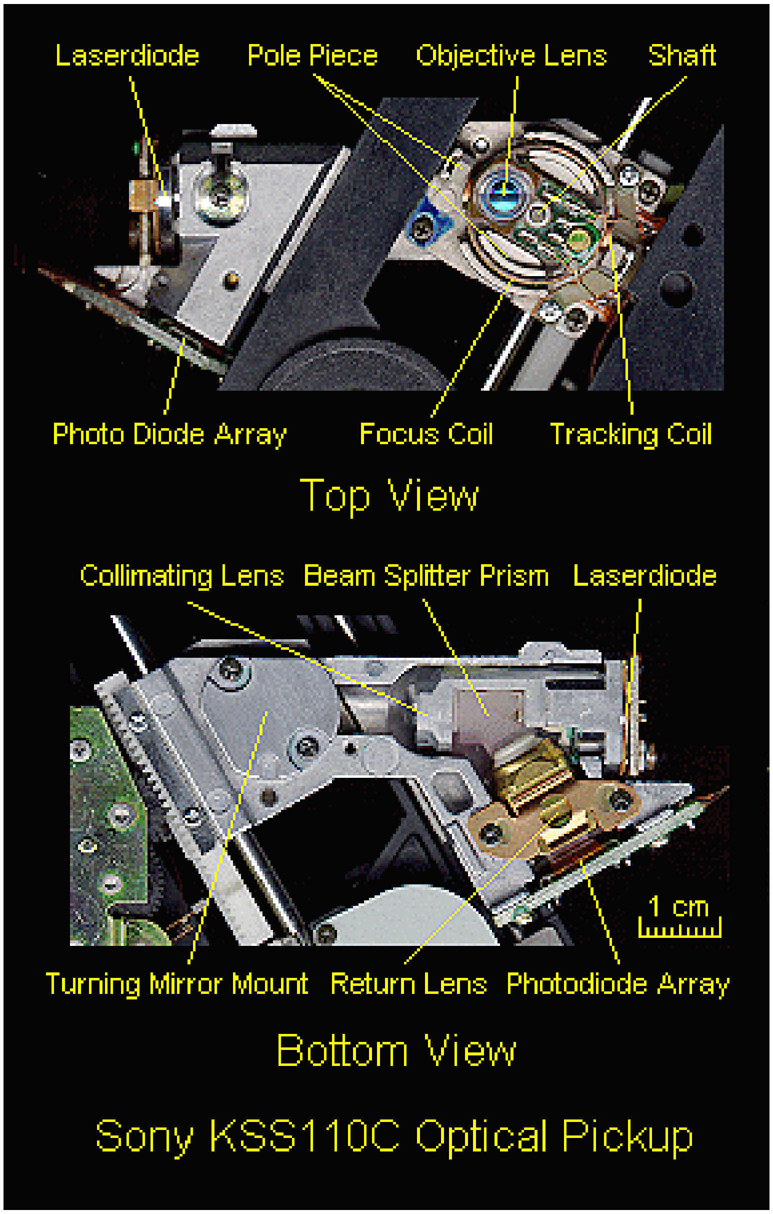


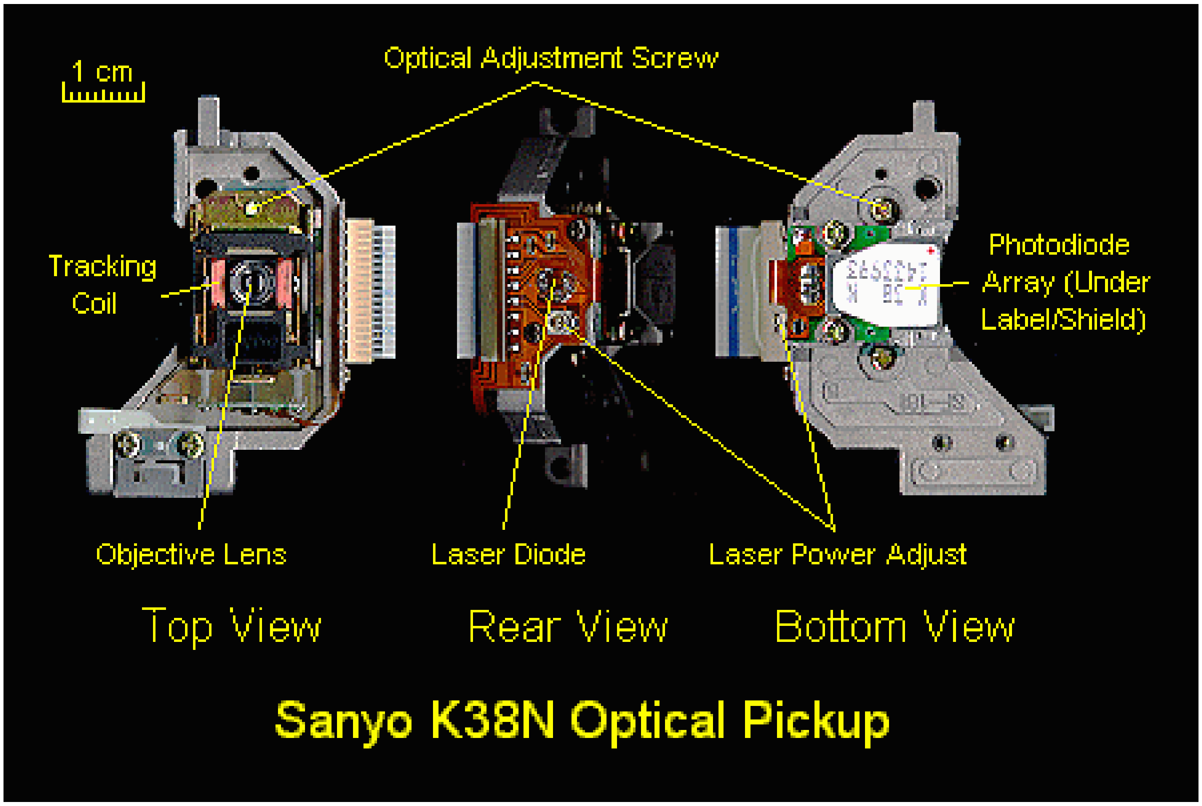
Front Mounted Crystal w/ 3 axis beam splitter

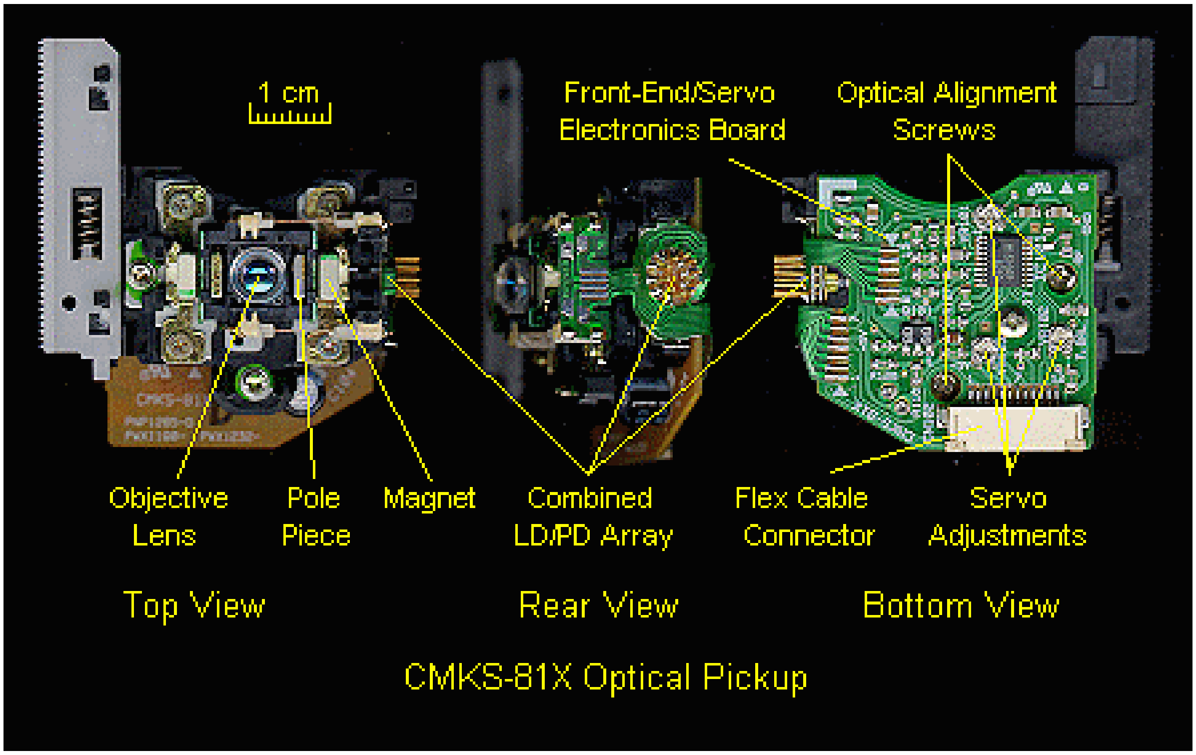


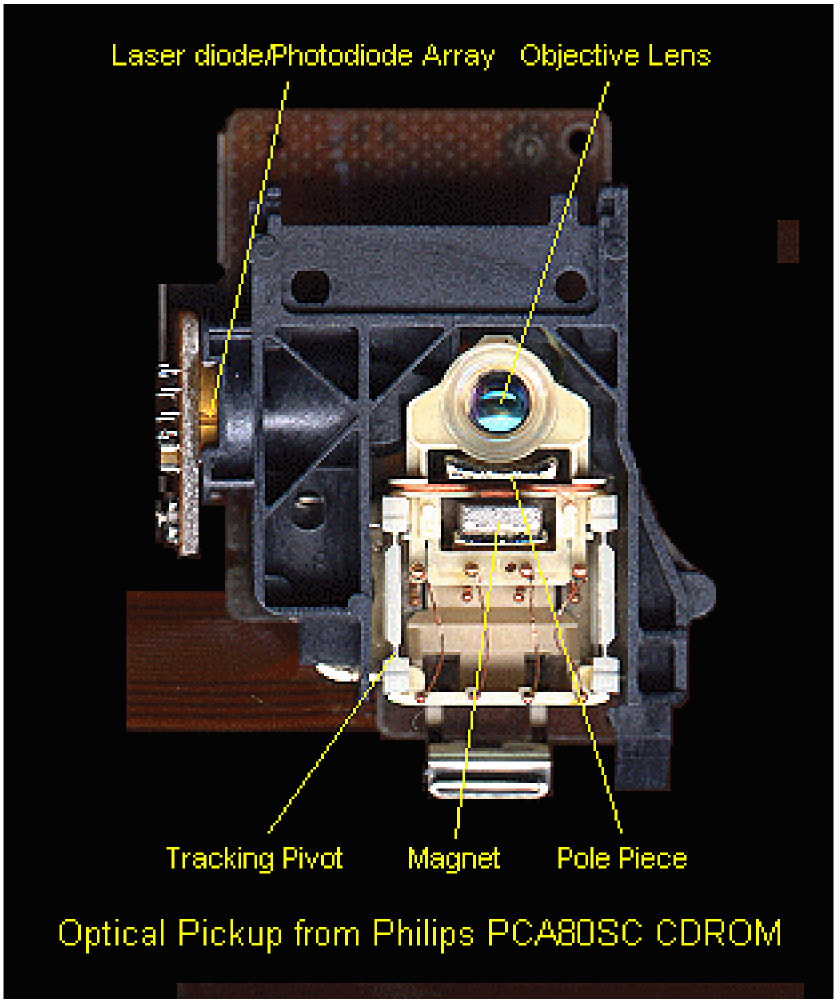
RCA RP-7903A Portable CD Player (Cover Removed)

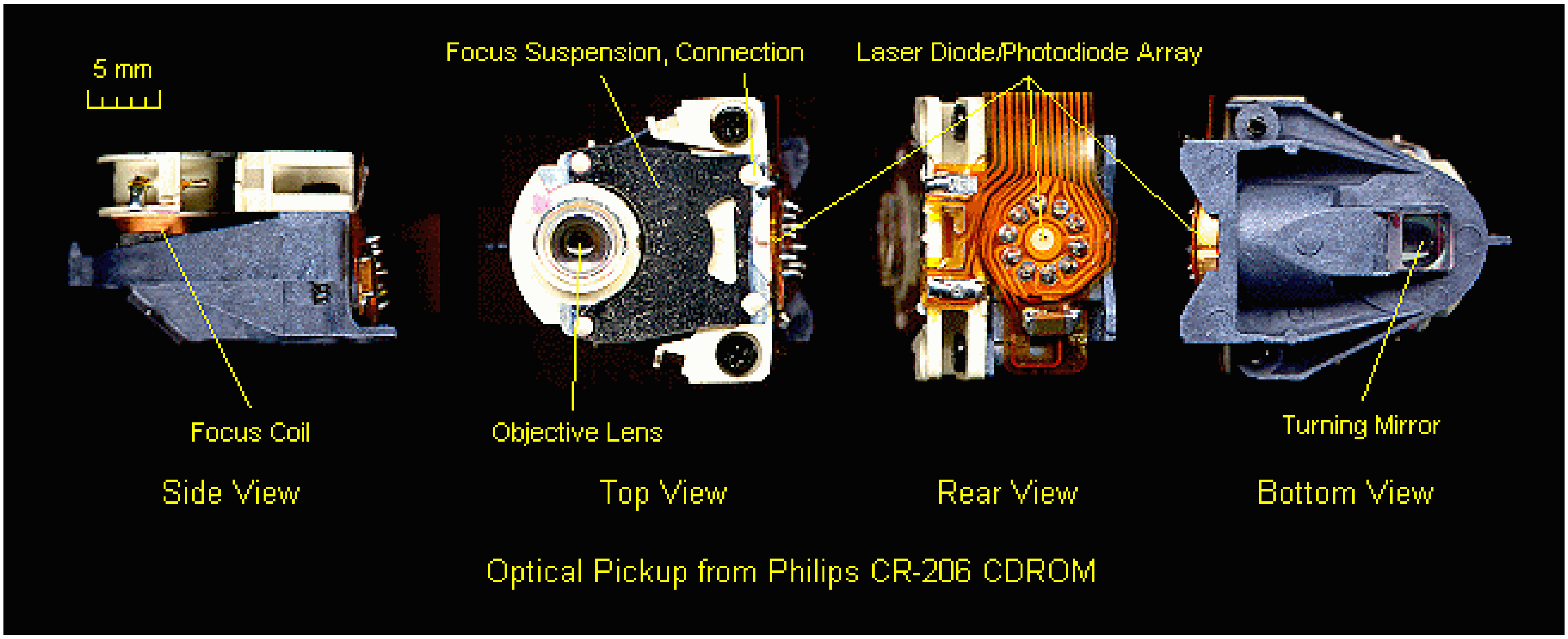

Magnet
Pole Piece
Tracking Coil
Focus Coil
Laser Diode
Tracking Pivot
Focus Pivot
Photodiode Array
Objective Lens
5 mm
Top View
Laser Power Adjust
Diffraction Grating
Optical Alignment Screws
Laser Diode
Beam Splitter
Turning Mirror Mount
Photodiode Array
Bottom View
Sony KSS361A Optical Pickup

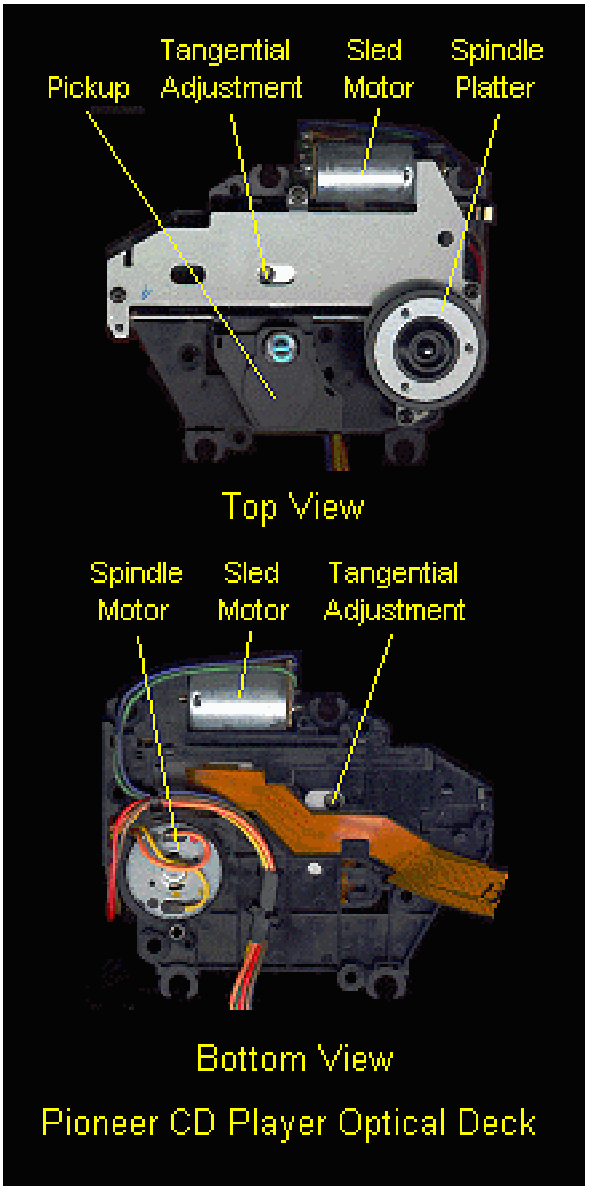

Laserdiode
Pole Piece
Objective Lens
Shaft
Photo Diode Array
Focus Coil
Tracking Coil
Top View
Collimating Lens
Beam Splitter Prism
Laserdiode
1 cm
Turning Mirror Mount
Return Lens
Photodiode Array
Bottom View
Sony KSS110C Optical Pickup


1 cm
Optical Adjustment Screw
Tracking Coil
Photodiode Array (Under Label/Shield)
Objective Lens
Laser Diode
Laser Power Adjust
Top View
Rear View
Bottom View
Sanyo K38N Optical Pickup

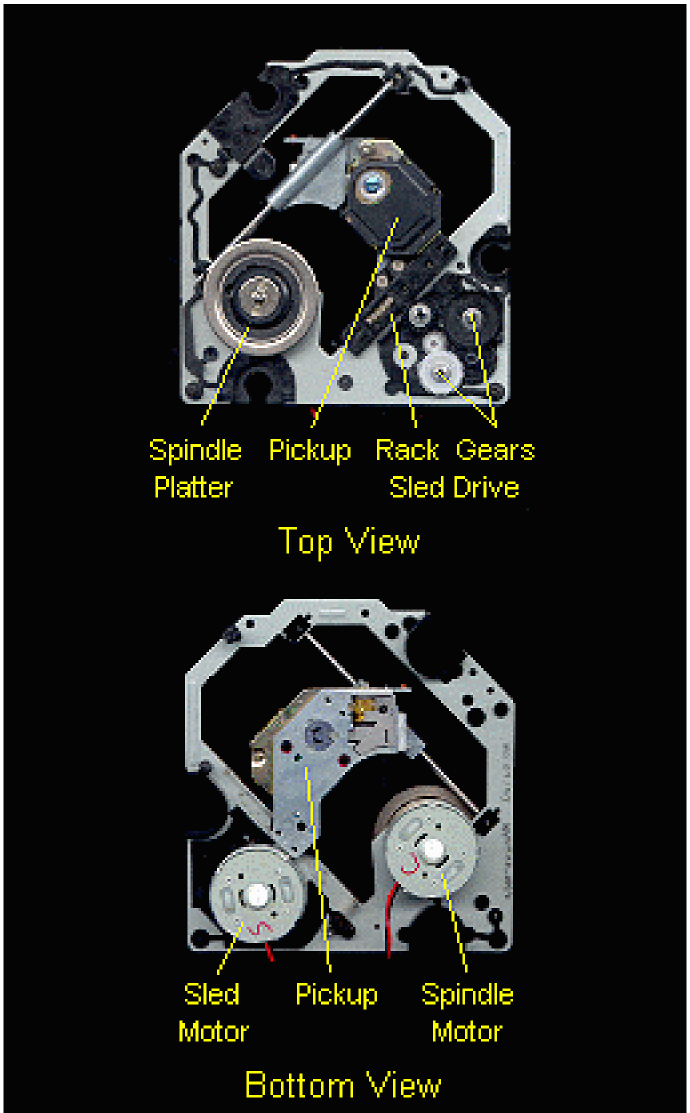

1 cm
Front-End/Servo Electronics Board
Optical Alignment Screws
Objective Lens
Pole Piece
Magnet
Combined LD/PD Array
Flex Cable Connector
Servo Adjustments
Top View
Rear View
Bottom View
CMKS-81X Optical Pickup


Laser diode/Photodiode Array
Objective Lens
Tracking Pivot
Magnet
Pole Piece
Optical Pickup from Philips PCA80SC CDROM

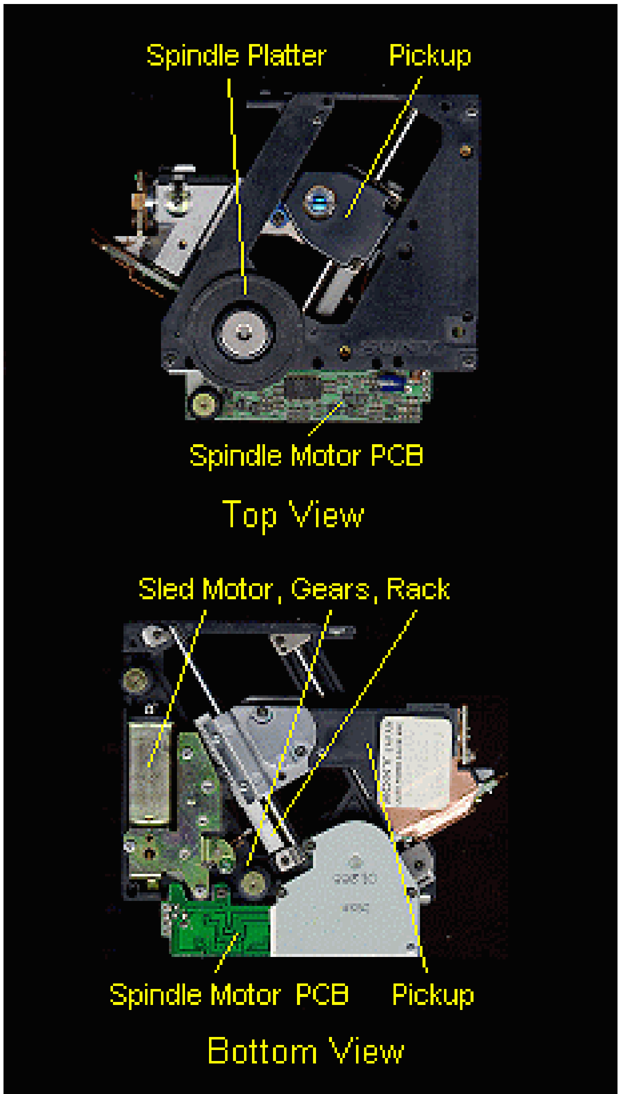

5 mm
Focus Suspension, Connection
Laser Diode/Photodiode Array
Focus Coil
Objective Lens
Turning Mirror
Side View
Top View
Rear View
Bottom View
Optical Pickup from Philips CR-206 CDROM



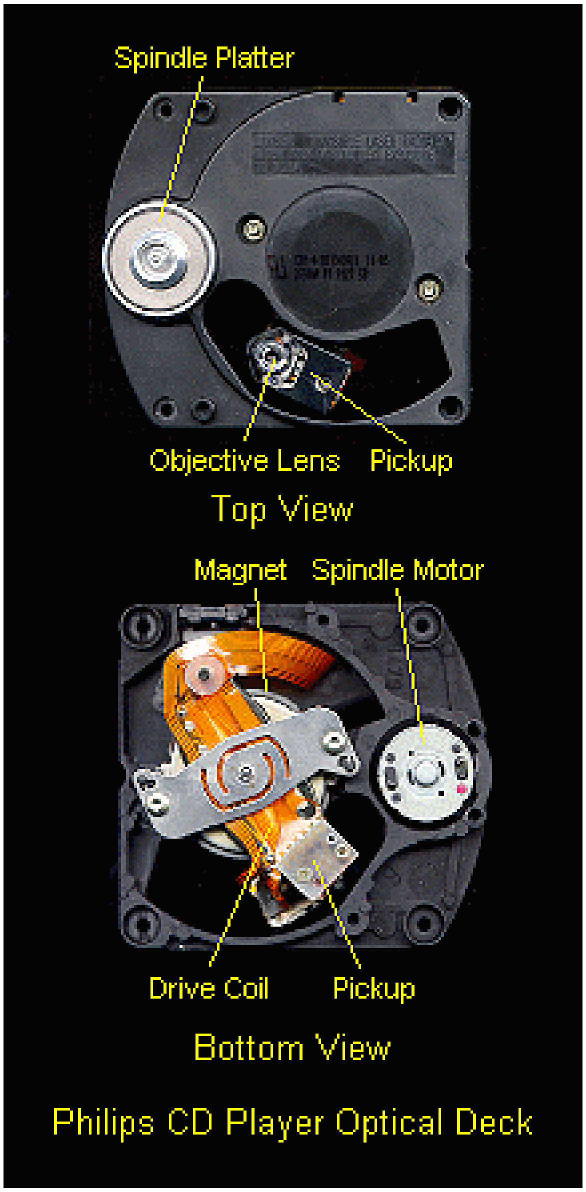
Pioneer CD Player Optical Deck



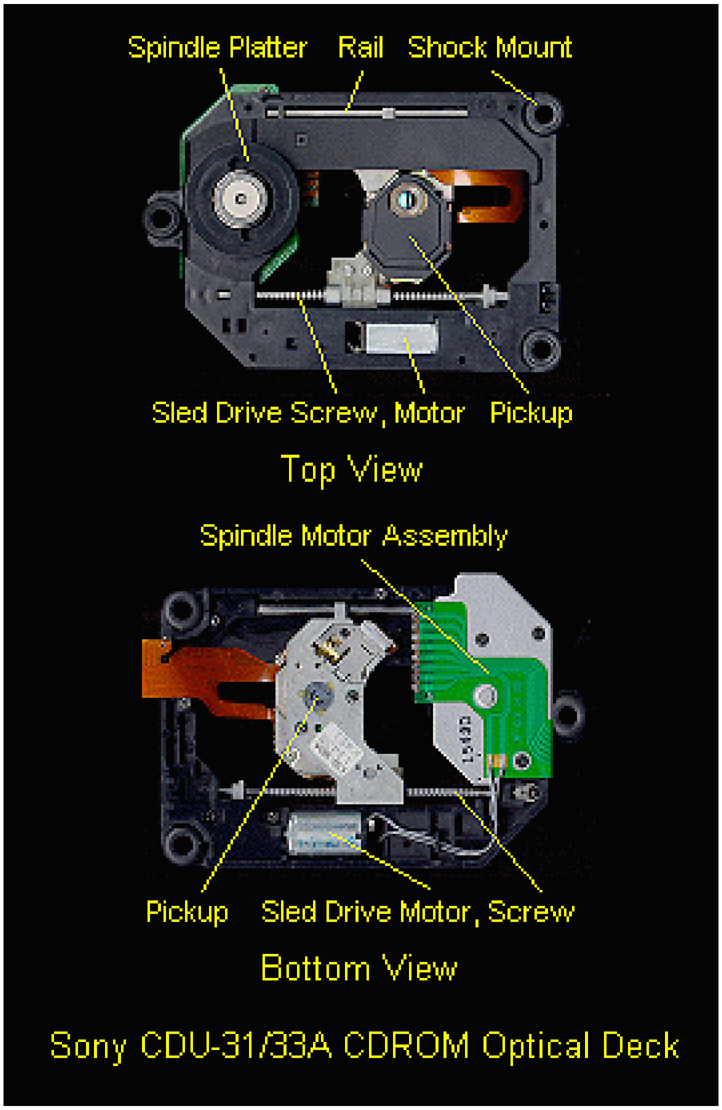
Sony D-2 CD Player Optical Deck Deck



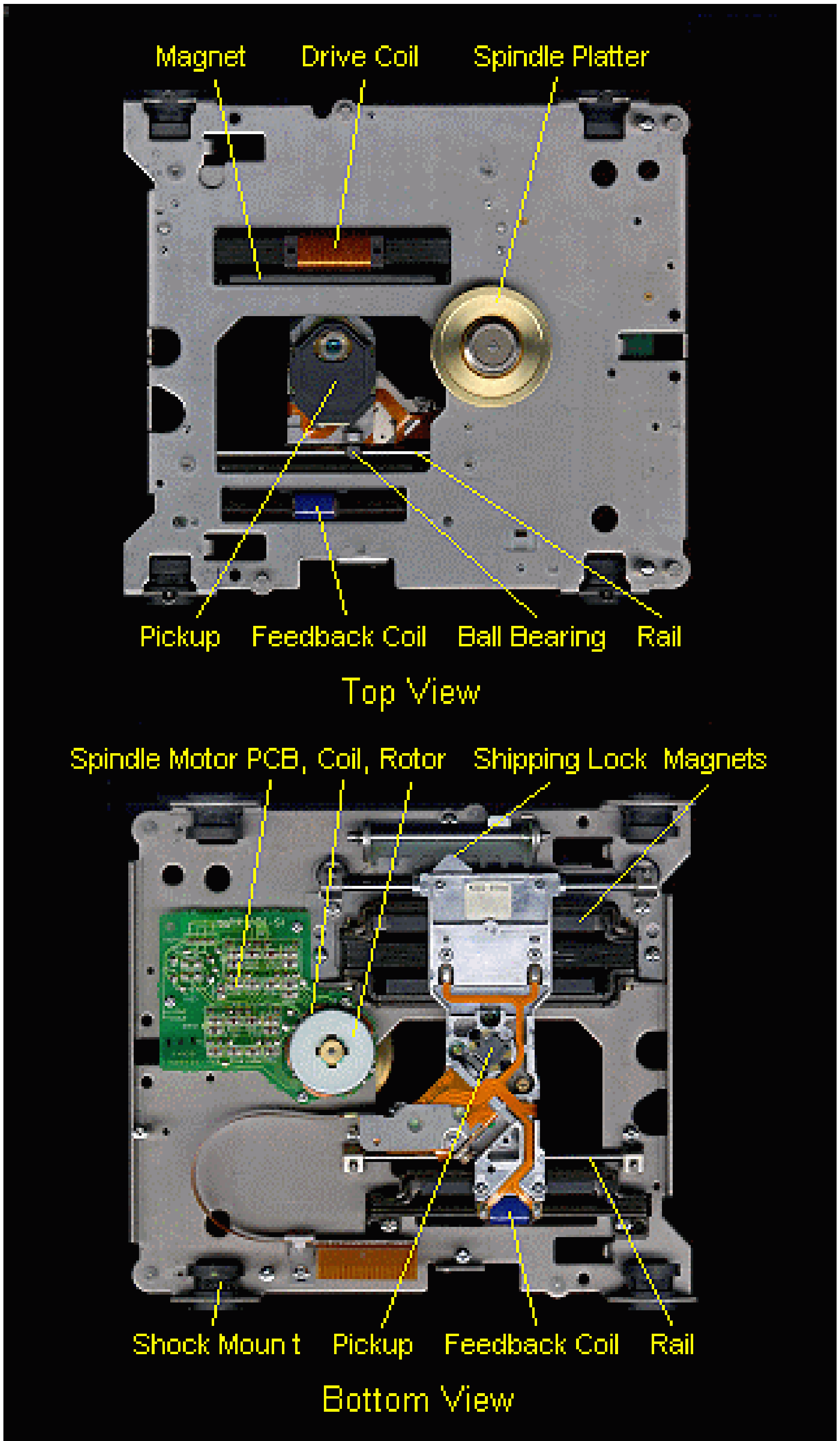
Sony D-14 CD Player Optical Deck



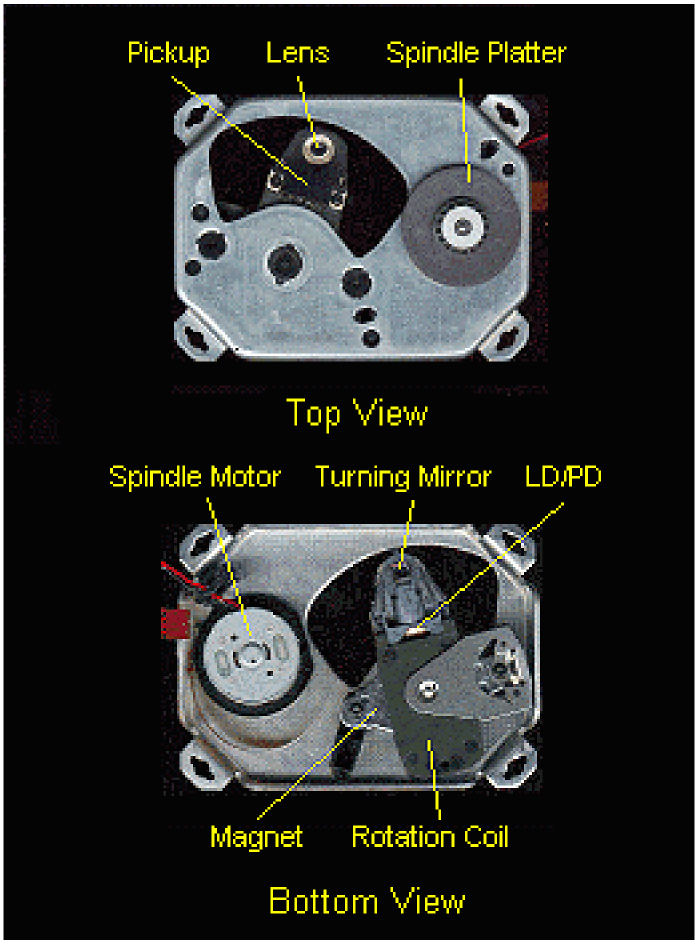
Philips CD Player Optical Deck



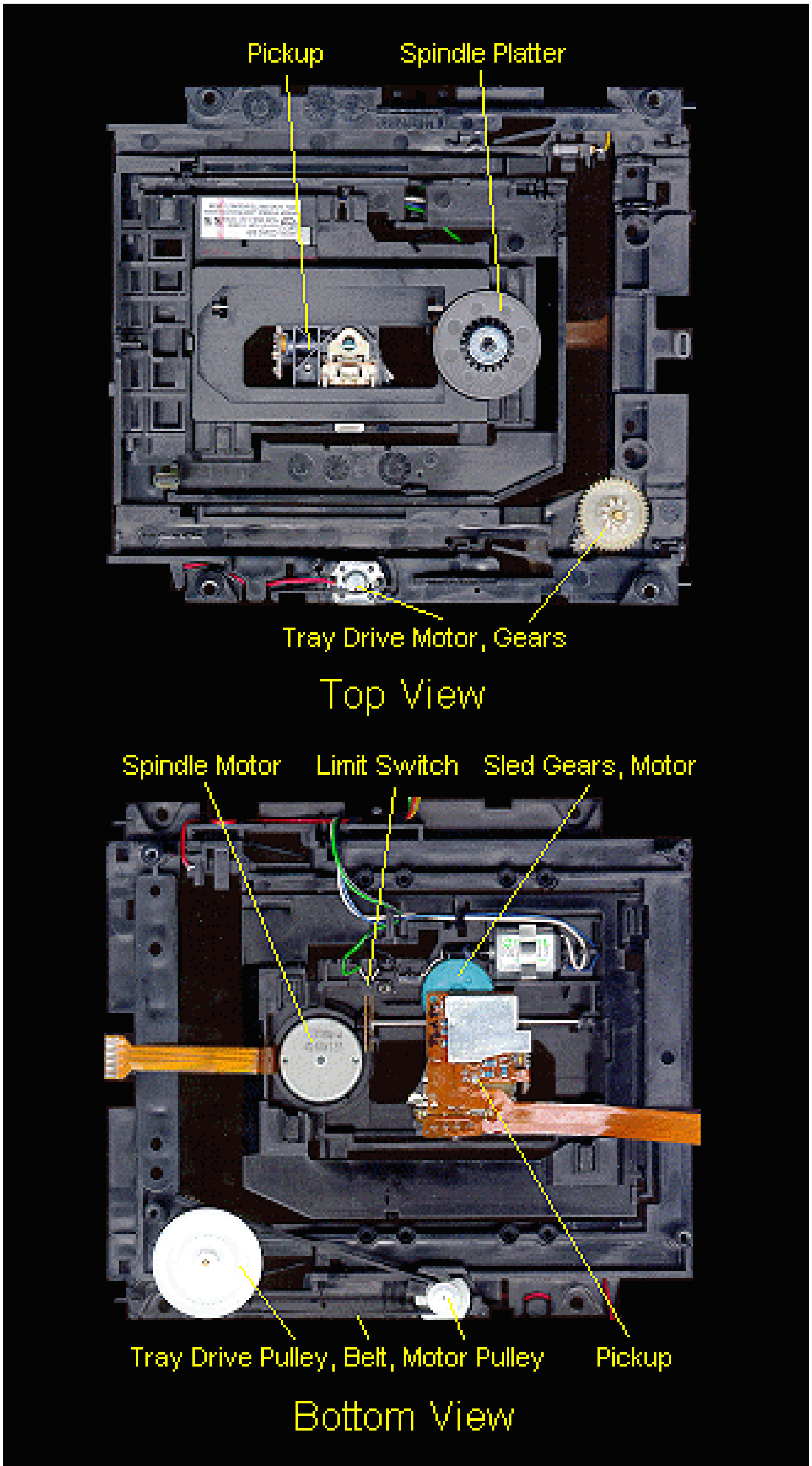
Sony CDU-31/33A CDROM Optical Deck



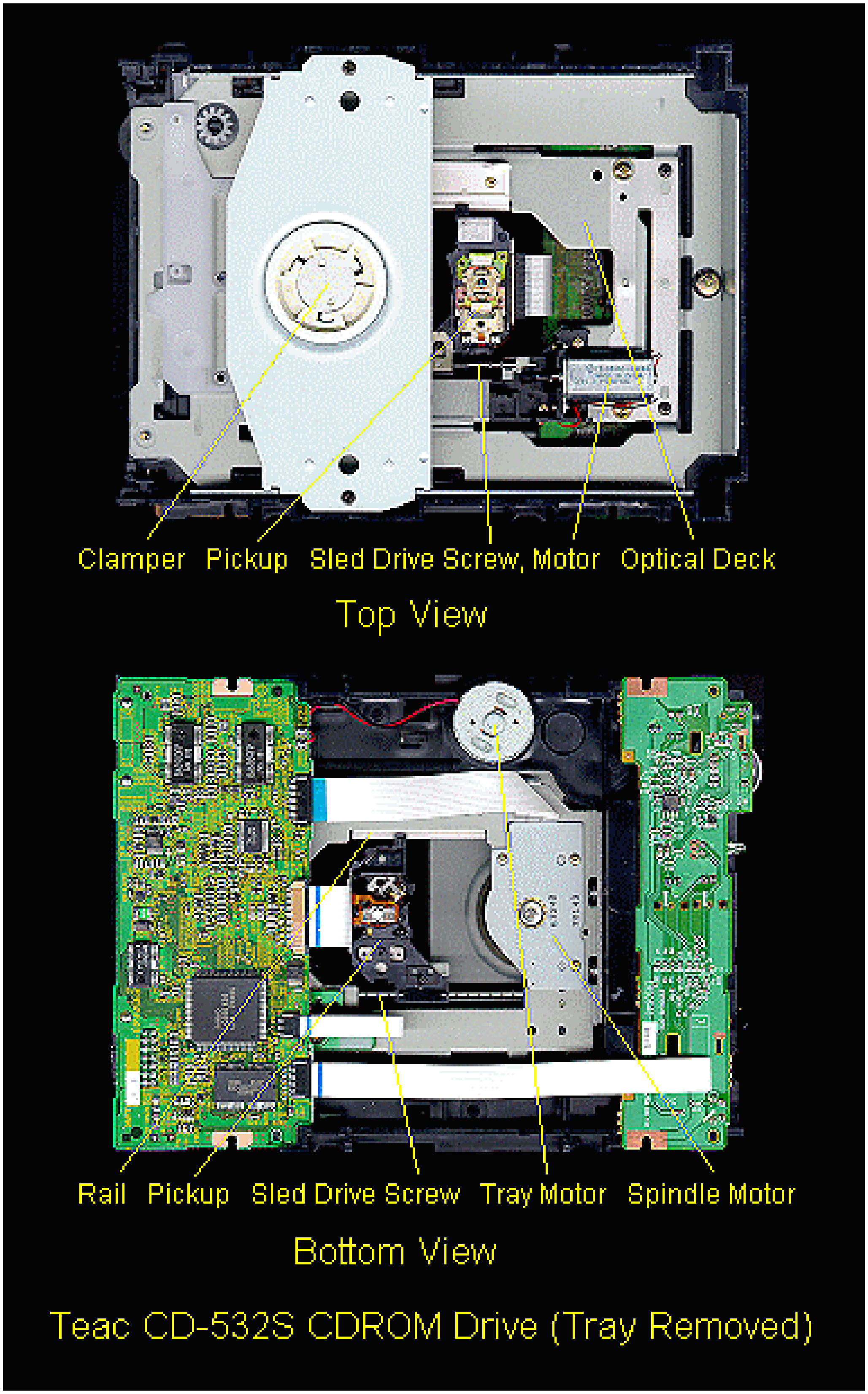
Sony CDU-8001 CDROM Optical Deck



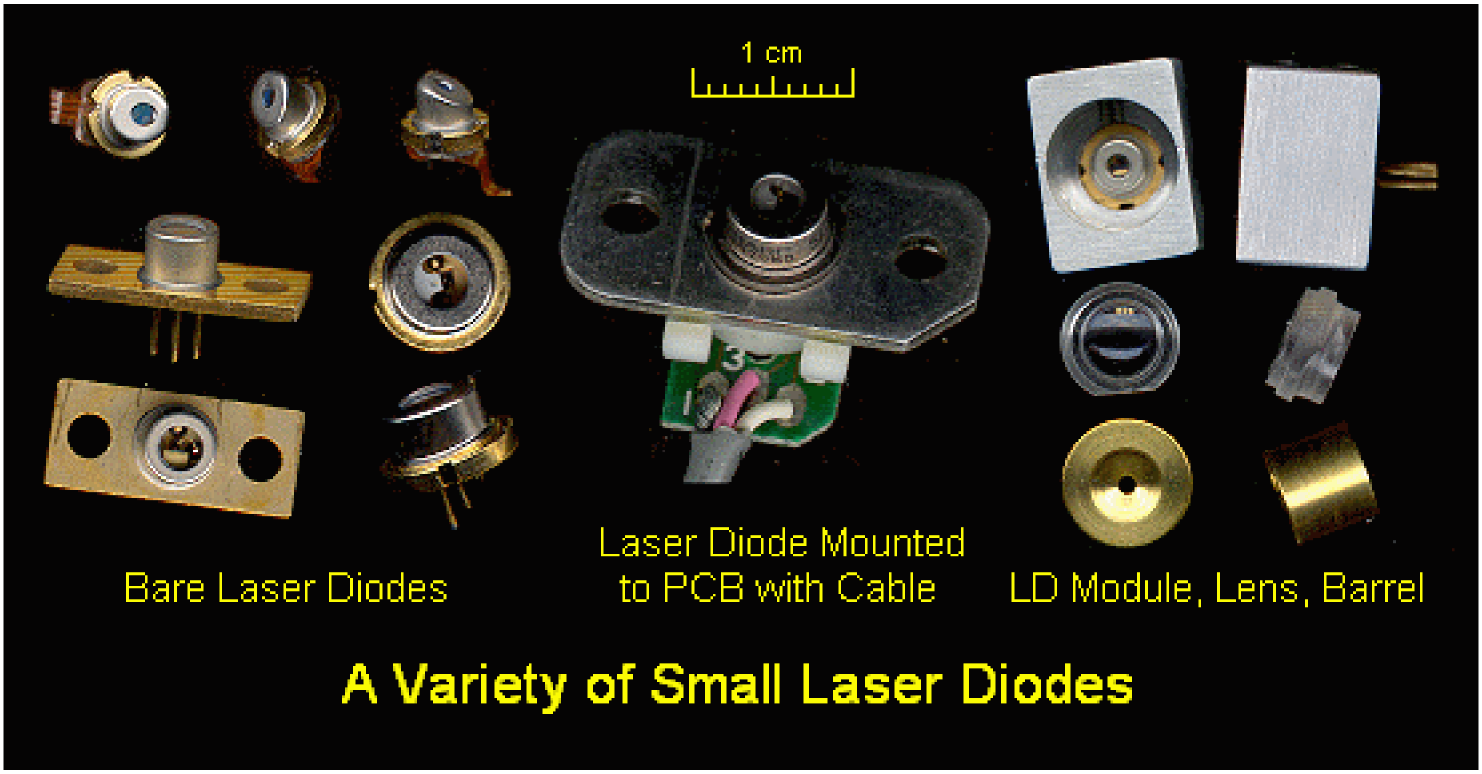
Philips CD-206 CDROM Optical Deck

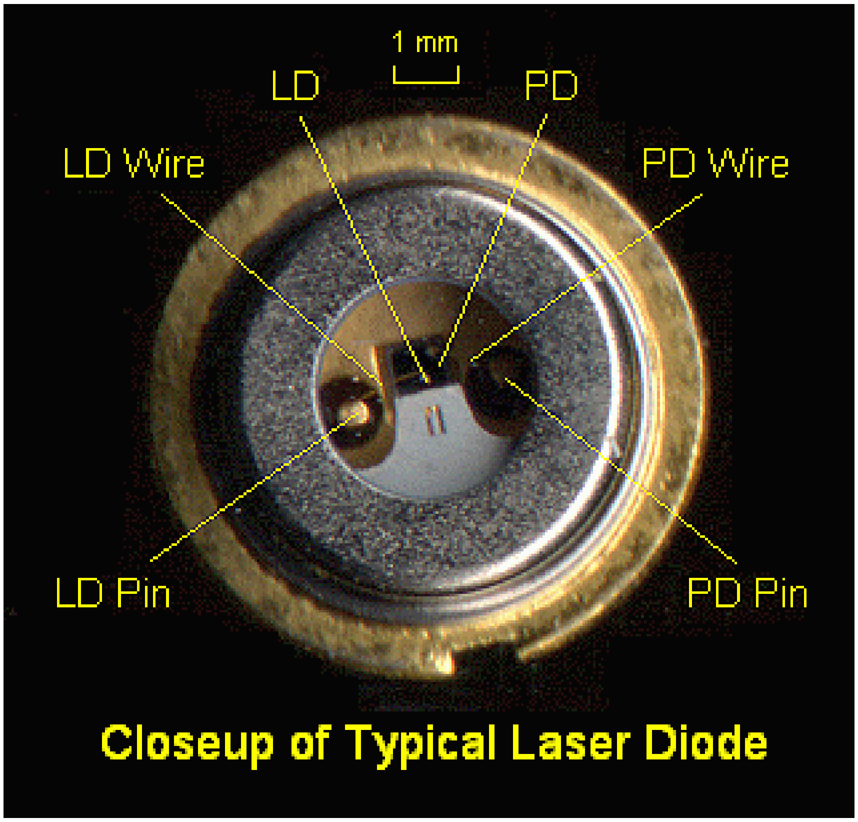


Philips PCA80SC CDROM Optical Deck

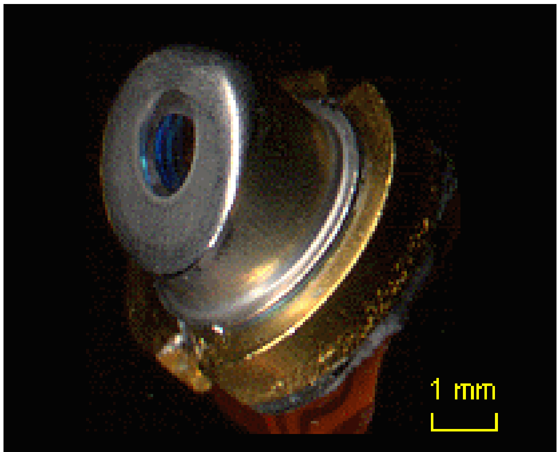


Teac CD-532S CDROM Drive (Tray Removed)

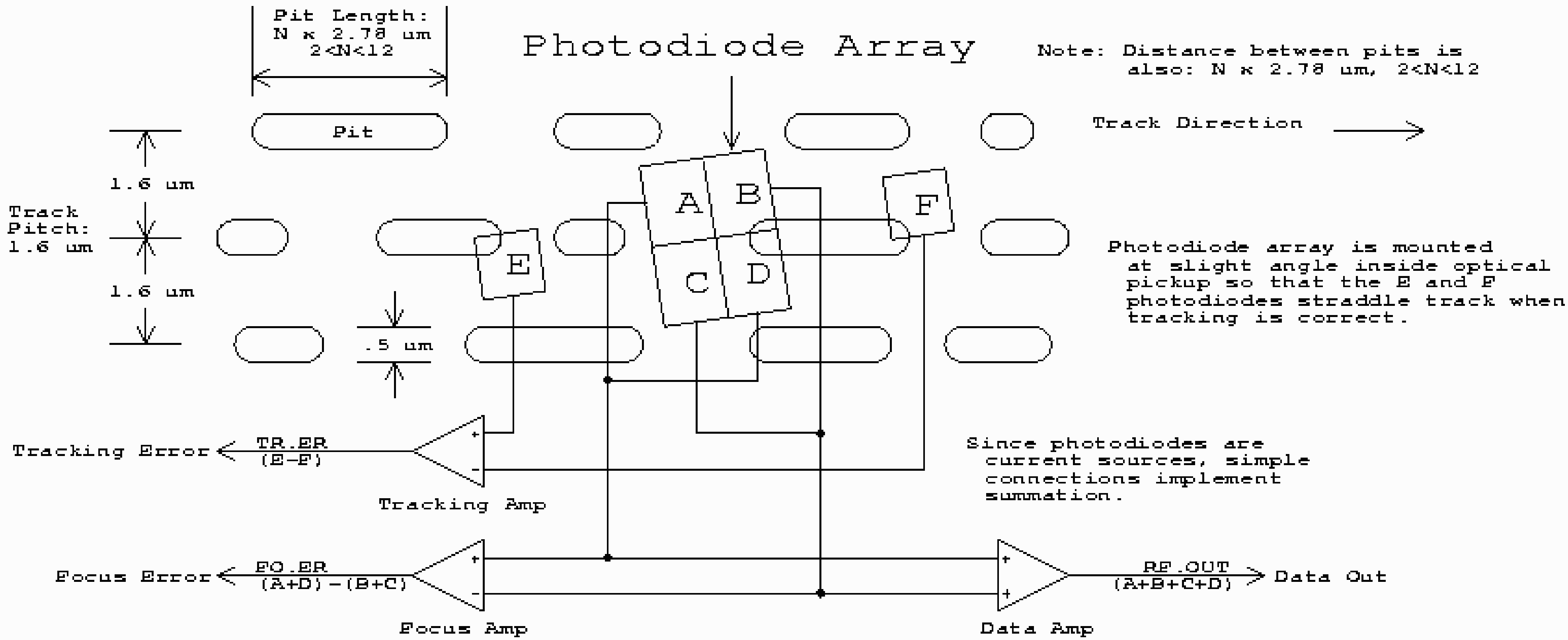

1 cm
Bare Laser Diodes
Laser Diode Mounted
to PCB with Cable
LD Module, Lens, Barrel
A Variety of Small Laser Diodes



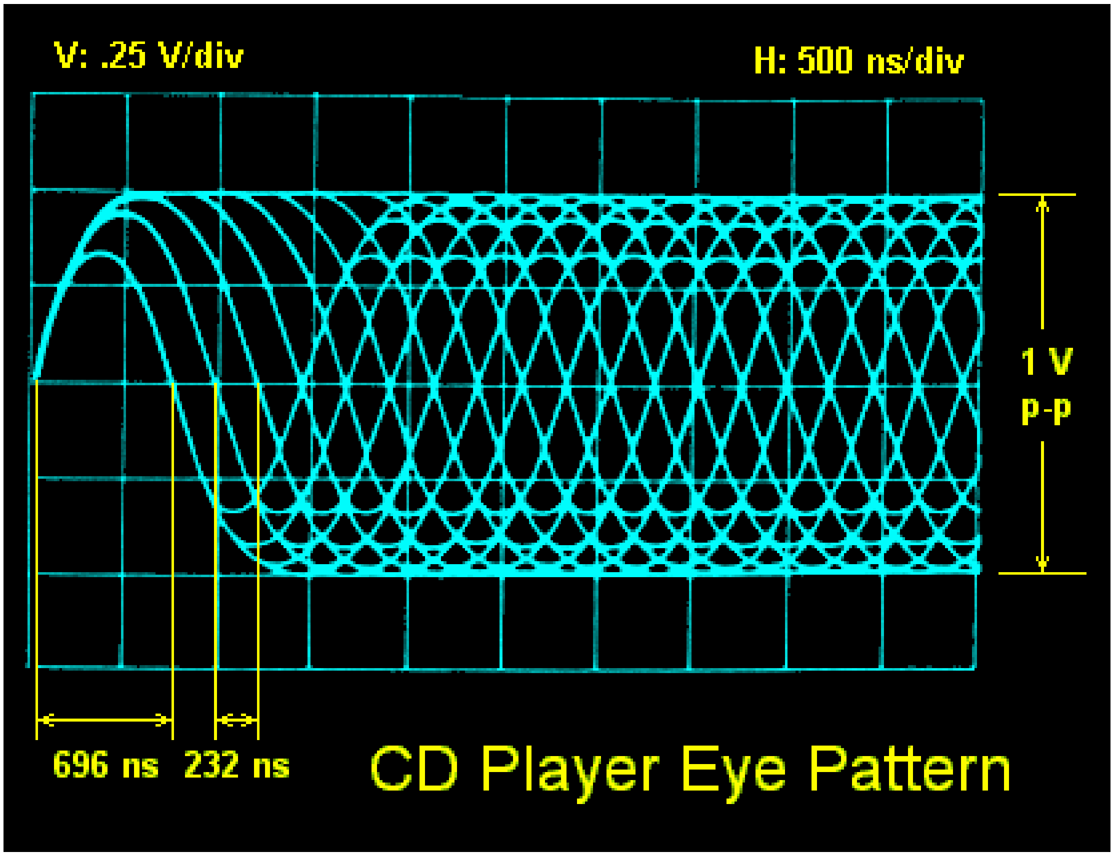
Closeup of Typical Laser Diode



Closeup of Laser Diode from
Sony KSS361A Optical Pickup



CD Player Front-End


V: .25 V/div
H: 500 ns/div
1 V
p-p
696 ns
232 ns
CD Player Eye Pattern

Notes on the Troubleshooting and Repair of Audio Equipment and Other Miscellaneous Stuff

Version 3.30

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Although working on small audio and related electronic equipment is generally less risky than dealing with equipment like microwave ovens, TVs, and computer monitors, devices that plug into the wall can still produce a very lethal electric shock as well cause a fire from incorrect or careless repairs both during servicing or later on. It is essential that you read, understand, and follow all safety guidelines contained in this document and in the document: Safety Guidelines for High Voltage and/or Line Powered Equipment.

Improper repair of battery operated devices can also result in bad consequences for you, the device, and any equipment attached to it.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Introduction

Note: Information on AC adapters, power supplies, batteries, and electronic flash units has been relocated to other documents (with what should be obvious titles) in this same directory.

Why is all that junk in your attic?

If you have ever tried to get a piece of consumer electronic equipment repaired, you understand why so much dead stuff is likely to be gathering dust in your attic or basement closet or junk box. It does not pay! This may be partially by design. However, to be fair, it may take just as much time to diagnose and repair a problem with a $20 Walkman as a $300 VCR and time is money for a repair shop. It is often not even economical to repair the more expensive equipment let alone a $40 answering machine. The cost of the estimate alone would probably buy at least one new unit and possibly many more.

However, if you can do the repair yourself, the equation changes dramatically as your parts costs will be 1/2 to 1/4 of what a professional will charge and of course your time is free. The educational aspects may also be appealing. You will learn a lot in the process. Many problems can be solved quickly and inexpensively. Fixing an old boombox to take take to the beach may just make sense after all.

This document provides maintenance and repair information for a variety of consumer electronic devices not covered by other documents in the "Notes on the Troubleshooting and Repair of..." series. Suggestions for additions (and, of course, correction) are always welcome.

You will be able to diagnose problems and in most cases, correct them as well. As most difficulties encountered with this type of equipment are mechanical, there is significant emphasis on dirt, lubrication, deteriorated rubber parts, broken doohickies, and so forth. With minor exceptions, specific manufacturers and models will not be covered as there are so many variations that such a treatment would require a huge and very detailed text. Rather, the most common problems will be addressed and enough basic principles of operation will be provided to enable you to narrow the problem down and likely determine a course of action for repair - or decide that replacement is indeed the better option. However, in many cases, you will be able to do what is required to repair a piece of equipment for a fraction of what would be charged by a repair center. Perhaps, you will even be able to revive something that would otherwise have gone into the dumpster - or remained in that closet until you moved out of your house (or longer)!

Should you still not be able to find a solution, you will have learned a great deal and be able to ask appropriate questions and supply relevant information if you decide to post to sci.electronics.repair. It will also be easier to do further research using a repair book or guide. In any case, you will have the satisfaction of knowing you did as much as you could before finally giving up or (if it is worthwhile cost-wise) taking it in for professional repair. With your new-found knowledge, you will have the upper hand and will not easily be snowed by a dishonest or incompetent technician.

If you are just getting started, you should refer to "Repair Briefs, an Introduction" for additional troubleshooting tips, recommended test equipment, suggested parts inventory, and other general information.

Information on consumer electronics technology

Your local public library (621.384 if your library is numbered that way) or technical bookstore represents a valuable resource for books on both the technology and repair of a large variety of consumer electronics devices.

For general troubleshooting techniques, see the section: Some general references.

The How Stuff Works Web site has some really nice introductory material (with graphics) on a variety of topics relating to technology in the modern world. Of relevance to this document are articles on motors, power adapters, relays, batteries, etc.

Check out "Sam's Neat, Nifty, and Handy Bookmarks" (at this site) in the "Education and Tutorials" area for links to basic introductory material on electronics and other related fields.

Web sites dealing with low voltage wiring

These sites deal with non-power wiring information: phones, audio, video, home automation, etc. Since much of the content of this document relates to home electronics that may involve such wiring, these sites may be of interest. The first also has a pile of links to other related sites.

- Phone Man's Wiring Page
- Future Standard Systems, Inc.
- David Barnett's Engineering Notebook

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Maintenance and Troubleshooting Guide

SAFETY

The only danger to you in most audio equipment and the other devices covered in this document is from the AC line connection (if any) and getting sucked into any mechanical people traps. Before you plug in the unit with any covers removed, make note and cover up any exposed AC line connections. The rest of the circuitry is low voltage and while you can destroy your equipment by your actions, you should be fairly safe. Exceptions to this are noted where appropriate.

- Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current, or get caught in moving parts (protect long hair as well).

- If circuit boards need to be removed from their mountings, put insulating material between the boards and anything they may short to. Hold them in place with string or electrical tape. Prop them up with insulation sticks - plastic or wood.

- Connect/disconnect any test leads with the equipment unpowered and unplugged. Use clip leads or solder temporary wires to reach cramped locations or difficult to access locations.

- If you must probe live, put electrical tape over all but the last 1/16" of the test probes to avoid the possibility of an accidental short which could cause damage to various components. Clip the reference end of the meter or scope to the appropriate ground return.

- Perform as many tests as possible with power off and the equipment unplugged. For example, the semiconductors in the power supply of an audio amplifier can be tested for shorts and the fusable resistors can be tested for opens.

- If you need to probe, solder, or otherwise touch circuits in a switching power supply with the power off, discharge (across) large power supply filter capacitors with a 2 W or greater 20-100K resistor and then verify with your voltmeter.

- The use of GFCI (Ground Fault Circuit Interrupter) protected outlet is a good idea but will not protect you from shock from many points in a line connected power supply. A circuit breaker is too slow and insensitive to provide any protection for you or in many cases, your equipment. A GFCI may prevent your scope probe ground from melting should you accidentally connect it to a live circuit, however.

- Don't attempt repair work when you are tired. Not only will you be more careless, but your primary diagnostic tool - deductive reasoning - will not be operating at full capacity.

- Finally, never assume anything without checking it out for yourself! Don't take shortcuts!

Getting zapped from a piece of audio (or other A/V) equipment

A slight (or not so slight) tingle when touching cabinet parts, or even a sort of vibration not due to actual physical movement as you run a finger over the metal may be an indication of some electrical leakage. Usually, this is harmless but can probably be eliminated.

Check with a multimeter on the AC volts range between any combination of user accessible parts - cases, antenna jacks, etc., and an earth ground like the third hole of a properly grounded outlets.

- If you measure an AC voltage up to about 1/2 the line voltage where you live (110 VAC or 220 VAC), it may just be due to the various capacitors inside the equipment coupling to a live chassis.

- However, if you measure the full line voltage, you may have a serious fault somewhere that requires immediate attention. Modern equipment must be designed in such a way that no matter how it is plugged in, no user accessible parts can be live. (Some really old AC/DC sets may indeed have one side of the line connected to an uninsulated chassis.) However, a short circuit somewhere inside can produce such a fault - a very hazardous situation.

  For the slight tingle case:

- Check outlet wiring - check H-N polarity, and for 3-prong outlets, that there is a proper ground. Plug everything into a single circuit if possible.

- Make sure each piece of equipment is plugged into its outlet properly with its polarized plug.

- Check the case and connectors of each piece of equipment between a known ground for voltage. Also check the cable itself. If you read a high voltage on it, have your cable company check it out.

- Reversing a two prong plug in the outlet may help if it isn't polarized. If it is, the outlet or the equipment itself might be improperly wired.

Troubleshooting tips

Many problems have simple solutions. Don't immediately assume that your problem is some combination of esoteric complex convoluted failures. For a tape deck, it may just be a bad belt or a bad tape. Try to remember that the problems with the most catastrophic impact on operation (a dead AC adapter) have the simplest solutions (repair the wires broken due to flexing in the power cable).

If you get stuck, sleep on it. Sometimes, just letting the problem bounce around in your head will lead to a different more successful approach or solution. Don't work when you are really tired - it is both dangerous and mostly non-productive (or possibly destructive).

Whenever working on precision equipment, make copious notes and diagrams. You will be eternally grateful when the time comes to reassemble the unit. Most connectors are keyed against incorrect insertion or interchange of cables, but not always. Apparently identical screws may be of differing lengths or have slightly different thread types. Little parts may fit in more than one place or orientation. Etc. Etc.

Pill bottles, film canisters, and plastic ice cube trays come in handy for sorting and storing screws and other small parts after disassembly.

Select a work area which is well lighted and where dropped parts can be located - not on a deep pile shag rug. Something like a large plastic tray with a slight lip may come in handy as it prevents small parts from rolling off of the work table. The best location will also be relatively dust free and allow you to suspend your troubleshooting to eat or sleep or think without having to pile everything into a cardboard box for storage.

Another consideration is ESD - Electro-Static Discharge. The electronic components in a some devices like cassette decks, Walkmen, and portable phones, are vulnerable to ESD. There is no need to go overboard but taking reasonable precautions like not wearing clothing made of wool that tends to generate static. When working on larger devices like cassette decks, get into the habit of touching a ground like the metal chassis before touching any circuit components.

A basic set of precision hand tools will be all you need to disassemble and perform adjustments on most consumer electronic equipment. These do not need to be really expensive but poor quality tools are worse than useless and can cause damage. Needed tools include a selection of Philips and straight blade screwdrivers, needlenose pliers, wire cutters, tweezers, and dental picks. A jeweler's screwdriver set is a must particularly if you are working on compact equipment. For adjustments, a miniature (1/16" blade) screwdriver with a non-metallic tip is desirable both to prevent the presence of metal from altering the electrical properties of the circuit and to minimize the possibility of shorting something from accidental contact with the circuitry.

For thermal or warmup problems, a can of 'cold spray' or 'circuit chiller' (they are the same) and a heat gun or blow dryer come in handy to identify components whose characteristics may be drifting with temperature. Using the extension tube of the spray can or making a cardboard nozzle for the heat gun can provide very precise control of which components you are affecting.

Basic cleaning supplies include Q-tips (you may know them as cotton buds) for everything BUT the video heads on VCRs and other helical scan tape transports, chamois covered cleaning sticks (for video heads), lint free cloths or paper towels, water, and isopropyl alcohol (preferably 91 percent medicinal grade or better).

For info on useful chemicals, adhesives, and lubricants, see "Repair Briefs, an Introduction" as well as other documents available at this site.

Soldering equipment

The ease and quality of your work will depend both on proper soldering as well as desoldering (often called rework) equipment.

- A low wattage (25 W) iron for delicate components including discrete semiconductors, ICs, other small parts).
- A medium wattage (40-50W) iron for heavy duty circuit board work including power components, power plane connections, and large transformers).
- A 100-140 W soldering gun for chassis connections.

Three wire grounded soldering equipment is recommended but I do not consider it essential for this type of repair work. However, a temperature regulated soldering station is a really nice piece of equipment if you can afford it or happen on a really good deal.

I consider fine gauge rosin core solder (.030 or less) to be best for most applications (e.g., Ersin Multicore).

- Desoldering pump - SoldaPullit or similar 'solder sucker' for removing components easily and usually nondestructively. SolderWick is also handy for cleaning up desoldered connections.

  A vacuum rework station is not needed unless you are removing your soldered in 1,500 pin Intel P8!

CAUTION: You can easily turn a simple repair (e.g., bad solder connections) into an expensive mess if you use inappropriate soldering equipment and/or lack the soldering skills to go along with it. If in doubt, find someone else to do the soldering or at least practice, practice, practice, soldering and desoldering on a junk circuit board first!

Soldering techniques

Soldering is a skill that is handy to know for many types of construction and repair. For modern small appliances, it is less important than it once was as solderless connectors have virtually replaced solder for internal wiring.

However, there are times where soldering is more convenient. Use of the proper technique is critical to reliability and safety. A good solder connection is not just a bunch of wires and terminals with solder dribbled over them. When done correctly, the solder actually bonds to the surface of the metal (usually copper) parts.

Effective soldering is by no means difficult but some practice may be needed to perfect your technique.

The following guidelines will assure reliable solder joints:

- Only use rosin core solder (e.g., 60/40 tin/lead) for electronics work. A 1 pound spool will last a long time and costs about $10. Suggested diameter is .030 to .060 inches for appliances. The smaller size is preferred as it will be useful for other types of precision electronics repairs or construction as well. The rosin is used as a flux to clean the metal surface to assure a secure bond. NEVER use acid core solder or the stuff used to sweat copper pipes! The flux is corrosive and it is not possible to adequately clean up the connections afterward to remove all residue.

- Keep the tip of the soldering iron or gun clean and tinned. Buy tips that are permanently tinned - they are coated and will outlast countless normal copper tips. A quick wipe on a wet sponge when hot and a bit of solder and they will be as good as new for a long time. (These should never be filed or sanded).

- Make sure every part to be soldered - terminal, wire, component leads - is free of any surface film, insulation, or oxidation. Fine sandpaper or an Xacto knife may be used, for example, to clean the surfaces. The secret to a good solder joint is to make sure everything is perfectly clean and shiny and not depend on the flux alone to accomplish this. Just make sure the scrapings are cleared away so they don't cause short circuits.

- Start with a strong mechanical joint. Don't depend on the solder to hold the connection together. If possible, loop each wire or component lead through the hole in the terminal. If there is no hole, wrap them once around the terminal. Gently anchor them with a pair of needlenose pliers.

- Use a properly sized soldering iron or gun: 20-25 W iron for fine circuit board work; 25-50 W iron for general soldering of terminals and wires and power circuit boards; 100-200 W soldering gun for chassis and large area circuit planes. With a properly sized iron or gun, the task will be fast - 1 to 2 seconds for a typical connection - and will result in little or no damage to the circuit board, plastic switch housings, insulation, etc. Large soldering jobs will take longer but no more than 5 to 10 seconds for a large expanse of copper. If it is taking too long, your iron is undersized for the task, is dirty, or has not reached operating temperature. For appliance work there is no need for a fancy soldering station - a less than $10 soldering iron or $25 soldering gun as appropriate will be all that is required.

- Heat the parts to be soldered, not the solder. Touch the end of the solder to the parts, not the soldering iron or gun. Once the terminal, wires, or component leads are hot, the solder will flow via capillary action, fill all voids, and make a secure mechanical and electrical bond. Sometimes, applying a little from each side will more effectively reach all nooks and crannies.

- Don't overdo it. Only enough solder is needed to fill all voids. The resulting surface should be concave between the wires and terminal, not bulging with excess solder.

- Keep everything absolutely still for the few seconds it takes the solder to solidify. Otherwise, you will end up with a bad connection - what is called a 'cold solder joint'.

- A good solder connection will be quite shiny - not dull gray or granular. If your result is less than perfect reheat it and add a bit of new solder with flux to help it reflow.

Practice on some scrap wire and electronic parts. It should take you about 3 minutes to master the technique!

Desoldering techniques

Occasionally, it will be necessary to remove solder - either excess or to replace wires or components. A variety of tools are available for this purpose. The one I recommend is a vacuum solder pump called 'SoldaPullet' (about $20). Cock the pump, heat the joint to be cleared, and press the trigger. Molten solder is sucked up into the barrel of the device leaving the terminal nearly free of solder. Then use a pair of needlenose pliers and a dental pick to gently free the wires or component. Other approaches that may be used in place of or in addition to this: Solder Wick which is a copper braid that absorbs solder via capillary action; rubber bulb type solder pumps, and motor driven vacuum solder rework stations (pricey).

See the document: Troubleshooting and Repair of Consumer Electronics Equipment for additional info on desoldering of electronic components.

Soldering pins in plastic connectors

The thermoplastic used to mold many common cheap connectors softens or melts at relatively low temperatures. This can result in the pins popping out or shifting position (even shorting) as you attempt to solder to them to replace a bad connection, for example.

One approach that works in some cases is to use the mating socket to stabilize the pins so they remain in position as you solder. The plastic will still melt - not as much if you use an adequately sized iron since the socket will act as a heat sink - but will not move.

An important consideration is using the proper soldering iron. In some cases, a larger iron is better - you get in and out more quickly without heating up everything in the neighborhood.

Test equipment

Don't start with the electronic test equipment, start with some analytical thinking. Many problems associated with consumer electronic equipment do not require a schematic (though one may be useful). The majority of problems with consumer electronic equipment are mechanical and can be dealt with using nothing more than a good set of precision hand tools; some alcohol, degreaser, contact cleaner, light oil and grease; and your powers of observation (and a little experience). Your built in senses and that stuff between your ears represents the most important test equipment you have.

A DMM or VOM is necessary for checking of power supply voltages and testing of sensors, LEDs, switches, and other small components. This does not need to be expensive but since you will be depending on its readings, reliability is important. Even a relatively inexpensive DMM from Radio Shack will be fine for most repair work. You will wonder how you ever lived without one! Cost: $25-50.

Unless you get deep into electronic repair, a high bandwidth oscilloscope is not required. However, a relatively inexpensive 5 or 10 MHz dual trace scope is very handy and you will find all kinds of uses for it. Such a scope should cost less than $150 on the used market.

There are several specific pieces of test equipment that you may already own which are required depending on the devices being fixed.

Audio equipment:

- Stereo tuner or other audio signal source. An audio signal generator is nice but not really essential.
- An audio amp connected to a loudspeaker. The input should be selectable between line level and mic level and be brought out through a shielded cable to a test probe and ground clip. This is useful for tracing an audio circuit to determine where a signal is getting lost. Inexpensive signal tracers are also available but this option is likely free.

  If you intend to test phonograph (e.g., vinyl) or low level signals from tape heads, the amp should have magnetic phono level (average of 2 to 5 mV which is equivalent to -54 dBV to -46 dBV) in addition to line level (CD, DVD, tape, etc., average of 250 mV, peak of 2 V) inputs.
- Prerecorded and garbage cassettes or tapes for testing of component and walkman tape transports.

Video games, cable boxes, and other video sources:

- A TV (preferably color) with RF (antenna) inputs connected to a VCR with a working tuner and RF modulator or a TV with both RF and A/V (RCA jacks) inputs.
- A known good game cartridge to confirm that the problem is in the game console.

Telephone equipment:

- A working tone dialing phone. If I had a choice, it would be a good old reliable ATT Touch Tone desk phone.
- A working rotary dialing phone. If I had a choice, it would be a good old reliable ATT rotary dial desk phone. (This is really only needed if you are doing repairs where tone dialing isn't available.)
- A dual connector phone jack. Two independent phone lines are desirable for answering machine or modem testing.
- A PC or laptop with a fax-modem (for modem and fax machine testing).
- A low voltage DC power supply or wall wart to perform certain tests without a telephone connection or phone line simulator.
- A handy-dandy phone line tester. The inexpensive variety is just a pair of LEDs in series with a resistor for each line attached to an RJ11 connector. However, this is much more convenient than fumbling with a multimeter! You can buy one at Radio Shack (about $7) or easily build your own. See the section: Handy-dandy phone line tester for details.

Handy-dandy phone line tester

This simple device (total cost about $3) will show at a glance the status of all of the phone lines connected to a modular jack.

Parts list:

- Surface mount RJ11 modular jack.
- RJ11 extension cord.

For each phone line:

- 2 LEDs (red and green).
- 10K resistor.

Construct the following circuit for each line and attach to the appropriate color terminals/wires of the modular jack:

```
                          10K             Green LED
Line 1:     (Green) o------/\/\-----+--------|>|-------+------o (Red
Line 2:     (Black)                 |  Wiring Correct  |        (Yellow)
Line 3:     (White)                 |                  |        (Blue)
                                    |      Red LED     |
                                    +--------|<|-------+
                                     Reverse Polarity
```

Note: Polarity of Tip and Ring are reversed with respect to the wire colors because of swap that occurs using the RJ11 extension cord.

Mount the LEDs in holes drilled in the plastic cover of the modular jack (making sure they clear the base when the cover is screwed down).

To test old style 4 prong phone jacks, use an adapter on the end of the RJ11 extension cord.

Correctly wired lines will light up green, reverse polarity will be red, dead line will be dark, line-in-use will be dark or nearly dark. If you catch a line that is ringing. both LEDs will flicker.

Putting just the LED portion (leave out the resistor) of this circuit in *series* with the phone line will implement an off-hook (in use) indicator.

Getting inside consumer electronic equipment

Yes, you will void the warranty, but you knew this already.

Note: the sections on loudspeakers, cameras, and watches have additional 'getting inside' info.

Manufacturers seem to take great pride in being very mysterious as to how to open their equipment. Not always, but this is too common to just be a coincidence.

A variety of techniques are used to secure the covers on consumer electronic equipment:

1. Screws. Yes, many still use this somewhat antiquated technique. Sometimes, there are even embossed arrows on the case indicating which screws need to be removed to get at the guts. In addition to obvious screw holes, there may be some that are only accessible when a battery or cassette compartment is opened or a trim panel is popped off.

   These will often be of the Philips variety. (Strictly speaking, many of these are not actual Philips head screws but a slight variation. Nonetheless, a Philips screwdriver of suitable size will work on them.) A precision jeweler's screwdriver set including miniature Philips head drivers is a must for repair of miniature portable devices.

   Sometimes, you will find Torx or a variety of security type fasteners. Suitable driver bits are available. Sometimes, you can improvise using regular tools. In the case of security Torx, the center post can usually be broken off with a pair of needlenose pliers allowing a normal Torx driver to be used. In a pinch, a suitable size hex wrench can substitute for a Torx driver. Places like MCM Electronics carry a variety of security bits.

2. Hidden screws. These will require prying up a plug or peeling off a decorative decal. It will be obvious that you were tinkering - it is virtually impossible to put a decal back in an undetectable way. Sometimes the rubber feet can be pryed out revealing screw holes. For a stick-on label, rubbing your finger over it may permit you to locate a hidden screw hole. Just puncture the label to access the screw as this may be less messy then attempting to peel it off.

3. Snaps. Look around the seam between the two halves. You may (if you are lucky) see points at which gently (or forcibly) pressing with a screwdriver will unlock the covers. Sometimes, just going around the seam with a butter knife will pop the cover at one location which will then reveal the locations of the other snaps.

4. Glue. Or more likely, the plastic is fused together. This is particularly common with AC adapters (wall warts). In this case, I usually carefully go around the seam with a hacksaw blade taking extreme care not to go through and damage internal components. Reassemble with plastic electrical tape.

5. It isn't designed for repair. Don't laugh. I feel we will see more and more of this in our disposable society. Some devices are totally potted in Epoxy and are throwaways. With others, the only way to open them non-destructively is from the inside.

Don't force anything unless you are sure there is no alternative - most of the time, once you determine the method of fastening, covers will come apart easily. If they get hung up, there may be an undetected screw or snap still in place.

The most annoying (to be polite) situation is when after removing the 18 screws holding the case together (losing 3 of them entirely and mangling the heads on 2 others), removing three subassemblies, and two other circuit boards, you find that the adjustment you wanted was accessible through a hole in the case just by partially peeling back a rubber hand grip!

When reassembling the equipment make sure to route cables and other wiring such that they will not get pinched or snagged and possibly broken or have their insulation nicked or pierced and that they will not get caught in moving parts. Replace any cable ties that were cut or removed during disassembly and add additional ones of your own if needed. Some electrical tape may sometimes come in handy to provide insulation insurance as well.

Getting built up dust and dirt out of a equipment

This should be the first step in any inspection and cleaning procedure.

Do not be tempted to use compressed air!

I would quicker use a soft brush to carefully dust off the circuit boards and power supply. Work in such a way that the resulting dust does not fall on the mechanical parts.

For intricate mechanisms, using compressed air could dislodge dirt and dust which may then settle on lubricated parts contaminating them. High pressure air could move oil or grease from where it is to where it should not be. If you are talking about a shop air line, the pressure may be much much too high and there may be contaminants as well.

A Q-tip (cotton swab) moistened with politically correct alcohol can be used to remove dust and dirt from various surfaces of the deck (in addition to the normal proper cleaning procedures for the guides, rollers, heads, wheels, belts, etc.)

What to do if a tiny tiny part falls inside

We have all done this: a tiny washer or spring pops off and disappears from sight inside the guts of the unit. Don't panic. First - unplug it if AC powered. Remove the battery pack if possible from a portable device.

Try to locate the part with a bright light without moving anything. You may have gotten lucky (yeh, right). Next, over an area where a dropped part will be visible (not a shag carpet!), try any reasonable means to shake it loose - upside down, a little gently tapping and shaking, etc. A hard surface is better in some ways as you might hear the part drop. On the other hand it may bounce into the great beyond.

If this does not work, you have two options:

1. Assume that the part has landed in a place that will not cause future problems. There could be electrical problems if it is metallic and shorts out some circuitry or there could be mechanical problems if it jams some part of the mechanism. There is an excellent chance that the part will never cause any harm. What chance? I don't know, maybe 99%. It is not worth taking the unit to pieces to locate the part. You are more likely to damage something else in the process. Obtain a replacement and get on with your life. The exception is, of course, if you now begin experiencing problems you **know** were not there before.

2. Take the unit to pieces in an attempt to locate the part. For all you know, it may be clear across the room and you will never find it inside. If all the gymnastics have not knocked it loose, then it may be really

wedged somewhere and will stay there - forever. If the unit behaves normally, then in all likelihood it will continue to do so.

To prevent this sort of thing from happening in the future you will no doubt be much more careful. Sure you will! Some suggestions to prevent ejection of an E-clip, split washer, or spring into the great beyond:

1. Construct a paper dam around the area.

2. Tie a thread or fine wire around the part before attempting to remove it. Keep this 'safety line' on until after it has been reinstalled, then just pull it free.

3. Keep one finger on the part as you attempt to pop it free.

4. Hold onto the part with a pair of needlenose pliers or tweezers while prying with a small screwdriver.

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Audio Cassette and Open Reel Tape Equipment

Parts of an audio tape transport

The following description applies to most cassette and open reel tape transports including those used in portable and microcassette recorders, Walkmen, and telephone answering machines.

Looking at the top of the deck such that the tape heads are at the bottom:

- Supply reel table - left hand side platform on which the supply tape reel sits. Edge which contacts idler tire (if used) should be cleaned.

- Takeup reel table - right hand side platform on which the takeup tape reel sits. Edge which contacts idler tire (if used) should be cleaned.

- Idler - assembly which swings between supply and takeup reels and transfers power to the appropriate reel to wind the tape up during play and record and often to drive FF and REW. In some designs, this uses gears or some other type of mechanism. In very expensive decks, individual motors are used for each reel and there is no intermediate drive.

- Idler tire - the black rubber ring on the outside of one part of the idler which actually contacts the reel edges. This is not as common in audio tape decks as VCRs. If one is used, it should be cleaned and inspected for deterioration, dirt, and wear.

- Capstan - right side after tape exits from area of record/playback/erase heads. The capstan is a shaft (about 1/16" diameter in cassette decks, recorders, and Walkmen, 3/16" or larger diameter in open reel machines) which during play and record modes precisely controls tape movement when the pinch roller is pressed against it. For autoreverse transports, there will be two capstans - one on each side of the head assembly so that the tape is always pulled across the heads as this is most precise. (In a VCR, there is only one capstan and it is also used for reverse play or search modes.) Clean to assure proper tape movement during play and record modes.

- Pinch Roller - black rubber roller which spins freely and is pressed against the capstan during play, record, and search modes. For autoreverse decks, there will be two pinch rollers, one for each capstan. A hard, shiny, cracked, or dried out pinch roller can lead to tape edge munching and erratic or wavering sound. Clean thoroughly (until no more black stuff comes off). Inspect for cracked or deteriorated rubber.

- Tape heads. Most low to mid priced tape decks have two - an erase head and a combined record/playback head. High-end decks will have separate record and playback heads supporting sound-on-sound mixing to the same track and allowing recording quality to be monitored off of the tape. These may be physically independent assemblies or combined into a single unit. Autoreverse decks often have a head assembly that rotates 180 degrees depending on tape direction. This is less expensive than having two erase heads and two record/playback heads or a single record/playback head that shifted position to align with the appropriate tracks and electronic switching of the record and playback signals.

  Play-only transports such as found in car cassette decks and Walkmen do not need an erase head. Autoreverse play-only decks often do just shift the position of the playback head a fraction of a mm depending on playback direction to line up with the tracks and interchanges the connections for L and R channels.

  Clean the polished surfaces thoroughly (DO NOT use anything abrasive!).

- Various other guide posts - vertical stationary metal posts which tape contacts. Should be cleaned but rarely need adjustment.

- Belts - various size black rubber bands - a typical transport will have between 0 and 4 belts, usually below decks. These will require replacement after a few years. Clean and inspect.

General guide to tape deck cleaning and rubber parts replacement

The following procedures apply to boom boxes, cassette decks, microcassette and other portable tape recorders, open reel tape decks, and telephone answering machines. While the tape transports used in these devices are less complex than those used in VCRs and other helical scan recording equipment, some routine maintenance can go a long way towards preventing future problems. All the guideposts, wheels, and rubber parts should be inspected and cleaned periodically - how often depends on usage. Of course, no one really does this unless something goes wrong.

Qtips and alcohol (91% medicinal is ok, pure isopropyl is better. Avoid rubbing alcohol especially if it contains any additives) can be used everywhere EXCEPT on the rotating heads of VCRs and camcorders (and other helical scan devices like 8mm and 4mm (DAT) storage drives) - see the document: Notes on the Troubleshooting and Repair of Video Cassette Recorders for detailed procedures on cleaning of video heads - you can destroy the most expensive part of your VCR by improper cleaning techniques. Dry quickly to avoid leaving residue behind. Sometimes good old fashioned water (just a damp cloth) will work better on sugar based gunk and other kids' grime.

Cleaning may get your machine going well enough to get by until any replacement rubber parts arrive.

Things to clean:

(Some of these components may not be present in your particular equipment).

- Capstan and pinch roller. These collect a lot of crud mostly oxide which flakes off of (old) tapes. Use as many Q-tips (wet but not dripping with alcohol) as necessary to remove all foreign matter from the capstan (the shiny shaft that pulls the tape through the unit for play and record). Just don't get impatient and use something sharp - the crud will come off with the Qtips and maybe some help from a fingernail. On autoreverse decks, there will usually be two capstans and pinch rollers.

  Clean the pinch roller (presses against the capstan in play and record) until no more black stuff comes off. Use as many Qtips as necessary.

  If the pinch roller is still hard and/or shiny or has a cracked surface, it will probably need replacement. Many are available from the sources listed in the section: Recommended parts suppliers.

- Various guideposts that the tape contacts. Clean like the capstan.

- Idler tire (idler swings between reels and transfers motor power to reels - clean until no more black stuff comes off. A dirty or worn idler tire may prevent the takeup reel from turning resulting in spilled tape.

  Also, the idler assembly includes a slip clutch. If this weakens, the idler may not have enough force to press on the reel table edges.

- Reel table edges - surface on the reel tables where the idler contacts.

- Audio head(s) and erase head. Q-tips and alcohol are ok for these. Do not use anything sharp or abrasive!

- Anything else that the tape contacts on its exciting journey through your machine.

- Rubber belts. Access to some of these may require the services of a Swiss watchmaker (if any still exist). Some boomboxes seem to be designed specifically to be difficult to service. After noting where each belt goes, remove them individually (if possible) and clean with alcohol and Qtips or a lint free cloth. Dry quickly to avoid degrading the rubber from contact with the alcohol. If a belt is trapped by some assembly and not easy to remove, use the Qtip on the belt and/or pulley in place. However, if it is stretched, flabby, or damaged, you will need to figure out how to free it.

  Note that on some equipment like dual cassette boomboxes and telephone answering machines, the belt(s) may follow a highly circuitous path - make a detailed diagram!

  Any belts that appear loose, flabby or do not return instantly to their relaxed size when stretched by 25%

or so will need to be replaced and may be the cause of your problems. Belts cost about $.30-$2.00. Meanwhile, the belts will function better once they are cleaned, maybe just enough to get by until your replacements arrive.

Lubrication of electronic equipment

The short recommendation is: Don't add any oil or grease unless you are positively sure it is needed. Most parts are lubricated at the factory and do not need any further lubrication over their lifetime. Too much lubrication is worse then too little. It is easy to add a drop of oil but difficult and time consuming to restore a tape deck that has taken a swim.

NEVER, ever, use WD40! WD40 is not a good lubricant despite the claims on the label. Legend has it that the WD stands for Water Displacer - which is one of the functions of WD40 when used to coat tools for rust prevention. WD40 is much too thin to do any good as a general lubricant and will quickly collect dirt and dry up. It is also quite flammable and a pretty good solvent - there is no telling what will be affected by this.

A light machine oil like electric motor or sewing machine oil should be used for gear or wheel shafts. A plastic safe grease like silicone grease or Molylube is suitable for gears, cams, or mechanical (piano key) type mode selectors. Never use oil or grease on electrical contacts.

Unless the unit was not properly lubricated at the factory (which is quite possible), don't add any unless your inspection reveals the specific need. Sometimes you will find a dry capstan, motor, lever, or gear shaft. If possible, disassemble and clean out the old lubricant before adding fresh oil or grease.

Note that in most cases, oil is for plain bearings (not ball or roller) and pivots while grease is used on sliding parts and gear teeth.

In general, do not lubricate anything unless you know there is a need. Never 'shotgun' a problem by lubricating everything in sight! You might as well literally use a shotgun on the equipment!

Tape head demagnetizing

With audio tape decks, demagnetizing is often recommended to improve sound quality and frequency response. There is some debate as to how much benefit there is to this practice but if done properly, there is little risk. Demagnetizing removes the residual magnetic fields that can build up on ferrous pole pieces of the tape heads and various guideposts and other parts in the tape path which may affect frequency response.

Use a small demagnetizer designed for a tape deck or cassette deck. See the section: Homemade audio tape head demagnetizer if you don't have one or don't want to buy one. However, do not use anything that might be too powerful or a bulk tape eraser which would certainly be too powerful.

Make sure the tip is covered with a soft material to prevent damage to the finely polished surfaces in the tape transport.

The tape deck should be off (unpowered) during this process. (Strictly speaking, this doesn't really matter but it's just safer that way.)

Turn power on to the demagnetizer when a couple of feet away from the unit. Then, slowly bring it in close and slowly go over all surfaces of anything that the tape contacts or comes close to in the tape path. The key word here is **slowly**. Move fast, and you will make the magnetic fields stronger. When finished, slowly draw the demagnetizer away to a distance of a couple of feet before turning it off.

Homemade audio tape head demagnetizer

A perfectly serviceable tape head demagnetizer can be easily constructed using a large nail, 100 turns of insulated wire (just guessing here) and an AC wall adapter (from an obsolete modem, for example). Grind down the end of the nail so that it is not sharp and coat it with a soft material or cover the end with electrical tape to protect the finely polished heads from scratches.

Adjust the number of turns and input voltage for desired strength. How strong should it be? A direct comparison with a commercial unit would be best but when in close proximity to a steel surface, you should be able to feel the 120 Hz attraction but it shouldn't jump out of your hand! Sort of like "Use a pinch of salt you will know how much" :-)

Building a bulk tape eraser

A variety of approaches work for this - all based on strong magnetic fields. These will erase floppy diskettes, audio and video tapes, and all your credit cards and Turnpike passes!

- Magnets removed from large loudspeakers (including the pole pieces where the voice coil went) and microwave oven magnetrons.
- Some motors, transformers, the butt-end of some soldering guns, etc.

(From: Steven L. Bender (buqu35d@prodigy.com).)

You need a power transformer about 3" in each direction, can be like a low voltage 12 volt / 3 Amp unit or rated higher. Remove end bells if any, remove all the metal laminations (break the first one, yank it, and the rest will come easier). Re-insert all the metal laminations facing in the same direction, with the "E" all pointed the same, re-glue, varnish, or whatever. Connect AC Plug to the Primary, then insulate the whole works with Plastic tape and outre layer of Duct tape. After insulating it with several layers of tape - Instant Bulk Eraser.

WARNING: Do not apply power for more than 60 seconds at a time! (It will get hot and burn your hand after two minutes.)

I had one of those for some years, but accidentally left it plugged in, (pulled the wrong wire out of the 6 to 1 outlet box) and after a few minutes, it smelled and was too hot to touch, and made a nasty noise as the copper started to melt... (Sounds Effects of Liquid Krell Metal in the distance...., Forbidden Planet - Paramount, 1956).

Luckily I didn't walk out, another few minutes and it would have caught fire..

I am not liable for any personal, profession, or consequential damages from use of this information !!!

(From: Steve Walz (rstevew@armory.com).)

Use a transformer and remove the EI core pieces and replace all the E's only in the same direction. Current limit it with a wire-wound resistor so it doesn't overheat and put a momentary pushbutton on it and a power cord to wall AC and insulate it so you don't shock yourself. Then place it so the open face of the E core pieces faces the tape or disk or whatever to be erased and push the button. Run it all over both sides of the tape or disk and pull the tape or disk away before letting up on the button if you wish to erase it. If you wish to magnetize a tool or such, simply let up on the button while the object or tool is still in contact with it. That's how that works! (You may have to do it a couple times before you catch the AC cycle at the peak! --- Sam.)

(From: Pat Swayne (me@patswayne.com).)

Here's a safety tip for your homemade bulk tape eraser: Use a small length of very thin solder as a fusable link. Place this as close to, but insulated from, the primary windings as possible, and pass the current through it. If the thing gets too hot, it will melt the solder and break the connection.

(From: Sam.)

It would have to get mighty hot for that to be effective but it's cheap enough. Of course, a thermal fuse or thermostat would be a more well controlled alternative.

Splicing of audio tapes

If a tape is broken or seriously crinkled, cutting out the bad section and joining the remaining ends will be necessary. There are special splicing kits for this. I don't know if a place like Radio Shack carries these but an audio dealer or electronics distributor should have one. In a pinch, you could very carefully use a razor blade or Xacto knife to cut the tape an a 45 degree angle and ordinary transparent to mend it. Then, it is best to copy the tape to a new one. At least with an audio deck, you don't really have to worry about ruining the heads with an improperly made splice though you do want to avoid depositing adhesive from the mending tape onto parts of the transport!

Tape or cassette deck, recorder, or Walkman transport problems

The following are common problems with audio tape transports:

1. No movement in PLAY or REC - most likely capstan is not turning or not engaged. If the motor is not working (listen for a hum from inside the transport), refer to the chapter: "Motors and Relays". Otherwise, see the list below.

2. Tape eating - the capstan is turning but the takeup reel is stationary or not turning rapidly enough to take up the tape as it feeds from the capstan/pinch roller.

3. FF and/or REW are inoperative or sluggish - assuming the motor is working, the driven reel is not being powered at all or does not have sufficient torque to overcome the tape friction. The driven reel alone must pull the tape through the transport.

Note that the required torque for the driven reel is much less for PLAY and REC compared to FF and REW as the capstan in contact with the pinch roller pulls the tape from the supply reel.

The most likely causes are similar for all of these symptoms. The driven reel and/or capstan is not turning due to:

- A broken or stretched belt, an old and deteriorated, dirty, or worn idler tire. Refer to the section: General guide to tape deck cleaning and rubber parts replacement.
- Worn or broken. For example, a spring may have popped off an idler clutch or a press-fit gear or pulley may have split.
- Gummed up lubrication which is preventing the idler gear or tire that operates the takeup reel from engaging. See the section Lubrication of electronic equipment.
- A solenoid that is not engaging properly due to a weak spring, insufficient drive, lubrication problems, or broken parts.

If the cause is not immediately evident once the bottom of the transport is visible, try to observe exactly what is happening when you play a garbage tape or run the deck with no tape present. Look for broken parts or bits of parts that may have failed off.

If the transport shuts down shortly after entering any mode, check for a missing or stretched tape counter drive belt or a defective reel rotation sensor. The tape eating protection circuits are shutting down the unit improperly due to a lack of reel sensor pulses. A related symptom will be that the tape counter (mechanical or electronic) does not change during the period when the tape is moving.

If the logic is not properly controlling the various solenoids or other actuators in a 'soft touch deck', then a service manual will be needed to proceed much further.

Tape transport azimith adjustment 1 (single REC/PLAY head)

When prerecorded tapes or tapes recorded on another deck sound muddy, the azimith alignment of the suspect deck may have shifted or be misadjusted. Azimith refers to the angle that the record/playback head gap makes with respect to recorded audio tracks. This angle should be exactly 90 degrees. If it is not, than high frequencies will tend to be reduced in amplitude during playback of a tape not recorded on this machine. Similarly, a tape recorded on a transport with an improper azimith setting will sound muddy on a properly adjusted deck.

A simple test to determine if azimith alignment is your problem is to record some music on your machine and immediately play it back. If this recording sounds fine but it sounds muddy on another deck, then improper azimith alignment is the likely cause.

If the recording is still muddy, your deck may have electronic problems like excessive bias (check to make sure you have selected the proper type of tape or bias setting), a worn record/playback head, or the heads or other parts may be magnetized (see the section: Tape head demagnetizing. However, dirty heads as well other mechanical problems can also result in weak muddy sound. See the section: General guide to tape deck cleaning and rubber parts replacement.

The best way to adjust azimith is while playing a recording that was made on a known good deck - commercial tapes are usually (but not always) a good choice.

WARNING: once you adjust the azimith, any tapes previously recorded on this transport may sound muddy. If you only record and play your own tapes on this deck, you may want to just leave it alone.

The azimith adjustment is usually a screw that pivots the record/playback head. It may be spring loaded and possibly fixed in place with a some Loctite or varnish. Often it will be accessible through a hole without removing any covers but not always. Look for it while in play or record mode in back of any holes (which you had no idea had a purpose until now). If there are no access holes, you will have to remove the loading door, cover, or front panel. Be sure you have the correct screw before turning wildly - others may affect critical height or simply be mounting screws.

Play a tape with lots of good highs - classical instrumental music or jazz are excellent. Now, simply set the azimith adjustment for best sounding and strongest high frequencies which should result in most natural sound. Go slow - a 1/16 of a turn is significant. Turn the screw back and forth and leave it in the best sounding position. Carefully put a dab of Loctite or nail polish on the screw to prevent it from moving.

Tape transport azimith adjustment 2 (separate REC/PLAY heads)

This applies to 3 head decks where there are separate record, playback, and erase heads. First, read the section: Tape transport azimith adjustment 1 (single REC/PLAY head). Once you have located the correct adjustment screws:

1. Using a known good tape (a commercial tape perhaps), adjust your Playback (PB) head azimuth for best high frequency (treble) response.

2. While recording from a source with lots of high frequency (e.g., a string quartet or composition for brass) and monitoring using the PB head, adjust the REC head azimuth for best treble response. Note: do the adjustments a bit at a time since there will be slight delay until they take effect due to the spacing of the REC and PB heads.

Walkman/Discman power or sound intermittent

Note: for actual tape speed, operation, or sound quality issues, start with the section: General guide to tape deck cleaning and rubber parts replacement.

The socket that the AC adapter or headphones plug into is often quite abused during normal operation. This can lead to broken solder connections where it joins the circuit board inside the unit. Test for this possibility by wiggling the plug without moving or flexing the cable itself. If the sound cuts in and out or the tape player starts and stops or the radio goes on and off, or the CD player resets or stops, then there is likely a bad connection here. Note: eliminate the alternate possibility that the AC adapter or headphone cable is bad by wiggling and tugging on the cable while holding the plug steady. Further verify that it is not simply a matter of dirt or grime interfering with a good connection.

The connections can be easily resoldered but you will need to open up the case using. Hopefully this will only require jeweler's screwdrivers and great care. (However, some Walkmen are constructed such that access to the interior is virtually impossible without a hand-grenade.) To repair the connections, use a low wattage iron and fine rosin core solder. Make sure you do not introduce any solder bridges. Try not to lose any of the microscrews.

Cassette or tape playback - one channel dead

This could be a bad playback head, bad connections, or a bad component in the playback electronics.

First, confirm that the problem is not in your headphones, patch cables, or the remainder of your audio system - try an alternate audio source where possible.

To determine if the playback circuitry is working, gain access to the terminals on the playback head - a metal cased little cube near the center of the tape side of the cassette. There should be four wires coming from it. While the machine is supposed to be playing, touch the end of a jeweler's screwdriver gently to each of the four terminals in turn. When you touch the good channel, you should hear a buzz from the appropriate speaker. If you touch one terminal and get a buzz from the 'dead' channel, then it is possible that the head is bad for that channel. If you can touch two different terminals and get a buzz in the bad channel for both, the it is likely that the ground connection to the input preamp has fallen off. If you do not get anything from the bad channel, then there is likely an electronic problem in that channel. Bad connections aside, the most common problem area would be the audio amplifier - bad IC or capacitor.

Distorted or erratic recording

First determine if it is a record or playback problem - play a tape recorded on another machine or a commercial prerecorded tape. Try a tape from this machine on another known working tape player.

If record is the problem and it has very distorted sound, this may be a sign of a bad bias oscillator or switching circuit or record switch. The bias is an ultrasonic signal that is impressed on the tape along with the input signal. Without it, the sound will be highly distorted. In effect, it is a linearizing signal.

Check that the record select switch is clean - it may have many contacts and may have collected a lot of crud. If behavior changes with each activation of the record switch, get some contact or tuner cleaner spray and use the extension tube to spray inside the switch (with the power off), put the switch through its paces several times and allow to dry before powering it up.

If it is a portable subject to abuse, check for bad connections as well, especially if, say, one channel comes and goes.

Beyond this, you can try to measure the signal going to the record heads while in record mode. You should be able to see a high frequency signal in addition to the input signal. If the either of these is absent, then you need to trace back to its source and at this point will probably need a schematic.

Previous recording not erased

In this case both the original and new audio appear on the tape. The most likely cause (assuming your deck doesn't have some fancy sound-with-sound or sound-on-sound modes that may be engaged) is a faulty erase head or its driving signal.

The erase head precedes the record head and probably uses the same high frequency signal as that for record bias to totally wipe the previous recording. (However, on really really cheap tape recorders, erase may just be performed by a permanent magnet.) If the new recordings are really distorted, the bias oscillator itself may not be working. The erase head is either part of the REC/PLAY head assembly or a totally separate head. Check for broken wires to this head as well. If you have an oscilloscope, monitor the signal during record. The erase head could also be defective or really dirty.

Cassette player erratic autoreverse

Some of the autoreverse decks use a rotating magnet under or part of the each reel and a reed switch or hall effect device to detect lack of motion and do the autoreverse thing.

I had one from a Toyota where the plastic drive gear which included the magnet and was part of the reel split and was getting stuck at the broken tooth causing a reverse and eventually eating the tape. It was $9 for that little plastic gear.

Others are entirely mechanical and if there is a lack of lubrication, dirt, tired belts or idlers, or broken parts they may start acting erratically.

Although there could be an electronic fault, carefully examine the mechanism for obvious or subtle problems before breaking out the 'scope.

The following methods are use for autoreverse:

1. Optical sensor detecting the clear leader on the cassette. Better tape decks use this for sensing at the end so that the reverse occurs just quickly at the end of the tape rather than waiting for the leader to go by and a second or two for the tape to stop.

2. Totally mechanical where a lever arm presses against the tape and when the tension increases with the reel stopped, it trips a mechanism to reverse.

3. Optical sensors on reel rotation.

4. Magnetic sensors on reel rotation - either hall effect devices or simple reed switches.

If the transport will run without a tape in place, see if the takeup reel is rotating properly and whether the reverse still occurs. If reel rotation is normal but it still reverses, the either you have the optical tape end sensor or there is some fault in the sensors for the reel rotation. If the takeup reel does not rotate, then as suggested above, check for bad belts or idler tire.

Belts and idler tires are readily available from places like MCM Electronics.

Autoreverse audio not correct for either or both directions

This may mean that one or both directions is weak or erratic or that both sets of tracks are playing simultaneously (one in reverse).

There are three common ways of implementing autoreverse with respect to the tape heads:

1. Locate both the record/play heads and erase head on an assembly that can rotate (flip) 180 degrees depending on the direction. Mechanical stops determine the precise position.

2. Locate both the record/play heads and erase head on an assembly that can shift transversely across the tape by one track distance depending on direction. The connections to the L and R channels must be interchanged electronically in this case for one of the directions.

3. Provide a complete set of heads for both directions. Selection is then done electronically or via a set of switch contacts controlled by the direction reversing mechanism. (This would require duplicating 6 heads for a full record/play deck so it is more likely with a simple player which would then only require a total of 4 heads.)

Problems may be mechanical or electronic. However, it is probably not what you would consider head alignment.

In either design, the mechanism could be gummed up and not being properly positioned in one or both directions. There could be broken cables or bad connections since (particularly with (1) and (2).)there could be significant cable movement.

Check, clean, and lubricate the mechanics first before considering electronic faults. However, since all of these must select channels based on direction, electronic or switching problems are quite possible.

Walkman plays both sides of tape at once

One set of tracks will be playing backwards which may make for interesting conversation! There are two possibilities:

- Where a single pair of heads is used, the head assembly is misaligned and straddling both sets of tracks. This would be the case with a non-autoreverse player or with an autoreverse player that shifts head position when it reverses direction.

  This is a mechanical problem with head alignment (height) or the shifting mechanism (autoreverse).

- For an autoreverse unit where the heads do not shift position (there are four heads gaps - one for each track but only 2 get selected for each direction), the head selection circuitry or switch is routing both sets of head signals to the amp.

  This is an electronic or switch contact problem.

General tape speed problems - slow, fast, or dead

Are the speed problems sudden or gradual? Over what period of time? Seconds, minutes? For portable devices, are you using a good set of their recommended type of batteries? If the error in speed is significant, then there is something wrong. It isn't a matter of an adjustment!

Did this problem start suddenly or was this a tape recorder you found buried under an inch thick layer of dust in an attic?

If the latter, then there could very well be multiple mechanical problems due to deteriorated rubber parts - replace then or toss it.

Fast play could be an indication of a hard deteriorated pinch roller. Or, you could have forgotten to turn off a 'fast dub' or 'quick copy' switch!

Clean and lubricate the mechanism. Check for dry or tight bearings.

Is there any pattern to the problems - like with respect to the start and end of cassettes?

Where the tape speed has suddenly become excessive, here are some possibilities:

1. Mechanical. If you had a recent tape eating episode, there may be a wad of tape wrapped around the capstan. Remove it. Alternatively, the pinch roller may not be fully engaging against the capstan and the takeup reel is simply pulling the tape through without any speed control. Clean the mechanism, check for tired belts and springs.

2. Electrical. The motor speed control is not working. This may be either a mechanical governor inside the motor or a voltage regulator or other electronic control often also inside the motor. In the latter case, you may be able to disassemble the motor and repair it. One possibility is that the series regulator has decided to turn into a short circuit. This may be external or internal to the motor.

3. Cockpit error. Some tape recorders and tape decks have various features (which you no doubt never use) that may have been inadvertently turned on or twiddled (perhaps by your 3 year old). These include high speed dub as well as selectable and/or adjustable record or playback speed.

Slight tape speed error may simply mean that an internal adjustment is needed. There may be an access hole on the motor or an external pot. (Use a plastic tool to avoid shorting out something!) However, keep in mind that any tapes you recorded on this machine (assuming it can record) recently will play at an incorrect speed once you adjust the speed.

Is it slow and steady - no more wow and flutter than normal? Or slow and erratic indicating that (1) the speed regulator is faulty, (2) some bearings may need oil, (3) the pinch roller is glazed.

If the mechanics seem ok, then check for electronic problems with the motor or regulator. Sometimes there is a trimpot for speed adjustment inside or external to the motor. A faulty regulator or even a bad connection may be the cause.

A variety of techniques are used to regulate the record/playback speed:

1. Mechanical governor inside motor - centrifugal contacts open at correct speed reducing current to motor. If speed is too low, than springs could have weakened or contacts could be bad - open. If speed is too high, contacts may be welded closed. There may be a resistor and/or capacitor across the contacts. An open resistor could conceivably cause unstable speed fluctuations. A capacitor may be present to reduce electrical noise.

2. Voltage regulator inside motor case or external to motor. The regulator or transistor may be faulty. If power for the motor seems to come directly from an unregulated supply, check across the motor terminals with an ohmmeter. A low reading which is identical in both directions would indicate a direct connection to the motor brushes with no internal regulator (or perhaps a shorted regulator). A high reading or one that is different in each direction indicates an internal electronic regulator - or you could just use your eyeballs to determine if there are any electronics inside the motor. These can be disassembled and bad parts replaced. There may be an access hole on the motor for an adjustment. (Use a plastic screwdriver for the adjustment to avoid the possibility of shorting something inside the motor!) Alternatively, you could remove the guts and install an external regulator using an LM317 or similar part.

3. Active regulator with tachometer feedback from motor winding - there would be 4 wires instead of two coming out of the motor - 2 for power and 2 for tach. Control circuitry could be bad or the tach output could be dead (speed too high).

4. If an optical strobe disk is located on the motor shaft, then it may be part of a speed control circuit. If it is on one of the reels - probably the takeup reel - then it simply operates the (electronic) tape counter or signals the controller that the takeup reel is turning - to catch tape spills.

Tape speed problems on older equipment

Older reel-to-reel decks (maybe even some cassette decks) likely use an AC induction or synchronous motor driven from the power line. Speed selection is usually done by switching in different sets of motor windings and the use of slip-on capstan/pinch roller sleeves.

Speed problems are most likely a result of

- Decayed rubber parts - belts, idler tires, pinch roller.
- Gummed up lubrication or worn bearings.
- Dried up or otherwise faulty capacitors in the motor circuitry.
- Faulty switches or wiring in associated with speed selection.
- An actual bad motor is possible but not that common.

See the appropriate sections in the chapters: "Turntables" and "Motors and Relays" for specific information on these types of problems.

Tape speed adjustment made easy

OK, you have found the magic screw, but how to set the speed accurately? Sometimes, there will be strobe disks on tape decks which will appear stationary under fluorescent lighting (magnetic ballasts only - electronic ballasts are usually high frequency and do not modulate the light intensity at the power line frequency) but not usually. So, you do it by ear:

Make a recording of a single tone on a tape recorder you trust - one with accurate speed.

Suitable sources include: a signal generator, electronic instrument, Touch-Tone phone tone, PC sound card output or PC speaker, etc. A frequency around 400-1000 Hz should work well.

Then, adjust the speed while listening to this same source simultaneously with the tape being played back on the unit to be adjusted. As you adjust the speed, you will hear the pitch change. As it approaches the correct setting, you will hear the tones beat against each other. When you are set correctly, the pitches will be equal and the beat frequency will go to zero. Even if you are tone deaf, you will easily be able to adjust pitch accuracy to better than 1/10 of a semitone using this method.

Recording the 60 or 50 Hz power line (through a suitable isolated attenuator) and using this as a test tone will work if you have an oscilloscope. Trigger on 'line' and adjust playback speed to stop the trace from drifting. However, this is too low a frequency to be used accurately with your Mark I ears!

Some alternatives:

(From: Helling Bernie (helling@uwindsor.ca).)

A while ago I hit upon a way to set the speed on old cassette decks that have gone out of speed.

Use an electronic guitar tuner

They cost about $40, can be borrowed, etc... Find a pro cassette deck that is in speed, (the local campus radio station had a nice one) and record a tape full of A tone. My guitar tuner puts out tones too, so that was easy....

Play the tape in the suspect deck, while adjusting the motor trim to replay a A tone perfectly on the tuner meter...

Tadah....

I never did have the patience to learn to play the guitar, so I got some use off the tuning meter....

(From: Paul Temple" (mri@earthlink.net).)

Get a song on CD and a tape of the same album. Play both at the same time and adjust away!

Sudden increase in flutter on tape decks or Walkmen

If your prized Walkman suddenly develops a severe case of warbling sound check:

1. Batteries (where appropriate). Almost dead batteries will greatly increase flutter. Use of Nickel-Cadmium rechargeable batteries in place of alkalines may result in problems due to their lower voltage (1.2 V vs, 1.5 V per cell).

2. Tired belts - loose flabby deteriorated belts will produce varying, probably slow, speed as well.

3. Dirt or goo on pulleys. Sometimes a glob of stuff gets stuck to a pulley and produces a periodic variation in speed. I picked one up at a garage sale that had this problem. I thought it was a bad motor until a careful examination revealed that the belt was jumping a mm or so on each rotation of an idler pulley.

4. Lack of lubrication - a dry or worn bearing may result in a variety of speed problems.

5. Bad speed regulator - either mechanical or electronic including bad solder connections or cracks in circuit board traces.

6. Bad power supply.

7. Bad tape. Don't overlook this obvious possibility, try another one.

Annoying tick every 30 seconds or so from audio output

This may be an almost inaudible tick, click, or pop which occurs fairly regularly. Its frequency may be dependent on many factors including temperature, humidity, even whether you are at the start or end of a cassette! I may occur even if no cassette is present but the motors are running.

The tick is probably due to a static discharge though other causes are possible including mechanical problems and bad capacitors in the power supply.

(From: Paul Grohe (grohe@galaxy.nsc.com).)

The problem is with a plastic or nylon gear, in contact with a rubber belt or tire, generating a charge and discharging to some nearby metal. (It acts just like a miniature Van De Graff generator --- sam.)

You have to listen around for it. Murphy sez it will probably be buried deep in the "guts" of the machine ;^)

I found it by touching a small wire to each of the pulleys until it stopped "snapping" (actually, I got a little "snap" when I found it).

My "cure" was to use some stranded wire to create a "brush" that lightly brushed against the pulley to bleed off the charge to the chassis.

I would first check the two big capstan flywheels and anything powered by the main motor belt. Look for any plastic, or metal with plastic bushings and parts in contact with belts or tires.

(From: Ylo Mets (ylo@mango.mef.ki.se).)

I have experienced similar ticking in an old two-motor deck. There was some dust collected between the takeup/wind motor shaft end and the metal chassis, which evidently generated static electricity. Cleaning the dust did the trick, although at first I thought the shaft was too close to the metal chassis. You can check for the static by breathing slowly into the mechanism. The damp air should discharge the static and the frequency of ticks decreases. Such ticking is especially annoying because it is not exactly regular.

Reel-to-reel tape deck problems

> "I have a Teac 2300S reel to reel. 7" reel capacity, 1/4" tape. Two problems. First, right channel doesn't play back. Second, pinch roller doesn't come up to the capstan unless it's gently pushed."

(From: Davetech (dnesbitt@mindspring.com).)

I've repaired a few reel-to-reels in the past and generally find that they all need three main things done:

- They need all the rubber parts - belts, tires, rollers - replaced. Also the brake pads.
- They need all the controls and switches cleaned with a de-oxy type cleaner. (This may be the cause of your right channel problem).
- They need all the mechanical pivot points cleaned and re-lubed. (This may be the problem with your pinch roller).

The last one I did, the old grease had hardened up so much that the heads would not come up to contact the tape - and the grease was so hardened that I could not get the linkage pulled off even using pliers and pulling as hard as I could. I had to heat the post with a propane torch before the old grease would soften enough that I could separate the parts.

I put enough time in the last unit that I could have fixed 3 or 4 VCR's, so I'm not real big on taking them in. They are generally very time consuming to disassemble and reassemble and overhaul. But not usually technically difficult to fix.

Tape creeps off capstan

> "I have a Sony reel-to-reel tape recorder. When I play a tape, after a few seconds or minutes of playback, I can watch the tape creeping up the capstan between the rubber roller until it comes out the top and off the capstan."

The first thing to check - as with a VCR with similar symptoms - is the condition of the rubber parts, in particular, the pinch roller. Next, would be tape path alignment and wear:

(From: Jack Schidt (dbutler@airmail.net).)

Check the reel height as well. Capstans are upset if the reel tables have shifted. Use a straight edge between the two reel tables. There are set screws that sometimes get loose on some of these machines.

Check for a worn capstan bushing. Disconnect the drive belt (if any) and see it there is lateral play in the capstan. If so, perhaps you can shim it (either the motor [if equipped] or the idler).

Also make sure the tension is simply not too high. You should be unable to pull the tape through, but ridiculous force (as in something is BENT) will cause this problem as well.

8-track player problems

These compete with turntables for classification in the Jurassic era. 8-track equipment uses a cartridge with a single reel and enless loop tape (tape is pulled from the center and returned to the outside). The tape can only move in the forward direction - rewind is not possible.

There were also similar competing but incompatible 4-track systems as well as quadraphonic 8-track (when quad was all the rage).

Four pairs of channels allow for many hours of stereo playback without changing cartridges. A pair of playback heads is mechanically shifted among the 4 possible sets of tracks when a metallic strip on the tape passes over a set of contacts which operate a solenoid.

Most common problems are - you guessed it - mechanical with the cartridge or in the drive or head shifting mechanism. General comments with respect to cassette decks apply here as well.

If you are really interested in resurrecting that 8-track player found under the steamer trunk in your aunt's attic, there are many links to information on 8-track equipment, books, history, dealers, collecting, and everything else 8-track related that most people probably don't care much about anymore at the following web site:

- 8 Track Heaven

There may be links for specific 8-track player repair information but I could not locate them at this site.

However, this one seems to be the place to go for step-by-step 8-track cartridge repair:

- Jeremy Larsen's Web Page

Repairing a cassette tape

(From: Filip "I'll buy a vowel" Gieszczykiewicz (filipg@repairfaq.org).)

This will be either easy or very hard. Question: do both of these have SCREWS holding the tape together? If yes, EASY, if not, very HARD!

See what I'm getting at? Go to the store and get a quality tape that ALSO has screws holding it together... you will transplant the insides into the new cases. Take off the screws from both (old and new tape, do it one tape at a time). Remove both top covers - make sure you don't lose the thin plastic "lubricant" sheet (if any). Swap the tape reels - BE VERY SURE the old one doesn't go flying off or it's more or less toast. Put the old tape reels into the new case, make sure the tape follows the same path as the one you took out did - so it doesn't get trapped by the case when you replace the top. Put the "lubricant" sheet back on top of the two reels of old tape and replace the top. Put in all 5 screws. There you go. I'd say that this is 100% successful every time I've tried it.

If your tapes don't use screws but are, rather, glued together, you're on your own. I suggest a VERY sharp utility knife but tape damage is, alas, a very REAL possibility.

Another way you can do this if you want to also replace the REELs (or if it's a sealed unit) is to rewind the old tape, cut the tape LEADER and attach it to the new cassette that you have already gutted. Put the new tape together (2 screws will do) and attach a small motor to the takeup reel. When the tape has been transfereed to the new reel, cut it off the old one (the old cassette is now empty) and open the new one again, attach the tape to the reel and put it back together using all screws. Other than the leader being 2" shorter, you have the old SOUL in a new BODY.

Of course, watch out that you wind the tape EXACTLY as it was and not on the other side... etc. etc. I have done this twice. Grrrr.

It's a pain in the rear... so do it only if you have to... I wouldn't do this for money..... if that tells you anything.

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Turntables

Turntable (record changer) maintenance

Here are general comments on oiling dinosaurs, oops sorry, turntables.

Usually there is a 'C-clip' or 'E-clip' which holds the platter (the thing that rotates) onto the spindle. It may be covered with a decorative piece which can be easily removed. The clip can be pryed off (gently) with a small screwdriver (just don't lose it, though even this is not a biggie so long as you never turn the thing up-side-down).

The platter can then be lifted straight up and off the spindle. You will see several things (this will vary depending on your particular unit):

1. A flat washer, sitting on a ball bearing race sitting on another flat washer (one or both of these washers may be missing. Also, the top one may stick to the platter when it is removed.) The ball bearings, shaft, washers, etc. should all be cleaned with degreaser and then lubed with a light grease. If either the steel balls or the flat washers are corroded, replacement will be necessary or else there will be terrible audible rumble. For now, it will at least work well enough to determine what else, if anything, needs attention. Also clean and lubricate the platter bushing (center hole) and shaft (vertical post on which it rotates).

2. Changer gears etc. These will have varying amounts of grease on them if it is not gummed up, leave them alone. Put a drop or two of light oil on the shafts. Inspect other linkages as well. If the grease is gummed up on the gears or sliding linkages, you will need to clean it off thoroughly with degreaser and

then use a small amount of high quality grease suitable for delicate mechanisms. One cause of a changer failing to activate at the end of a record is gummed up grease.

3. Motor. Check to see if the motor shaft turns freely and smoothly even if spun quickly between your fingers. If it does - without squealing, don't do anything else. If it is tight or makes noise, then you will need to carefully disassemble the motor and clean and lubricate the bearings at each end with light oil. Don't lose any of the various washers/spacers that may be present on the shaft as it is removed from the end pieces and make sure to lubricate and return them to exactly the location and the same order they were in originally.

4. Clean the rubber parts with isopropyl alcohol and Q-tips or a lint free cloth until no more black stuff comes off and then dry thoroughly. Now, inspect the belts (if any). If belts are flabby or cracked or if they don't instantly return to their relaxed length if stretched 25% and released, they will need replacing. Check the idler tire (if present). If hard or cracked, it will need replacing as well.

Note: Light oil here means electric motor oil or even 3-In-One but NOT WD40. Light grease means something that is suitable for fine mechanisms and is safe for plastics. Automotive bearing grease may not qualify.

Where the drive belt is found to be bad, an exact replacement is best. Though something close will work, there may be a very slight change in speed which may or may not bother you (probably not if you either don't have perfect pitch or aren't playing an instrument along with the records). For turntables with servo lock circuitry or a drive motor with a speed adjustment, correction may be possible.

Speed control in turntables

Most inexpensive turntables/changers will use a synchronous motor or even just an induction motor. The only maintenance for the motor is cleaning and lubrication. A deteriorated drive belt can result in reduced, probably erratic speed or inability to start altogether.

Servo controlled turntables utilize a feedback technique which locks the platter speed to a stable reference - either the power line (50/60 Hz) or more commonly a crystal oscillator. Here is one example:

A Sony turntable I repaired used a magnetic stripe pattern on the inside of the platter which was sensed by a magnetic pickup. The resulting signal was phase locked to a stable reference and used to control a brushless DC direct drive motor. Speed would become erratic if (1) the magnetic pattern were damaged, (2) the pickup position was moved too far from the surface of the platter, (3) the Hall-effect sensors in the motor were bad, or (4) the control electronics went bad. In one case, it turned out that one of the Hall effect sensors had failed in the motor. This required disassembling the motor and replacing the sensor - $4 from Sony.

To determine whether the turntable is running at the proper speed or for adjusting it, many turntables came with a "strobe disk" built in that used the 60 Hz (or 50 Hz) power line frequency as a reference driving a neon indicator lamp. When the appropriate set of lines on the disc appear stationary under the neon illumination, the speed is correct. In the good old days, such a disc could be purchased at any record store. :) In the modern age, go to Nauck's Vintage Turntable Stroboscope Disc Page and download a program to print your own. Or, if you have a graphics program that will generate equally spaced radial lines, the relevant numbers are (for 60 Hz power): 432 (16-2/3 rpm), 216 (33-1/3 rpm), 160 (45 rpm), 92 (78.26 rpm).

Turntable runs slow or fast after being moved

This is likely to be a mechanical problem - a belt that has worked loose and is riding on the rim of the motor pulley or the wrong surface of the platter.

For an AC line driven motor (no electronics between the AC line and motor except possible for a power transformer), it is virtually impossible for any fault to result in a motor running faster than normal. A motor may run slow due to dirt, lubrication, or bearing problems.

Of course, check to see that any speed selector has not been accidentally moved to the '16' or '78' position!

For a servo-locked turntable, a misalignment of the sensor used for speed feedback could result in an incorrect - probably higher than normal (and uncontrolled) speed.

Servo locked turntables

The basic direct drive turntable consists of a DC brushless motor, some type of platter speed/position feedback, and an electronic control loop - a phase locked loop to regulate speed. Otherwise similar units may use a rubber belt to couple the motor to the platter.

A variety of faults can occur with these units resulting in incorrect or erratic speed, excessive wow and flutter, or no rotation at all:

- Mechanical problems like gummed up lubrication, deteriorated belt, or bad bearings. Note that any of these will not likely result in a constant slow speed but rather erratic or uneven operation (since the servo will be fighting with the mechanical resistance or slip).

- Inoperative or weak feedback sensor. This may be a magnetic pickup in close proximity to a magnetic pattern laid down on the inside of the perimeter of the platter. Check to make sure the pickup is positioned properly, as close as possible but making sure there is no chance of contact (which could scrape off the magnetic coating and pattern - impossible to restore).

- Defective power supply, especially for dried out filter capacitors in older units. Check voltages with a DMM. If you have a scope, check for excessive ripple. On a turntable more than, say, 10 years old, defective capacitors are quite likely.

- Bad connections and dirty speed select or other switches and/or pots. Inspect and resolder as needed and use contact cleaner if necessary on switches and pots. Just cycling the switches and rotating the pot(s) back and forth a few times may clean them up well enough for another thousand LPs. :) (However, mark their original position exactly unless you are able to do a complete calibration!)

- Defective components in the motor (Hall effect sensors), its driving circuits, or the controller. This will require a bit of low level troubleshooting but should be possible given the relative simplicity of the circuitry.

Wow, flutter, and rumble in a turntable

Wow and flutter refer to undesirable periodic variations in pitch caused by changes in turntable (or tape deck) speed. Wow would be a slow variation (e.g., once per rotation) while flutter would be rapid (e.g., a motor pulley with a bump). Even if very slight, these faults will be all too obvious with music but may go undetected at much higher levels for voice recordings.

Rumble is a very low frequency noise added to the audio caused by vibration due to cheap, worn, dirty, or dry spindle bearings or by vibrations coupled in from some other motor driven component or even from loudspeakers if the volume is turned way up. If really bad, rumble may sound like a freight train in the next room. Also see the section: Comments on turntable rumble.

Note that rumble should not be confused with hum - 50 or 60 Hz pickup from the power line. Hum can be virtually eliminated by the use of decent shielded cables (not that expensive, just decent), and making sure that the turntable frame is jumpered to the ground terminal of the amp or receiver. Hum can also result from mechanical causes - the vibration of an inexpensive motor or improperly mounted power transformer in the turntable (or almost anywhere else in the HiFi system). It may not be possible to eliminate some of these sources of hum except by redesign or other major modifications to the equipment.

For anyone only used to listening to CDs, even very small amounts of and of these will prove very obvious and extremely objectionable. Wow, flutter, and rumble are undetectable - for all intents and purposes nonexistent - with even the cheapest junkiest CD player.

For a common motor driven turntable, the following are likely causes:

1. Bad belt or idler. Rubber 'rusts'. If it is old, then almost certainly the rubber parts have deteriorated and will need replacement. Unfortunately, replacement parts are not as readily available as they once were. The places listed at the end of this document may have some and there are many other sources but it is not as easy as one would like.

2. Dirty or worn spindle bearing. This will cause rumble. The thrust ball bearing can be cleaned and lubricated or replaced. The platter bushing can be cleaned and lubricated.

3. Lump of crud stuck to motor pulley or idler, usually of unknown origin.

4. Dried up lubrication in motor, idler, or other rotating part. These can be cleaned and lubricated.

5. Bad motor (not that likely) except for lubrication in which case the motor can be disassembled, cleaned, and lubed.

6. Physical damage to platter - something heavy was dropped on it upsetting the delicate balance.

If you are attempting to restore a 20 year old turntable from Aunt Annie's attic, don't even bother to power it up before replacing all the rubber parts and cleaning and lubricating the motor, idler, and spindle bearing.

Comments on turntable rumble

Rumble is a low frequency, almost sub-sonic sound that is inevitable with most turntables. A turntable that doesn't rumble is possible but expect to pay about as much as for a small car. Buzz words like 'magnetic suspension and 'dynamically stabilized' drive will probably accompany the stratospheric price tag. :)

(From: JURB6005 (jurb6005@aol.comtere).)

A turntable that doesn't rumble may be purchased for a few thousand bucks, but for the rest of us.....

You failed to mention the type of drive, belt rim (idler) and I doubt it's direct. A rim drive, while it's off should be silent when you whip that platter up to about 200 rpm with your hand. A light platter should keep spinning for at least 2 minutes. The old 12 pound platter should spin for about 5 to 8 minutes. When you first spin it up, listen, in a quiet room to the turntable. You should hear NOTHING. If you hear anything, check those platter bearings and/ or any automatic linkage it may have.

Note: If it's a belt drive REMOVE THE BELT FIRST!! If it's a rim drive make sure the motor spindle is unscrupulously clean and the idler isn't hardened or out of round. If the rumble only occurs when you turn it loud (like feedback) you need to isolate the turntable from the speakers. This type of feedback rumble can sometimes be reduced by reversing the phase of ALL the speakers. i.e. they are still in phase with each other, but now reversed with respect to the input.

(From: Philip Nasadowski (nasadowsk@mail.hartford.edu).)

Also realize - these things aren't silent!!! Try seeing if your amp has a rumble filter (that's what it's there for!) Make sure the motor is clean, the drive wheel is good, etc. Oh yeah, and experiment with various greases on the bearings too. And make sure the order of the washer / bearing washer/ is right.

I have had the pleasure of enjoying several excellent turntables, the ones that you can put right on top of the speakers and track almost as well as a Zero One Hundred. They've included a Dual 1229, a couple of Elac Miracords and even a transcription grade BSR 810. My favorite was the 1229. And yes, with an Audio Technica AT13 ea (10-30,000Hz) >cartridge, they can sound better than a CD. Good luck.

Ever try a Grado cartridge? They're nice...

(From: Jerry Greenberg (jerryg50@hotmail.com).)

If I can remember correctly, is this the old direct drive turntable with a rubber wheel between the motor shaft and the platter?

If it is, putting on a new fresh rubber drive wheel will help it out a bit. But, because of the design of this table, there will always be some mechanical hum pickup. It starts at the motor...

Erratic sound from turntable

Sound that varies randomly in intensity or where one channel drops out will usually be due to bad connections in the various units. This could be:

1. At the pickup itself. There may be small press fit connectors at the cartridge. These sometimes become

loose. Gently remove each one (one at a time! so that you do not mix up the wiring) and squeeze with a pair of tweezers or needlenose pliers. Snap in cartridges may have dirty contacts the springiness may have disappeared.

2. At the RCA plugs under the turntable which connect to the tonearm. Depending on your design and problem, you may need to simply clean with contact cleaner or squeeze the metal shell or center contact.

3. At the receiver, preamp, or amplifier. Same as (2) above.

4. Sometimes the cables themselves will develop broken wires at one end or the other. Easiest is to try a different set of cables.

Turntable tracking and skating force adjustment

Tracking force keeps the stylus in the record's groove. Too little is as bad as too much. It is best to follow the recommendations of the cartridge/stylus manufacturer. If you do not have this information, start low and increase until you eliminate skipping or excessive distortion, buzzing, or stuttering. If too low, the stylus will make only partial contact with the groove during high amplitude segments - it will jump from peak to peak (or other portion) of the wave rather than smoothly and continuously following it. If too high, it will gouge the vinyl (or the shellac or whatever depending on the vintage of your records) or in extreme cases, bottom out on the cartridge's suspension.

Skating force compensation is applied to compensate for the fact that except at one distance from the spindle (or with a linear drive tone arm where this does not apply), the tone arm is not tangential to the groove. Imagine a perfectly flat record without any grooves. If you 'play' this, the tone arm will be stable at only one position somewhere in the middle - where a line drawn through its pivot point and the stylus is just tangential to a circle at that distance from the spindle. The skating is usually a simple spring which attempts to compensate for this in such a way that the side force tending to move the stylus is minimized at all positions. Otherwise, the inner and outer walls of the groove will experience a different force which will add distortion and affect stereo separate and balance.

Skating force compensation is usually set based on the tracking force.

Note that if you are used to CDs or high quality cassettes, all the horrors of records will be all to obvious unless you are using high-end equipment (the kind that likely costs as much as your automobile) and meticulously maintain your vinyl record collection. Sonic defects like wow, flutter, rumble, distortion, noise, imperfect stereo separation, skipping, and limited frequency response are all facts of life for this technology which has not changed in any fundamental way since Edison's time.

Turntable tracking/skating problems

(From: Bill Turner (wrt@eskimo.com).)

You're bringing back memories. I used to work for the leading Magnavox warranty repair station in Los Angeles and I've repaired hundreds of the good 'ol Micromatics.

Assuming there isn't something actually *pulling* the arm across the record (in other words it's just sort of sliding across on it's own) the problem is almost always the needle. Either the tip is worn out, broken, missing, etc or it could have just been dislodged from it's holder. Lift up the arm and look carefully at the needle. The actual diamond tip is on the end of a short shaft which in turn rests in a fork-shaped rubber holder. This shaft is easily knocked out of the holder, and if that's the case, just carefully put it back.

Hope this helps. The Micromatic was a fine record player in it's time. Good luck, and let me know if I can help some other way.

About stylus wear

So you still have one of those modified potters' wheels on which you place a pre-formed piece of plastic that looks like a flattened dinner plate with a hole in the middle and drag a needle over its surface to produce sound. How can you tell when the needle, err, stylus, has worn to the point (no pun...) of requiring replacement?

It used to be that you could take it to any record store. They would look at the stylus under a microscope, and after a few choice utterances of "Oh my!" followed by "This will strip the music right off your LPs", and would then tell you that your stylus required replacement IMMEDIATELY whether it did or not :-). Of course, record stores don't exist anymore.

If you have a semi-decent microscope, you can do the same and get an honest answer ;-). 100X should be more than sufficient, though getting the stylus into position to view it may prove to be challenge.

The tip of a good stylus looks smooth and is spherical or ellipsoidal in shape. A worn stylus will exhibit edges/corners due to the wear of the tip. Yes, even diamond will wear down if you drag it over thousands of miles of vinyl. Some of your LP record jackets may even have typical photos of good and worn styli so check these out as well.

If the stylus is visibly worn:

1. The physical result will be that it will grind away at the grooves in your records.

2. The audible result of a bad needle will be excessive distortion and loss of high frequencies from (1).

After you replace it, your old records will still never sound as good as they did before because of (1) :-(.

Changer won't cycle automatically

If it is a basic old fully mechanical record changer, this is usually due to gummed up grease. There is a large gear which gets activated to operate the lift-and-place mechanism. Attached to this gear is a small swinging segment that gets jogged by the tone arm reaching the proper position. The grease gets gummy and prevents this. You have to remove the platter.

If it is a fancier changer with fully electronic controls, then it may be a sensor or something in the circuitry.

Of course, there was this one I recently worked on where some previous repair person (I am using this term generously) had glued the moving parts of the changer mechanism together so it could not possibly ever have worked again (until I unglued them all).

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Loudspeakers

Loudspeaker anatomy

In this document, we use the terms 'loudspeaker' or 'speaker system' to denote a unit consisting of one or more drivers in an acoustic enclosure perhaps along with a frequency selective crossover, tone controls and switches, fuses or circuit breakers. Connections to the amplifier or receiver are via terminals on the rear. The front is covered with an (optically) opaque or semitransparent grille which provides protection and improves the appearance (depending on your point of view).

A 'driver' is the actual unit that converts electrical energy into sound energy. Most drivers use voice coil technology: a very low mass coil wound on a light rigid tube is suspended within a powerful magnetic field and attached to a paper, plastic, or composite cone. The audio signal causes the coil to move back and forth and this motion causes the cone to move which causes the air to move which we perceive as sound.

The typical driver consists of several parts:

- Frame - a rigid steel or composite structure on which the driver is constructed. The frame holds the magnet and core, cone suspension, and connection terminals.

- Magnet - this includes a powerful (usually ceramic, AlNiCo, or rare earth) magnet including a core structure provide a very narrow cylindrical air gap. This accounts for most of the mass of a driver.

- Voice coil - a one or two layer coil of fine wire wound on a light rigid cardboard, plastic, or composite tube suspended within the air gap of the magnet and connected via flexible wires to the electrical terminals.

- Cone - a roughly cone shaped very light and rigid structure that does the actual work of moving air molecules. The cone in a woofer may be 12 or more inches across. The cone in a tweeter may only be an inch in diameter. This is the part of the driver you actually see from the front of the speaker system with the grille removed. The center is usually protected with a small plastic dome.

- Suspension - a corrugated flexible mounting for the voice coil called a 'spider' and outer ring of very soft plastic or foam. Together, these allow the voice coil/cone combination to move readily in and out as a unit without tilting or or rubbing. For most designs, there is a certain amount of springiness to this suspension. Acoustic suspension loudspeaker, however, use the trapped air in a totally sealed speaker enclosure to provide the restoring force.

Inexpensive 'LoFi' devices like portable and clock radios, many TVs, intercoms, and so forth use a single, cheap driver. Some have a coaxial pair of cones but this does little to improve the frequency response.

HiFi speakers systems will divide the audio frequency spectrum into several bands and use drivers optimized for each. The reason is that it is not possible to design a single driver that has a uniform response for the entire audio frequency spectrum. A 'woofer' is large and massive and handles the low base notes. A 'tweeter' has a very low mass structure and is used for the high frequencies. A 'mid-range' handles the mid frequencies. There may also be 'sub-woofers' for the very very low notes that we feel more than hear. Some systems may include 'super-tweeters' for the very highest frequencies (which few people can hear. This may make for some impressive specifications but perhaps little else.)

A 'crossover' network - a set of inductors and capacitors - implements a set of filters to direct the electrical signal (mostly) to the proper drivers.

Various controls or switches may be provided to allow for the adjustment of low, mid, and high frequency response to match the room acoustics more faithfully or to taste. Fuses or circuit breakers may be included to protect the speaker system from intentional (high volume levels) or accidental (amplifier output stage blows) abuse.

Loudspeaker problems

If you have a high quality and expensive set of loudspeaker, then the cost of professional repair may be justified. However, if the problem is with speaker systems you might not write home about, then read on.

Playing your music system at very high volume levels, especially CDs which may have peaks that way exceed the ratings of your loudspeakers is asking for trouble - but you knew that! CDs can be deceiving because the noise floor is so low that you are tempted to turn up the volume. A peak comes along and your speaker cones are clear across the county (remember the movie 'Back to the Future'?). Loudspeaker systems are generally pretty robust but continuous abuse can take its toll.

Problems with loudspeakers:

1. An entire speaker system is dead.

   Verify that the connections both at the speaker system and at the source are secure. Check circuit breakers or fuses in the speaker system. Reset or replace as needed.

   Make sure it is not the amplifier or other source that is defective by swapping channels if that is possible. Alternatively, test for output using a speaker from another system or even a set of headphones (but keep the volume turned way down). Assuming that these tests confirm that the speaker system is indeed not responding, you will need to get inside.

   It would take quite a blast of power to kill an entire speaker system. Therefore, it is likely that there is a simple bad connection inside, perhaps right at the terminal block. You should be able to easily trace the circuitry - this is not a missile guidance system after all - to locate the bad connection. If nothing is found, then proceed to test the individual drivers as outlined below.

2. One or more drivers (the name for the individual speakers in a loudspeaker enclosure) is dead - no sound

at all even when you place you ear right up to it. The cause may be a bad driver, a bad component or bad connection in the crossover network. Test these components as outlined below.

3. One or more drivers produces distorted or weak sound. Distorted may mean fuzzy, buzzing, or scratchy a various volume levels. Most likely this is due to a bad driver but it could also be a defective component in the crossover - a capacitor for example or even a marginal connection.

Getting inside a speaker system usually means removing the decorative grille if it snaps off or unscrewing the backpanel and/or terminal block. Use your judgement. With the grille removed, you will be able to unscrew the individual drivers one at a time. With the back off, you will have access to all the internal components. If sealing putty is used, don't lose it or expect to obtain some replacement putty (non-hardening window caulking like Mortite is suitable).

Test the components in the crossover network with a multimeter. These are simple parts like capacitors, inductors, and potentiometers or reostats. Confirm that any circuit breakers or fuse holders have continuity.

Test the drivers on the low ohms scale of your multimeter. Disconnect one wire so that the crossover components will not influence the reading. Woofers and midrange drivers should measure a few ohms. If their impedance is marked, the reading you get will probably be somewhat lower but not 0. If possible compare your readings with the same driver in the good speaker system (if this is a stereo setup). Some tweeters (very small high frequency drivers) may have a series capacitor built in which will result in an infinite ohms measurement. Other than these, a high reading indicates an open voice coil which means a bad driver. In a comparison with an identical unit, a very low reading would mean a partially or totally shorted voice coil, again meaning a bad driver. Except for expensive systems with removable voice coil assemblies, either of these usually mean that a replacement will be required for the entire driver. Sometimes an open voice coil can be repaired if the break can be found.

To confirm these tests, use an audio source to power just the suspect driver. Your stereo system, a small amplifier attached to an audio source, or even a pocket radio (use its speaker output if the headphone output does not have enough power) will suffice. The resulting sound will not be of high quality because you do not have the enclosure sealed and it is only one of the drivers in the system, but it should give you some idea of its condition. Again, comparing with an identical unit would be another confirmation.

Electrical causes for loudspeaker damage

These are not going to be covered by any warranty! Of course, not mentioned below are: fire, flood, falling from a tenth story window, getting run over by a bulldozer, or being plugged into the wall outlet instead of the stereo, etc. :-).

(Portions from: Lasse Langwadt Christensen (fuz@control.auc.dk).)

1. DC bias across speaker will cause the voice coil to overheat. Windings may short out or open up. Also see (3), below. This usually results from an amplifier output stage failure - shorted capacitor, for example.

2. High power clipped signal:

- A clipped signal contains a lot of high frequency energy and that could burn a tweeter, because the voice coil overheats.

- The clipped signal could have a amplitude so large that the voice coil hits the magnet and is bent. It's a permanent damage but not always terminal, because the might still work, but make a scraping noise. If you play loud with it for a long time (and it doesn't burn out - see (3), the part scraping against the magnet might wear off.

3. If the speaker is overheated, because of high power for a long period of time, the voice coil could expand and scrape against the magnet, and perhaps short some of the turns. This is not always permanent, and some manufacturers use Teflon on the magnet, so that it's less likely to cause damage.

Repairing loudspeaker drivers

As noted above, if you are dealing with a high quality system, leave these repairs to professionals or obtain an entire replacement as some reduction in audio quality may result from the abuse you are about to inflict on the poor defenseless driver.

We will address two types of repairs: physical damage to a speaker driver cone and an open voice coil (actually, wiring outside the voice coil). However, serious damage to the cone or just plain deterioration of the suspension components may require replacement of the entire driver unless a close enough match can be found.

For more information on loudspeaker repair, see: "Speakers (big, small, in between)" also at this site.

(From: Roy J. Tellason (rtellason@pa.net).)

I've worked with a lot of both Musical Instrument stuff (guitar amps and such) and also pro sound gear (a whole 'nother world, really) and this stuff gets used pretty hard. It's not uncommon to find a driver failure, either from the high levels at which this stuff is commonly used, or the abuse it takes getting hauled around on the road, etc.

I noted with interest the comments in one section regarding the voice coil rubbing. In the type of thing I'm talking about above, any such rubbing means a bad driver, no ifs ands or buts about it. The test for it is easy -- just push on the cone, from the front side. In some enclosures you may have to remove the driver for this. If there's a problem, you'll hear a rubbing sound, and the driver is a candidate for replacement or re-coning. It should move freely, in both directions, with no rubbing at all. But you need to press evenly with both hands on either side of the middle!

I also ran across one that had me going for a bit. I'd play audio through it (my stereo supplied the test signal, but through a little box with a pot in it to avoid overdriving the amp), and it sounded okay to me, but the musician who owned it (a piano and organ player) wasn't happy with the way it sounded for him. Piano is some of the most demanding music, with the high transients...

Anyway, he told me that the unit had been "funny" for him ever since one occasion when the amp had fallen on its face.

I pulled the speaker out, and was I surprised when I tried the "push test" - that cone didn't seem to want to move _at all_. It apparently moved enough to play the audio I was feeding through it, but not near enough for his use.

Not the first time me being a tech but not a musician has given me a bit of trouble...

One other comment that I can offer is that both MI and Pro Audio folks do a *lot* of re-coning, the prices on a lot of their hardware make it more practical than in most home equipment. These guys can also supply replacement drivers in some pretty hefty configurations, both size-wise and in terms of power-handling capability. I wouldn't recommend putting an MI-type (guitar amp, say) speaker into a pro audio application, though I don't see why the other way around wouldn't work, even if it would be a bit more expensive.

Repairing speaker driver cones

Minor damage to the cone can be repaired using a flexible adhesive like weatherstrip cement and a piece of thick paper to reinforce the seam or hole if necessary. Since this will not totally perfect match with the original paper cone, there could be audible distortion at certain frequencies particularly at higher volume levels. However, such a repair will be better than nothing. Cut the paper in a shape and size to just overlap both sides of the torn area or completely cover the puncture. Use just the smallest amount of adhesive to fasten your 'splint' to the cone. The less material you add, the more likely that the audio effects will be minimal.

Note: Almost any general purpose adhesive can be used. However, it is advised to avoid RTV silicone (bathtub caulk, etc.) since wherever this stuff goes, nothing else will every stick again. For a little hole, this probably doesn't matter but you definitely don't want to replace the surround with it!

(From: M. Przytarski (m.r.p.@ix.netcom.com).)

I have repaired many field-coil speakers, and there is one sure proof way my grandfather showed me (and several Tube Radio rebuilding mags suggest the same).

Take a milk glue (Elmers or such), and rub it around the crack. Then take a piece of brown lunch bag and rub it with glue. Place it over the crack, and rub some glue on it, pressing it in place. The glue should by now soak the paper of the cone and bag. When dried you cant tell the difference in sound and its as sturdy as ever. This also works for those units that a animal (or kid) has put a hole in. I repaired a speaker that was missing almost half of the cone from mice. It sounds great and was cheap to do.

Recommended adhesives and solvents

(From: Greg (EB) Danner (gdanner@prairienet.org).)

I've been using surrounds from MAT and also from Dalbani. They are MUCH cheaper than some of the other sources, but appear to be of good quality. What I've been using for glue is:

1. "Elmer's Craft Bond Tacky Glue". A 4 oz. bottle is about $3.00 from local OSCO drug store, found it in their school and office supply aisle. Nice and thick, stays where you put it, dries quickly, and stays flexible (unlike some white glues which dry hard and brittle and might crack when vibrated in a speaker).

2. "Weldwood Universal Space Age Adhesive (concentrated)", 4 oz. bottle was about $4.00 at a local hardware store. Thinner and runnier than (1), but also dries flexible, and it supposedly bonds more

materials than (1). If you check some of the pictures on the DECWARE speaker repair pages, you will see a bottle of this glue next to the speaker.

For cleaning off the old glue and bits of old surround, as well as for softening the glue around the dust-cap so it can be non-destructively removed for cleaning the voice coil gap and shimming the voice coil while replacing the surround, the following solvent works great:

3. "Oatey Cleaner for CPVC or PVC or ABS - Clear", 16 oz can, white and yellow label. Available in plumbing department at local hardware stores. This is a solvent (MEK and acetone) based cleaner, so be sure to follow label directions, as it is flammable and you don't want to inhale the vapors. Just brush it on with a small paint brush, wait 30-60 seconds, and it will soften the old glue so you can peel it off.

(Portions from: rbeez99@aol.com)

If you are actually rebuilding the voice coil on a large driver, you really need a high temperature adhesive. Much of that power becomes heat! JB Weld is a good two part Epoxy for this application.

Some sources for loudspeaker repair parts and services

(I have not dealt with any of these places personally - these are all based on recommendations of others.)

- Simply Speakers, 11203 49th St. N., Clearwater, FL 34622, Voice phone: (813) 571-1245, Fax: (813) 571-4041, http://www.simply-speakers.com, provides speaker repair services and also sells do-it-yourself refoaming kits for repairing foam edge surrounds on most round 4" to 15" and oval 6" x 9" speakers.

- Stepp Audio Technologies, P.O. Box 1088, Flat Rock, NC 28731, 1-704-697-9001.

- The Circuit Shop, 3716 28th Street, Kentwood, MI 49512, 1-800-593-0869 or 1-616-285-1144.

- (From: Raymond Carlsen (rrcc@u.washington.edu).)

  Various sizes of paper cones and foam-edge replacements are available from MAT Electronics @ 1-800-628-1118. They range in price from less than a dollar to about $5 for the largest (15") drivers. The downside is there is a $25 minimum. However, they also sell electronic components like flybacks, video heads and belts, ICs and transistors, etc. So coming up with a minimum order may not be too difficult.

- (From: Johnion (johnion@aol.com).)

  I was given a pair of infinity speakers and ordered replacement cones from "The Speaker Place". As long as the problem is just the cones, the kit is great (and cheap).

  These are the numbers I used around a 1-1/2 years ago:

  The Speaker Place - NEW FOAM, 3047 West Henrietta Road, Rochester, NY 14623, Phone: 1-800-NEWFOAM (1-800-639-3626), Fax: 1-800-2FXFOAM (1-800-239-3626), Voice Mail: 1-800-

FOAMMAIL (1-800-362-6624). Email NEWFOAM@msn.com, Web: http://www.NEWFOAM.com.

- (From: T Schwartz (toschwartz@worldnet.att.net).)

  I've had excellent results sending drivers to Millersound Labs:

  Millersound Labs, 1422 Taylor Road, Lansdale, PA 19446, Phone 215-412-7700, Fax 215-412-0542

  They can re-foam or re-cone depending on what is needed, they are fast, easy to deal with, and IMHO, reasonably priced. Call them for a quote.

- (From: jl (jlager@tir.com).)

  Orange County Speaker, 12141 Mariners Way, Garden Grove, California, 714-554-8520.

- (From: Aan Jerig (ajerig@gate.net).)

  Lakes Loudspeaker, 4400 W. Hillsboro Blvd., Coconut Creek, FL 33073, 1-800-367-7757.

Repairing an open driver

An open driver can sometimes be rescued by tracing the input wires through the cone and under the center protective dome. The most likely places for these wires to break are right at the place where they pass through the cone and just after they pass under the dome. Note: some drivers have replaceable voice coil units. If this is the case, you should probably just replace the entire unit.

First, scrape away the insulating varnish on the front of the cone where the wires emerge and head toward the center. Use your ohmmeter to test for continuity here. If you find that you now are measuring a reasonable resistance - a few ohms, then trace back to determine which of the two wires is broken or has had the solder connection come loose. If it is still infinite, you will have to go under the dome.

Use an Xacto knife to carefully remove the dome. Use a shallow angle and cut as near the edge as you can. Take care not to puncture the paper cone which may continue under the dome as the voice coil may be of a smaller diameter than the dome. The shallow cut will also provide a base to reattach the dome if you are successful. Carefully scrape off a bit of the enamel insulation as near to the voice coil as possible and test with your ohmmeter once again. If the resistance is still infinite, there is nothing more you can do but salvage the magnet for fun experiments or erasing floppy disks. There is essentially no way to replace just the voice coil unless your driver has a removable voice coil unit (in which case you would not be reading this).

If the resistance now measures normal - a few ohms, trace back to determine which wire is broken and use some fine (e.g., #30 gauge) wire to bridge the break. You will have to scrape off the enamel insulation to permit the solder to adhere. Make sure it is secure mechanically first - a speaker cone is a rather violent environment for soldered connections. Finally, use some flexible adhesive to protect and reinforce the solder connections, to glue down your new wire along its entire length, to protect and reinforce the place where the wire passes through the cone, and finally, to reattach the central dome. Let the adhesive dry thoroughly before playing the finale to the 1812 Overture.

Loudspeakers - repair or replace?

Assuming that the cabinet is in reasonable condition, the question arises: is it worth replacing broken, damaged, or worn out drivers or faulty crossover components that are not repairable rather than just dumping the speaker systems?

It is very straightforward to swap drivers as long as you get ones with similar characteristics. It all depends on what you want out of a loudspeaker. If you are basically happy with them, then it will be a lot cheaper than replacing the entire speaker system(s). However, speaker system quality has improved considerably in the last 15 years so now may be the time to upgrade.

As far as crossover components are concerned, these are basically common electronic parts and replacement is probably worthwhile.

However, if one driver has a deteriorated suspension, it is likely that its mate does as well and that other drivers may not far behind. Replacing **all** the internal components of a loudspeaker may not be worth it.

Radio Shack as well as places like MCM Electronics and Dalbani have a variety of replacement drivers, and crossovers and parts.

Speakers wired in series?

(From: Frank Fendley (frank.fendley@datacom.iglou.com).)

Wiring speakers in series increases the impedance of the load, generally allowing less expensive output chips and smaller heatsinks, due to reduced current. It also decreases the amount of output audio power in most cases, since power is inversely proportional to impedance for a given voltage.

Many cheaper home stereo receiver and power amps are configured in a similar manner. If you have a switch and output connectors for "A" and "B" speakers, in some cases when you turn the switch to "A+B", the two left speakers and the two right speakers are wired in series. To find out if this is the case on your stereo, hook up only one set of speakers to the "A" jacks. Turn the speaker select switch to "A+B". If you have no audio through the speakers, then your receiver or power amp is configured to place the speakers in series with both sets of speakers are connected. On better stereo equipment, if you have only one set of speakers and select the "A+B" switch setting, your speakers will still function, indicating that the speakers are wired in parallel in the "both" position.

Bottom line - the answer is money (isn't the answer always money?). It's cheaper for the manufacturers to design for speakers in series.

Comments on speaker shielding

When loudspeakers - even those little speakers that came with your PC - are near TVs or monitors, there may be problems with the fringe fields of the powerful magnets affecting color purity, convergence, or geometry. Speakers designed to be used with PCs in close proximity to their monitor will likely include some internal shielding. This may even be effective. However, the large powerful loudspeakers used with high performance stereo systems will likely not have such shielding. The best solution where display problems have been traced to the loudspeakers is to move them further away from the TV or monitor (and then degauss the CRT to remove the residual magnetism. Where this is not possible, shielding of the speakers may be possible:

(Also see the document: [TV and Monitor CRT (Picture Tube) Information](#).)

(From: Lionel Wagner (ck508@freenet.carleton.ca).)

Put a Tin can over the magnet. This will reduce the external field by about 50%. If more shielding is desired, put additional cans over the first, in layers, like Russian dolls. (Note: a Tin can is actually made nearly entirely of steel - the term 'Tin' is historical. --- sam)

(From: Nicholas Bodley (nbodley@tiac.net).)

While both electrostatic and electromagnetic (E/M) fields can affect the paths of the electron beams in a CRT, only E/M fields are likely to be strong enough to be a problem.

Magnetic shields have existed for about a century at least. Some decades ago, a tradenamed alloy called Mu-Metal became famous, but it lost its effectiveness when bent or otherwise stressed. Restoring it to usefulness required hydrogen annealing, something rarely done in a home shop (maybe one or two in the USA).

More-recent alloys are much less fussy; tradenames are Netic and Co-Netic.

Magnetic shields don't block lines of force; they have high permeability, vastly more than air, and they guide the magnetism around what they are shielding; they make it bypass the protected items.

I have been around some shielded speakers recently, but never saw any disassembled. They looked conventional, must have had the "giant thick washer" (my term) magnet, and seemed to have a larger front polepiece than usual.

They had a shielding can around the magnet; there was a gap between the front edge of the can and the polepiece. I suspect that a second internal magnet was placed between the rear of the main magnet and the rear (bottom) of the can, so there would be minimal flux at the gap between the can and the front polepiece. Holding pieces of steel close to the gap between the can and the polepiece showed very little flux there.

Modern magnets are not easy to demagnetize, in general.

(From: Dave Roberts (dave@aasl.demon.co.uk).)

The *good* so-called magnetically screened speakers rely on two means of controlling stray flux. The static field from the magnet on the speaker (which would cause colour purity problems) is minimized by the design of the magnet. This is often at the expense of gap field linearity, leading to greater distortion - not that most users seem to worry about that...

The mains varying field is minimized by use of a toroidal mains transformer, but the more recent mains powered speakers seem to be coming with *plug top* PSUs, which take the problem further away.

His need is for loudspeakers already mounted in a wall, not the individual drivers. The assumption is that the woofer/tweeter/whatever are correctly wired inside the enclosure.

Loudspeaker phasing

Multiple speakers need to be driven so that they are in phase - positive peaks result in the cones of all drivers moving in the same direction. All drivers are marked in some way with + and -/red and black/etc. This results in the best base response, uniformity of sounds, and stereo imaging.

(Where you are actually constructing a loudspeaker system from individual drivers, this must be done inside the speaker enclosure as well matching the markings on each of the drivers.)

If the front cover (grill cloth) is removable or relatively transparent, than it is a simple matter to observe or feel which way the woofer cone moves when a 1.5 V battery is attached to the speaker wires. Make sure both speakers are wired to the amplifier outputs with the same polarity.

However, once a loudspeaker is mounted in the wall, for example, access to see the markings may not be possible. There may be no markings so it must be an acoustic method I would think - even observing the woofer cone may not be possible.

One can do this by feeding the same low frequency signal (say 60 Hz) to both channels and positioning a microphone about midway between them (and away from the wall). Then, the correct polarity will have greater amplitude. The acoustic wavelength of a 60 Hz signal is more than 18 feet so precise position shouldn't be critical. This is basically the same way one does phasing by ear except that a scope or sound level meter will be more precise!

(From: Robert Kesler (kesler@eunet.yu).)

Such a 'gadget' is available as a commercial instrument for 'synchronizing the polarity' of the speakers, microphones and/or cable polarity in a system, where many microphones amplifiers and speakers are used in each others fields.

There are two separate units:

- The first part is a generator, supplying an asymmetrical signal (e.g., short repetitive pulses with long pauses). The generator has an electrical output, to be fed in the speaker, amplifier or the cable to be tested and an audio output (small speaker) to be fed in the microphone.

- The receiver part, similarly, has two inputs: a microphone for checking the polarity of the speaker and an electrical input to be used for checking the amplifiers, cables etc. to be tested.

One possible simple way to make the receiver could be to amplify the peak-to-peak value of the received signal to drive a CMOS chip, and feed it in the input of an inverter and in a buffer, the inverter should feed a red LED, the buffer a green LED.

(From: Jim Coe (jimcoe@ix.netcom.com).)

1. If you have 2 speakers and you want them in same phase (but you don't care about absolute phase - i.e. whether a positive air pressure at the recording microphone reproduces as a positive air pressure at you ear, not negative) than the idea about measuring by interference 1/2 way between is OK. Except that:

   - If you measure with a microphone and the speakers are in a wall, DO put it against the wall - to get a purer pressure response and to get away from high frequency reflections.

   - Instead of looking for a summation of the pressure waves from the 2 drivers, look for a null zone when one driver is out of phase. A summation cannot be more than +6dB SPL (a "doubling"), but the null can be (theoretically infinite) much more (maybe -12 dBSPL to -30 dBSPL in practice). Once you know the drivers are out of phase, you know how to get them in phase.

2. If dealing with 1 driver and you can't access the leads and see the cone to use a battery, inject a positive waveform (diode across a sine, triangle or square wave generator? Look at the acoustic wave with a microphone driving an oscilloscope. You can use a small bare speaker, previously tested with a battery while observing the cone, to calibrate your setup. In this way, you can get the absolute phase.

Should you care about absolute phase? Yes - if you want the best 3-D sound effects. Also, with close microphone recording techniques, some sound sources do not produce symmetrical air pressure waves - so listening in the same phase as the recording can give more realism. That is, if the audio processing between you and the recorded signal doesn't mess things up too much.

Don't ever trust the markings on speaker terminals from the speaker manufacturers. I was once required to test many drivers from a famous American manufacturer, using a high quality phase tester, and found more than 20% of them mislabeled! They weren't testing them on their assembly line - just marking them by visual inspection of the driver wiring. They later became a customer for the same phase testers I was using (some friends of mine invented it and I was one of their beta testers).

Electrostatic Loudspeakers and Headphones

While the vast majority of sound producing devices utilize a moving coil (or at least are magnetically actuated), there are also some that are both very expensive and which supposedly provide very accurate sound reproduction based on electrostatic principles. Basically, a conductive membrane or diaphragm is charged to a high DC voltage with respect to a fixed plate - several hundred volts for a headphone driver but several thousand volts for a wall-size loudspeaker. This sets up a bias field that draws the diaphragms together and keeps them tight. The audio signal is boosted to a high AC voltage and added to the DC bias. The resulting change in force results in the movement of the diaphragm and thus the production of sound. The claimed advantages of such an approach is that the sound emitting area can be very large and the movement very small minimizing various types of distortions.

The DC bias voltage can be supplied by any number of means - directly from the AC line via a transformer and/or voltage multiplier or using a high frequency inverter. The current requirement is essentially 0.

(Note: There are also some 'planar magnetic' loudspeakers in existence which may look similar to electrostatic types but have no external power source and special circuitry inside. The planar voice coil is etched onto a thin diaphragm suspended within the magnetic structure.)

The audio signal from the output of a normal amplifier may be boosted to a higher voltage by another special amplifier which is part of the electrostatic loudspeaker 'energizer' before being further boosted by a transformer to drive the speakers themselves.

The energizer schematic below is for a pair of Radio Shack electrostatic headphones. A room-size set of Thunderblasters would require a somewhat more sophisticated set of electronics - probably including its own amplifier as well as operating at much higher voltage and higher power - but the basic idea will be the same.

```
                          o--o L Spkr Out               5.1K         1
      Left Chan In o---o                          +-----/\/\---+-----o L Drive
                         \o---/\/\----+---+ ||(                |
                              3.3     |    )||(                |
                              PTC  30 /    )||(       100pF _|_
                                   5W \    )|| +--+    500V ---
                                      /    )||(   |            |
                                      |    )||(   |            |
                   o------------------+---+ ||(   |            |     4
                                                  +--|---------+-----o L Ret
                                                     |
                          o--o R Spkr Out            |  5.1K         3
     Right Chan In o---o                          +--|--/\/\---+-----o R Drive
                         \o---/\/\----+---+ ||(   |            |
                              3.3     |    )||(   |            |
                              PTC  30 /    )||(   |  100pF _|_
                                   5W \    )|| +--+    500V ---
                                      /    )||(   |            |
                                      |    )||(   |            |
                   o------------------+---+ ||(   |            |     5
                                                  +--|---------+-----o R Ret
                                                     |
               25K            1N4004       5M        |               2
      AC H o---/\/\---+-----+--|>|---+----/\/\---|---------------o Bias Com
                      |     |       _|_   1/2W    |
                      /     |   1uF ---           |
                 100K \     |  160V  |            |
                      /  +--|--------+            |
                      \  |  |   1uF _|_           |
               25K    |  |  |  160V ---           |
      AC N o---/\/\---+--+  |        |     1M     |
                            +--|<|---+----/\/\---+
                              1N4004      1/2W
```

The 3.3 ohm PTC (Positive Temperature Coefficient) thermistors are supposed to provide some sort of protection for the transformer and its circuitry in case the unit is fed with too much power. Now how could that happen? :) However, if abused too much, they can fail as well. Problems may occur in the voltage doubler and high value resistors sometimes just go bad on their own.

Trying to find replacements can be a treat but it appears that some PolySwitch protectors fit the description and should be available from major electronics distributors. For example, the 3.3 ohm device has a hold current spec of 0.17 A (.1 W) and a trip current of 0.34 A (.4 W). However, I don't know if this is adequate for the headphones described above.

Comments on electrostatic headphone operation and repair

(From: bill_h (bill_h@sunsouthwest.com).)

I have a couple pair of the Radio Shack electrostatics that I've used from time to time over the years (about thirty, I think!)

When they were closing them out, I ordered a couple spare 'replacement elements', and from looking them over, I think I have some ideas about repairing them, if it ever becomes necessary.

You'd have to come up with a frame to stretch the mylar. Then you would glue the plastic 'element' frame to it. Don't know how much tension you'd need, but I'm sure it can't have any slack whatever.

I was thinking about looking for one of those metal silk screen frames that used to be pretty common around circuit board houses. A nice size would be maybe 8" or 10" square, so a 'standard' mylar (Saran wrap? (I don't think so, but it might work --- Sam) would fit. Lay a piece onto the frame, clamp it, then tighten the screws to put some tension on the film and make sure it's even (use a torque wrench) and flat.

After the glue dries, just trim away the excess film. Put the spacer rings and metal plates back and basically you have a new 'element'.

I'm assuming everybody knows the way these things work - a mylar film is pushed and pulled between a couple highly charged (maybe 300vdc) metal plates, with a lot of holes in them. The mylar moves the air, so you get sound, which has to pass through the metal plates.

There is one other thing I've noticed. Probably for protection, there's a VERY high value resistor in series with the DC supply, and when the 'phones have been sitting un-energized for a while (weeks/months) they can take a DAY or more to become fully charged. And until they charge, the sound output is VERY LOW.

In other words, you can't plug Realistic electrostatics in, send audio into them, and tell anything about whether they work or not, for HOURS, at least.

Over the years I've tried every type of earphone that's come along. While there are some positive things that have come along, for my money nothing has yet equaled a good electrostatic for super clean mid/upper frequencies from the large area (planar) radiator.

I've long suspected small radiators, trying to move large amounts of air by extreme motion, run into the adiabatic characteristics of air whereby some of that extreme motion is turned into HEAT instead of sound. And that may account for some unpleasant distortion.

A large area radiator doesn't impart as much force to the air molecules nearest its surface, and doesn't run as much risk of this non-linear effect.

Might explain the superior sound from large planar speakers like Magnapans.

With headphones, you don't have a limited 'sweet spot' to worry about.

Repairing Acoustic Research (AR) Speakers

The following will also apply to many other brands of loudspeaker systems.

(From: Jim Adney (jadney@vwtype3.org).)

You must go in through the front hole that the woofer mounts in. The hard part is removing the grill cloth and its frame without damaging it. Mine have all been glued in place so you have to use a thin piece of metal that you can work around the side and in back and then pull out carefully. Do this carefully all around until you have broken all the glue bonds; the grill cloth frames are usually plastic, so you have to be careful not to break them. You should probably inspect the face of the cloth for staples first, as AR used staples on the AR-2ax's that I have taken apart. If you have staples, just carefully pull them all out from the front and then the grill cloth/frame will come out easily.

Then you can see all the speakers and you will notice that the woofer is just held in place with a ring of screws. Remove the screws and pry the speaker up (it is sealed in place with a compound that will still be somewhat soft and that you should just reuse when you're done.

Once the woofer is out, mark which color wire goes to which terminal on the woofer and then unsolder them. They MUST be put back the same way!

Inside you will find the speaker packed with fiberglass insulation. Carefully pull all this out and pack it in a box or paper bag for reuse later. Note how it is placed so you can do it the same way. I think there was also some kind of paper which was used to keep the fiberglass from rubbing against the backside of the speaker cones. Some kind of disposable gloves might be nice for handling the fiberglass.

Now you can see the crossover attached to the inside back of the cabinet. Make yourself a sketch of the wiring so that you can put it back the way you found it, and then unsolder the leads to the 2 pots and remove the pots. These disassemble easily, so clean/scrape until they work properly again. You can carefully clean the heavy oxidation off the slider and the wire with a dental tool or a small screwdriver; work slowly and carefully Reassemble and install.

Put everything back in reverse order. The crossover components all age well, so there is no point in just replacing things because they are old, but if something was obviously burned you might have to think about replacing it. I have never seen anything damaged there.

When I put these back together I use velcro to hold the grill cloth/frames in place. You can buy velcro by the yard at fabric stores and glue the pieces in place. This makes future repairs MUCH easier.

I've done about 4 pairs of old AR speakers (2s and 3s) this way so far, and they have all fixed up nicely. My current set of AR-3s needed this when I found them, and they have worked nicely ever since they were repaired, about 8 years ago. Takes an afternoon, no parts required.

- Back to Audio and Misc Repair FAQ Table of Contents.

Telephone Equipment

Web resources for telephone information

In the old days, before dinosaurs and indoor plumbing, there were telephones. You rented your dial phone from the PHONE COMPANY and it came in two styles: desk phone or wall phone. You could have any color as long as it was black. A great advance was the introduction of decorator colors, which was emphasized when you ordered your telephone service. Then came Touch Tone phones but these still looked like phones! And for the most part, all of these were very reliable. A 50 year old phone is very likely to be in perfect operating condition today having never required repair despite long faithful service and much abuse (the PHONE COMPANY made mucho profits from those rentals year in and year out with no expenses!) and only their equipment could be plugged into the phone line. Now with deregulation we have almost every shape, style, color, and quality. Phones are throwaway items given away in cereal boxes. And all types of other equipment gets connected including modems, fax machines, intruder alarms, and college senior projects. Amazingly, the phone system remains very reliable.

There is a Telephone FAQ under development. While this is not an official document, the information in it seems to be accurate. I don't know that it has a lot more than what is covered in this chapter but might be worth checking out nonethless:

- Skip's Telephone FAQ

There are some additional Telephone related Web links in my bookmark file at Sam's Neat, Nifty, and Handy Bookmarks.

Telephone basics

- Connections to 'Plain Old Telephone Service (POTS)' is via two wires. POTS is the type nearly everyone currently has to their residence. Newer ISDN or fiber lines use different techniques.

- The wires are called 'Tip' and 'Ring'. This terminology has nothing to do with telephone ringing but is historical; Tip and Ring were connected to the tip and ring respectively of the plug used on manual switchboards.

- Tip and Ring color codes are as follows - this is not always adhered to!

```
                          Type A              Type B
     Phone line          Tip,Ring            Tip,Ring
  ------------------------------------------------------------
```

```
First line (Pair 1)       Green,Red               White,Blue
Second line (Pair 2)      Black,Yellow            White,Orange
Third line (Pair 3)       White,Blue              White,Green
```

Type A is often simply called 'quad' and is the most inexpensive cable. However, the conductors are usually not twisted and type A should not be employed in new installations especially where computer modems or fax machines are to be used on any of the lines as crosstalk between multiple phone circuits in the same cable may result in excessive transmission errors and interference with normal phone conversations.

For type B, the colors refer to the dominant one if the wires are striped. Each pair is twisted together which greatly reduces crosstalk.

- On RJ11 type connectors, Pair 1 is the central two wires, Pair 2 is the next two, and Pair 3 are the outer wires if there are 6 conductors - many RJ11 cables only have 2 or 4.
- Tip will be approximately +50 VDC with respect to Ring when phones (or computer modems or fax machines) are on-hook. Test with a multimeter.
- Ringing voltage is about 90 VAC. A neon light bulb (NE2) can be used to test for this if a multimeter is not available.
- When off-hook (dialing or talking), there will be a DC voltage of approximately 5 to 15 V between Tip and Ring. This is needed for the phone circuit and also is used to power the dialing in phones without a separate AC supply or adapter.
- The on-hook and ringing voltages can give you a shock but are probably not particularly dangerous to healthy people. Still, it is best to work on phone wiring with it disconnected from the telephone company's feed or with another phone on the same circuit off-hook.
- Some phones will work with only one of the two possible polarities of Tip and Ring while others incorporate a bridge rectifier (for power) and will work either way - test both ways if a phone does not dial or work at all.
- DTMF refers to the Dual Tone Multi-Frequency dialing touch tone codes. Each number, *, and #, are represented by a pair of audio frequencies. (You can hear the individual ones by holding down multiple buttons on an old style ATT Touch Tone phone). See the section: DTMF codes.

DTMF codes

DTMF (Dual Tone Multi-Frequency) are the tones that phones use. The frequencies are as follows:

```
  Hz      1209    1336   1477    1633
-----------------------------------
 697        1       2       3      A
 770        4       5       6      B
 852        7       8       9      C
```

```
941       *      0      #     D
```

Follow the rows and columns to the number you want to know the frequencies of and this table will show you. The column of letters at the right is on some Ham radios.

Where an old style ATT Touch Tone phone's DTMF frequencies need to be adjusted, accuracy of better than 1 Hz is easily obtained without fancy equipment - just another working tone dialing phone. See the section: Classic ATT Touch Tone phone will not dial properly.

For more information on DTMF coding, decoding, equipment, chips, etc., see the:

- DTMF FAQ

Phone jack or extension installation or repair

The phone companies would have you believe that installing or repairing phone wiring is somewhere between rocket science and nuclear physics in complexity. In fact:

- Installing new jacks consists of two parts: running the wires and hooking them up. The only difficulty with running the wires is getting between floors. Connecting them is a matter of matching the colors of the insulation, stripping, wrapping around screws, and tightening the screws. Even if you are color blind, this is not difficult.

- Unless you disturb it, phone wiring rarely goes bad - even in old houses. Thus, if you have any amount of handyperson ability, paying the $2 a month inside wiring insurance is throwing away $24 a year.

- Unlike electrical wiring, phone wiring does not have serious safety issues associated with it. However, you could get a mild shock from touching the two wires of an active phone line. The on-hook voltage is about 50 VDC and if someone were to try calling your number at the same time, the ringing voltage is around 90 VAC. Both of these are easily dealt with: put a jumper between the two phone wires where they enter your house while you are working on the wiring. This will result in an 'off hook' condition and outside callers will get a busy signal.

Telephone interference from local radio station

(From: Robert Myers (rmyers7@ibm.net).)

See the:

- RF Elimination Technical Bulletin

for an explanation of this problem.

(From: Gray Frierson Haertig (gfh@haertig.com).)

AM interference to telephones is very common. Most modern telephones are full of transistors and diodes which make splendid demodulators for the AM signal. Some of these semiconductors are in the part of the circuit that drives the earpiece, which might explain why only you hear the radio. We assume that there is really an 880 AM in your town so we can rule out psychosis. If the radio starts telling you to kill people, get help immediately.

The AM is probably coming in on the phone lines. The reason phones have this problem in particular, is because they are connected to really long antennas - the phone lines. Bet the 880 transmitter is pretty near your house.

The susceptibility of different kinds of phones is very different. And, depending on where in the circuit the detection is happening, one susceptible phone can put the AM audio on the phone line so all the phones will have problems. First thing to do is unplug all your phones. Then plug phones in one a time in their normal locations and see which phones are susceptible.

Check out Mike Sandman's Telecom and Cable Installation Products. These folks make a wide range of interference filters that frequently will help with the problem. It may be cheaper to replace seriously affected phones with phones that are not so susceptible. And remember, the price of the phone has absolutely nothing to do with it's susceptibility.

(From: Lord Valve (detritus@ix.netcom.com).)

Your phone wiring has a local ground, usually attached to a water pipe. Chances are better than even that this connection is oxidized. Remove the clamp and clean the copper pipe with a piece of Scotch-Brite. Clean the clamp, too, and the incoming ground wire. Put it all back together and cover the whole assembly with grease. (The grease will block moisture and prevent re-oxidation.)

(From: Michael Bell (mbell72398@aol.com).)

I find your post a common problem to an everyday experience to me. I work with a local telco and this is very much a problem. Some phones are more prone to this than others. Believe it or not, the electronic ringing (this is any phone that does not have the plain old bell in it) ones are more likely due to the circuits in them. The phone company will (at no charge to you) put a AM coil that will greatly lessen the interference in the protector outside your home. They should have a that blocks your local AM station's frequency before it comes in your home. However, this will not help if certain phones are acting as the antenae for your interference. Call your local telco first. Why pay if they can solve it.

Remember that they cannot charge you for work up to the protector.

(From: Anthony Falvo (afalvo@borg.com).)

I am the Chief Engineer of an AM radio station. We put out a measly 1000 watts of power but it has the same effect on all of our studio gear. What you need to do is open the affected phone and place a 40 mH coil in line with about .01 uf cap in series across the phone line values may very ans get a coil that is tunable slug like from an old TV IF section wire in series and tune the coil for best rejection of the offending signal you may completly eliminate it sometimes you need 2 of these FILTERS to ground from bolth sides of the phone line depending hoe bad the interfereing signal is what you are essentialy creating is a crude NOTCH filter that will

NOTCH out the offending freq according to the Tuning of the coil.

If I can eliminate the noise from our studio lines wich are no more the 20 feet from the Tower, then I'm sure this will work for you.

(From: Robert Blackshaw (blackshaw@erols.com).)

I spent 33 years with Bell Canada and have seen this phenomena in rural areas with open wire lines. The splice connectors would become oxidized (copper oxide) and treat every subscriber to "free" radio.

(From: Jim Muehlberg (muehlber@plains.nodak.edu)..

I'm currently in studying EE and took a course in electromagnetic compatibility (EMC) This is a huge field with many employment opportunities.

We conducted a lab experiment that simulated this problem. It is a fine example of what is called common mode currents. The idea to install the chokes as described above is likely to cure the problem. Perhaps a simpler quick check is to take the phone cord from the wall and wrap as many turns as possible around an IRON bar or big bolt or if you can find one surplus, a big ferrite toroid. It is important that each conductor be wrapped in the same direction. This constitutes a common mode choke. This will be "invisible" to the differential signal (desired) and be a large reactance to the common mode currents. If it works, install the whole shebang at the wire entrance.

Answering machine comments

Most answering machines still use one or two tape decks. Most problems are mechanical. Refer to the sections on the relevant tape player/recorder problems. The newest ones are fully digital electronic - forget repairs unless obvious bad connections, physical damage, power supply, or phone line side failure.

- Many non-mechanical problems with answering machines are related to the circuitry connected to the phone line. This is subject to the high on-hook and ringing voltage and possible voltage spikes due to lightning, etc.

  Testing of the components on the phone line side of the coupling transformer is a worthwhile exercise and may reveal a shorted semiconductor or capacitor.

  See the section: Checking phones and answering machines for electronic problems.

- If the outgoing message (OGM) or phone messages do not record or playback, check for broken wires at the appropriate tape heads and clean the mode selector switches.

- With endless loops outgoing message cassettes, the metal strip that is used to sense the beginning can wear or become dirty. Try a new cassette or clean it.

- Like VCRs, there may be various 'mode switches' or position sensors. Where these are physical switches, they may have dirty or worn contacts. Optical sensors can fail as well though it is unusual.

- Mechanical problems unique to answering machine tape transports are also possible. Some very clever engineering is often used to share parts where two tape transports are used. Parts may have popped off or broken. Springs may have sprung or weakened. Sliding parts may have jammed. Look for loose parts or broken pieces when the unit is disassembled. Careful inspection during operation may reveal whether it is getting stuck due to a mechanical failure.

- On erratic behavior where two phone lines share a common untwisted (e.g., "quad") cable, activity on one line may result in the answering machine picking up or otherwise messing up the other line, at least with some models. Solution: Separate the lines or use better cable.

Answering machine delays after playing OGM

This may be one of those machines where it has to go through the entire outgoing message (OGM) tape before allowing recording of the phone conversation - If it is, then just get yourself the shortest outgoing message tape you can find and time your OGM to nearly fill it.

Also, if you are trying to use an OGM tape recorded on another answering machine, even if the tape is compatible, the frequency or coding of the control tones - the beeps - may not be the same. Try re-recording it on the machine in question.

If these are not the problems, the machine may not be sensing the beep code put on the tape when you record the OGM or the beep is not being recorded properly. This is likely an electronic or logic problem requiring the schematic unless you get lucky with bad connections or a broken wire at the tape head.

Answering machine picks up then hangs up

- If it has a 'telco' and a 'phone' connector verify that you are plugged into the 'telco'. Otherwise, it may hang itself up. Who knows. If someone else attempted a repair, these jacks could even have been replaced interchanged.

- Measure voltage on the relay coil. If it actually disappears when the relay cuts out, then something is telling the relay to turn off. If it is just reduced, then there may be a power problem. If it is relatively stable, then the relay may be bad.

- Test components near the telephone connection for shorts/opens. Parts connected to the telephone line get abused by the ringing voltage and other transients. Maybe you will get lucky and find a fried part.

- If you can identify the power supply outputs, verify their voltages if possible. Check the 'wall wart' if it uses one for proper output.

- Make sure that the tape mechanisms have completed their cycles. While unlikely, it is possible that the logic gets confused if one of the tape units has not reset itself due to a mechanical fault like a bad belt.

- As usual with cheaply made consumer stuff (as well as cheaply made expensive industrial stuff), check for bad connections.

Beyond this, circuit diagrams would be a definite plus.

Answering machine does not complete cycle

This is often a mechanical problem. As it goes through the cycle, see if the mechanism is perhaps getting hung up at a certain point do to a weak spring or motor. A cam may get stuck or a solenoid may fail to engage. Gently prodding the uncooperative part (or any likely parts if the appropriate one is not obvious) may convince it to continue and allow you to make a diagnosis.

For endless loop outgoing cassettes make sure that the metal sense strip is not worn off and that the sensor is making good contact. Try a new outgoing message cassette or manually short the sensor contacts to see if it will then shut down.

Answering machine has weak outgoing message

You probably have no way of knowing since you probably never listen to the outgoing message, but did the problem happen suddenly?

Does playback of the outgoing message directly to the speaker appear to be at normal volume?

Do incoming messaged get recorded at normal volume?

First, confirm that the unit is in good mechanical condition. See the section: General guide to tape deck cleaning and rubber parts replacement. Clean the tape head and inspect for anything that may be interfering with good tape-head contact. Clean the internal record/play selector switches. Dirty contacts can result in any number of symptoms.

Assuming that none of this helps significantly, you are left with a problem in the electronics.

If local record and playback of the the outgoing message works normally, the problem is not a bad tape head. It is probably in the interface to the phone line.

If local record and/or playback do not work correctly, then there are likely problems with that circuitry.

One other slight possibility is that you have so much equipment (phones, modems, fax machines, etc.) on the phone line that in your house that the answering machine is not able to drive the line properly and reduced outgoing message volume is the result.

Newly installed phone will not tone dial

If a Touch Tone phone that was previously working now does not tone dial from a new jack or new residence (the button presses are totally ignored, but all other functions are unaffected), the red and green wires are probably interchanged at the new jack, or the phone itself is miswired (the wires inside the phone may have been interchanged to compensate for an incorrectly wired jack at the old location).

Newer electronic phones will utilize either polarity. The older ATT battlewagons will only dial when hooked up with the correct polarity. This does not affect conversation, ring, or rotary phones.

Cordless phone problems

There are several types of problems with cordless phones that can be diagnosed and repaired without sophisticated test equipment. Anything involving problems with the RF or digital circuitry is not likely to be within the scope of your capabilities, at least not without complete schematics (yeh, right), test equipment, and a miracle or two.

1. Bad rechargeable battery - dead, shorted cell(s), or reduced capacity. The NiCd battery packs in cordless phones are usually easily replaced for around $5-10. This really is the best solution. The problem is almost never in the charging circuits. Replacing individual cells is not recommended. Battery packs can be built up from individual NiCd cells with solder tabs for a modest cost savings. Reuse the old battery pack connector (you may need to do this with a replacement pack as well if the new connector is not identical to the old one), double check polarity, and tape and insulate your homemade pack after soldering to prevent shorts.

   A NiCd battery pack with shorted cells will either prevent operation totally or keep the 'battery low' light resulting in a weak, noisy, or intermittent connection. If the voltage measured on the battery pack after 24 hours of charging is less than 1.2 V times the number of cells in the pack, it is most likely bad.

2. Dirty keypad - resulting in intermittent, incorrect, or no operation of buttons on handset. This may be due to internal migration of some unidentified substance (how else to describe disgusting sticky gunk that has no right being there on multiple samples of the same model phone) or from external spills. If you are lucky, the keypad can be disassembled without resorting to drastic measures. There may be screws or it may snap apart once access is gained to the inside of the handset. Clean contact surfaces on both the rubber button panel (or plastic keys) and the circuit board first with soap and water and then with isopropyl alcohol. Dry thoroughly.

   If the keypad is assembled with 'upset' plastic (fancy term for little melted plastic posts), then you should probably try contact cleaner sprayed as best as possible through any openings before attempting to cut these away since reassembling the keypad without the plastic posts will be difficult. However, I have successfully repaired these by breaking off the tops of the posts to remove the circuit board and rubber keys, and then using a dab of windshield sealer on each post as an adhesive to hold the thing together after cleaning. However, I much prefer screws :-).

3. Bad AC adapter on base station - see the docuemnt: Notes on the Troubleshooting and Repair of AC Adapters, Power Supplies, and Battery Packs. This will likely result in a dead base station. If you have replaced the AC adapter or are using a universal type, double check the voltage setting AND polarity.

4. Bad phone line connection - don't ignore this possibility - test with another phone.

5. Bad circuitry on phone line side of interface (coupling transformer) - inspect for blown or shorted components.

6. Bad connections or broken circuit board - if the handset has seen violent service, these are likely

possibilities. See the section on: "Equipment dropped or abused".

7. You forgot the code number - some phones use a multidigit code number as a marginal security feature which must match on handset and base station. If the battery goes dead in the handset or the AC adapter is pulled on the base station, this code may be forgotten. You do have the user's manual, right?

   BTW, do set this code to a non-default value. I was once able to dial out on my neighbor's cordless phone using my phone from my house as a result, I suspect, of their phone being set to its default code!

8. Base station and handset out of sync - some models require that the base station initialize the handset before any communication is possible between them. Put the handset on the base station for a few seconds to reset. This can happen at any time due to circumstances beyond human control but will almost certainly happen if you replace or disconnect the battery in the handset of these model phones.

Cordless phone keypads

(From: Martin Sniedze (MSniedze@STRNNTS1.telecom.com.au).)

I found that the keypad was always getting wet/oily somehow. Cleaning with alcohol only fixed the dialing problem for about a week. A bit of asking at phone repairer revealed that sanyo has a 'possible' problem with the keypads absorbing/emitting the oily substance. The repairer sold me a membrane that goes between the silicon keypad and the PCB, it has carbon pads on the back. It stops the moisture getting through. It has completely fixed the problem in my phone (it was done 6 months ago). They should be free.

(From: Steve Lenaghan (tamerica@prairie.ca).)

We do a ton of cordless phones and I have never had to repair a conductive pad in my career (35 years). We soak them in scalding water and dish soap for 30 minutes. I clean the PC boards with alcohol and a rough cloth. Works every time.

Erratic or noisy telephone equipment

The following applies to normal desk or wall phones, cordless phones, modems, answering machines, fax machines - essentially anything plugged or wired into the phone system.

Always check the cords first - especially the one between the handset and the desk or wall phone itself since it gets a lot of abuse. Noisy, intermittent, or totally dead behavior is possible. In some cases, even the (electronics) ringer will not work if a wire in this cord is broken as the ringing signal is generated in the handset and sent back to the ringer unit. Try jiggling the cord at both ends to see if noise is generated or behavior changes. Even permanently wired in cords are replaceable - just take care to draw a diagram and/or label all the wires before disconnecting the old one.

Bad connections are relatively rare in original ATT dial or Touch Tone telephones. These old phones also used very high quality contacts for the on-hook, dial, and button switches which rarely resulted in problems. However, with the multitude of modern equipment of all degrees of quality, bad connections and dirty or degraded switches and relays are very common.

The various microswitches and/or relays for on-hook and other functions seem to be particularly prone to degredation if not properly specified in the design. If phone line pickup or mode switching is noisy or erratic, this is a likely cause. Most of these swiches and relays are replaceable although creativity may be required as an exact match may not be easy to locate.

To assure that the problem is actually with the particular piece of equipment, disconnect other devices on the same telephone line. Aside from the obvious oversight of a phone that has not been hung up, modems or fax machines that are not powered on may load the phone lines excessively. For example, if you have two PCs with modem connections to the same phone line, the signal quality on one of them may degrade to the point of reducing the effective transmission speed, producing an excessive error rate, or not successfully connecting at all if the other is turned off. (They may also behave strangely if the Originate/Answer settings of the modem are set incorrectly - but that is another matter.)

Checking phones and answering machines for electronic problems

Most signal problems will be related to failed components on the telephone line side of the coupling transformer including components in the phone line derived power supply (if used). Phone lines are subject to all kinds of abuse including lightning strikes (although something significant may do extensive damage beyond reasonably hope of repair).

- Test all the components on the telephone line side of the coupling transformer when line connect, detect, or dial problems are encountered. There may be shorted semiconductors due to a voltage spike or just bad luck.

- Some units extract power from the phone line and the rectifiers or other related components can go bad. This can result in either power problems (telephone is totally dead) or dialing problems.

- Make sure you are using the proper AC adapter and test it for correct output.

- There could be a defective power supply inside the phone - the regulator could be shorted or a filter capacitor could be dried up. See the chapter: "Equipment Power Supplies".

- Check for loose or broken connections - phones get dropped.

- For erratic dialing problems, inspect and clean the keypad and other switch contacts. Also see the section: Cordless phone problems.

Modem problems

First, confirm that your modem settings are correct - reset the modem to factory defaults using the Hayes AT commands (e.g., AT&F1) or dip switch settings. Confirm that your software is set up correctly and that there are no IRQ or IO address conflicts.

If the modem starts to dial but aborts and hangs up, confirm that you do not have the wiring of the 'telco' and 'phone' connectors interchanges.

Also see the section: Erratic or noisy telephone equipment.

Since the phone line is subject to all kinds of abuse, most actual problems (that are not software related), will be on the phone line side of the coupling transformer.

- There will be various resistors, diodes, transistors, capacitors, opto-isolators, and relays for routing the incoming and outgoing signals, or for protection and these can fail shorted or open, or change value.

  On one U.S. Robotics 56K modem, I found a pair of 10 ohm surface mount resistors that failed due to a storm related surge - one had changed value to about 20 ohms and the other had opened. The difference between 10 and 20 ohms made no difference (I left it that way though it could be less reliable and fail eventually) but the open resistor resulted in a "No Dial Tone" error. More below as this is a common occurrance with modest surges.

- There may be an actual fuse (or more than one) as well - but it will probably not look like a common fuse but may be very tiny - more like a resistor - or even a surface mount part. Hopefully, the circuit board will be marked 'F1' or 'PR1' or something similar. Check fuses for opens.

- A lightning strike is likely to obliterate components in the modem beyond even your abilities to salvage it. If it arcs over the coupling transformer or just induces a large enough voltage spike, the logic circuitry will be history. However, in many cases, damage is minor.

If you have signal problems - a modem will try to dial out but not make its way to the phone line, testing on each side of the couping transformer with a scope or Hi-Z headphones should be able to determine if the problem is on the logic or phone line side of the device.

Check that the proper AC adapter is being used (if relevant) and that is is putting out the proper voltage. Check the internal power supply components for proper output. They are often common IC regulators like the 7805 and are easily tested. Replacements are inexpensive and plentiful.

(From: Rick Miller (wizkid@mv.mv.com).)

First thing to check: almost all modems have a pair of low-value resistors (10-20 ohm) between the phone line and their line transformer.

I got a 2400 baud voicemail modem for free this way! Repaired an "unrepairable" modem (according to the ACER computer technician! :))

Replaced a "booger resister" with a real 1/2 job.... had to work hard to get the leads soldered onto the SMT pads!:)

(From: Jordan Hazen (jnh@aardvark.cen.ufl.edu).)

Yes, in my experience you're much more likely to sustain damage from a phone-line surge than anything on the power grid. Modem electronics tend to be more delicate than the stuff in your power supply.

First thing to check: almost all modems have a pair of low-value resistors (10-20 ohm) between the phone line and their line transformer. These are intended to take the brunt of a lightning hit and protect the electronics upstream. Traditionally, these have been large, high-current resistors (like 1/2 watt), but sometimes now they try to get away with little 1/16-watt surface mount ones that are much more likely to blow. Sometimes it's obvious when the resistors have died, with visible singe marks, pieces blown away(!), etc. Usually these fail as an open, resulting in "NO DIALTONE" on trying to connect.

Other vulnerable stuff includes the zener diodes intended to clip down incoming ring voltage, on the transformer "primary" (telco) side. These may fail as a short-circuit. The ring-detect optoisolator may also blow, and it can simply be removed if you don't need to take incoming calls.

One of my modems actually had the line relay's contacts welded together by a lightning hit, so it stayed off-hook constantly! Check the isolation transformer for a open coil on either side. If it's a high-speed modem, be sure to replace blown transformers with one of about the same type & quality... the ones on 2400-baud modems usually had poor frequency response/linearity.

Any damage beyond the transformer will be hard to repair w/o a schematic, since the surface-mount diodes, transistors, etc. damaged may be hard to ID for replacement on a surface-mount board. Something blown in this area may cause slow/error-prone connections, rather than complete failure. It happened to be with a particularly nasty strike (the one welding the line relay closed), transforming a 33.6k modem into a 4800 :-(

Oh, and if the modem's completely dead - no response to AT commands-- you're probably out of luck... this means there's damage to the digital logic, and it's invariably the 200-pin custom ASICs that blow rather that 74xxx buffers.

(From: jlager@tir.com).

My experiences with the front end of answering machines are welded relay contacts mostly. The symptom is usually holding down the line.

Testing a Fax machine without a second phone line

Note: This was written for phone systems in the UK but should apply elsewhere.

(From: Peter Duck (pduck@zetnet.co.uk).)

All you need is another fax machine or a computer w/faxmodem and fax software plus a small circuit to simulate the phone-system.

(This doesn't provide/check 'ringing', so one must tell the receiving end when to Answer/Start, but I use this for modems and/or fax machines.)

```
                        33 ohms        E      C     LED
         o---------+----/\/\----------.      .----|<|-----+-----o(+)
          To        |                  _\___/_             |
        two-way     |                      |               |
        adaptor     +----|<|--|<|---------+-------/\/\----+   PP3 (9V)
```

```
    for both      2 X 1N4148-ish       B        3.3k       Battery
     modems
       o-----------------------------------------------------o (-)
```

The current is approximately 20 ma, so almost any small transistor is OK. Shown for NPN: adapt if you only have a PNP. The LED is optional, but reminds you to unplug things instead of having to buy a new battery each time. :-)

If you're trying to figure out how it works, the 'constant' current will be such that the (voltage drop across 33 ohms) + Vbe = (2 * (Vf of a diode))

Though a phone-line would be fed from a 50 V source (in the UK, anyway), all that's needed to keep the modems happy (or fax machine) is some excess over the Vfs of the diode bridges that enable them to cope with either polarity of line-voltage.

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Calculators, Clocks, and Watches

Web site for clock and watch information and repair

The following Web site has links to lots of clock repair informaion including a repair FAQ, clock/watch companies, and more:

- Mike's Clock Clinic's Web and FTP Pages.

Problems with calculators

Small hand held and desk calculators share many of the same afflictions as hand held IR remote controls. In particular, battery and keypad problems are common.

Caution: many devices using LCD displays utilize a printed flex cable to interconnect the electronics and the display. Often, this is simply glued to the LCD panel and possibly to the logic board as well. The cables are quite fragile and easily torn. They are also easily ripped from the adhesive on the LCD panel or logic board. If the unit is fairly old, this adhesive may be very weak and brittle. Repair or replacement should this occur is virtually impossible. The material used for the conductors is a type of conductive paint that cannot be soldered. It may be possible to use a similar material like the conductive Epoxy used to repair printed circuit boards but this would be extremely tedious painstaking work. Be extremely careful when moving any of the internal components - LCD, logic board, keyboard, battery holder/pack, and printer.

The following problems are likely:

1. Batteries - one or more cells are dead, weak, or have leaked. Try a new set if normal primary cells (e.g., alkaline) are used. Clean the battery contacts. Where rechargeable (usually NiCd) batteries are used, one

or more cells may have shorted resulting in a dead calculator or dim display, or printer that doesn't work reliably. See the chapter: "Batteries". Test each cell after charging for the recommended time or overnight. NiCd cells should be about 1.2 V when fully charged. If any are 0 V, the cell is shorted. This is particularly likely with a unit that has been left in a closet unused for an extended period of time. It is generally recommended that the entire battery pack be replaced rather than a single cell as the others are probably on their way out and the capacities will not be equalized anyhow. Rechargeable batteries may be the cause of a calculator that does not work properly on AC power as well since they are usually used like a large filter capacitor and shorted cells will prevent the required DC voltage from being provided to the electronics. Open cells or bad battery connections will prevent this filtering as well and may result in erratic operation or other symptoms. For this reason, it may not be possible to run a unit of this type reliably or at all with the rechargeable batteries removed.

 Some calculators that use rechargeable batteries like older HPs and TIs have a battery pack of 24.4 to 3.6 V with a DC-DC inverter to obtain the 9 V or so that the NMOS chipset required. These rarely fail except possibly due to leakage of neglected dead batteries. However, good batteries need to be in place for the calculator to work properly. If you are not interested in using these types of calculators on batteries, disconnect the DC=DC convertor and substitute a suitable AC adapter. Check the voltage and current requirements for your particular model.

2. Keypad - dirt, gunk, and wear may result in one or more keys that are intermittent or bounce (result in multiple entries). Disassemble, clean and restore the conductive coating if necessary. See the document: Notes on the Troubleshooting and Repair of Hand Held Remote Controls.

3. Printer (where applicable) - in addition to replacing the ribbon when the print quality deteriorates, cleaning and lubrication may be needed periodically. Dust, dirt, and paper particles collect and gum up the works. Clean and then relube with light machine oil or grease as appropriate. Sometimes, gears or other parts break resulting in erratic operation or paper or other jams. Locating service parts is virtually impossible.

4. AC adapter - if the calculator does not work when plugged into the AC line, this may be defective - broken wires at either end of the cord are very common. However, shorted cells in an internal NiCd battery will likely prevent the proper voltage from being supplied to the electronics even when using AC power since the battery is often used like a large filter capacitor at the same time it is being charged. Open cells or bad connections to the battery pack may result in erratic operation or other symptoms as well.

 Don't overlook the obvious: are you using the proper adapter and if it is a universal type, is the polarity and voltage set correctly? Check the specifications. With the proliferation of AC adapters, it is all to easy to accidentally substitute one from another device.

Repairing a calculator (or other device) with a fried power transformer

There may be a thermal fuse (under the outer layers of insulation, between the bobbin and core, or molded into the bobbin) which is the only casualty and it may be replaceable but don't just bypass it (except for testing), so this is worth checking out. Also see the document: Notes on the Troubleshooting and Repair of AC Adapters, Power Supplies, and Battery Packs.

(The specific example below is for a Sharp desktop calculator, model CS-1608. It has a power transformer with 6 wires on the secondary: 2 red, 2 yellow, 1 orange, and 1 brown.)

Power surges, overheating, or connecting a 115 V device to a 220 V line can all blow the primary. An overload could also but is likely not the problem. In my experience, it seems that the transformers in these things are designed so close to core saturation that excess voltage will not be transferred to the secondary and even plugging a 115 transformer device like a digital clock into a 220 line will not kill the logic, but just melts the transformer primary. I have a bag full of the things (including a cordless phone) which were damaged in this manner when someone decided to do a little house rewiring. You can guess the rest.

As far as the calculator goes, there are probably 2 sets of secondary windings probably with centertaps - check it with a multimeter. I would guess that the brown is the centertap for the reds and the orange is the centertap for the yellows but simple tests will confirm or refute this. One may be for the logic and the other for the printer motors, LCD, who knows?

Obviously, if you can obtain an exact replacement, **this** is truly the best solution. Short of this, try to find someone who can measure the secondary voltages on a working model of this calculator. Then, you could replace the transformer with a pair of readily available transformers with suitable ratings.

If you feel on the lucky side and can at least determine which wires go with which windings, you could carefully bring up power on one output and see if there is any response. It will be at least 5 V. Examining the regulation circuitry and filter capacitors could also provide a clue. Also, you could determine the ratio of the secondaries by powering one from a low voltage AC source and measuring the output of the other (assuming the primary isn't so messed up as to load down the transformer due to shorts).

There are many options besides giving up.

Getting inside calculators

Many will have a couple of screws (possibly hidden under rubber feet or inside the battery compartment) or snaps which will permit the two halves of the case to be separated. However, some very popular models are apparently not designed to be repaired at all:

Note: I have heard that there is a somewhat less destructive (but not any easier) procedure for getting inside HP48s than that given below but have not seen it.

(From: A.R. Duell (ard12@eng.cam.ac.uk).)

Have you ever tried to open up an HP48 (or just about any HP calculator later than the 71B)? It's non-trivial to do non-destructively - these darn things are held together by pegs that were melted over after the case was assembled.

From memory (and I've never actually done a 48, just the smaller ones) you have to:

1. Remove batteries, cards, etc.

2. Carefully peel off the metal overlay on the keyboard. This can be done without putting a fold in it, but it

takes practice.

3. Use a 4 mm (I think) drill held in the fingers to remove the tops of the moulded studs holding the case together

4. Pull off the back part of the case.

You can now see the circuit board. It's held down by twisted metal tabs. The keyboard is under it, and is held together by a lot more of those infernal moulded studs.

Battery powered digital clock problems

First, try a fresh battery and clean the battery contacts if necessary. If the battery is very low or dead, well.... When the battery is low or the connections are bad, the countdown logic may run erratically - fast as well as slow. Give it a week and then see if the problem still exists.

If it does - and the error is only a few minutes a week - then an adjustment may be all that is needed. If the error is much worse - like it is running at half speed - then there is a problem in the logic - time for new clock (or at least a new movement).

There should be a recessed screw for fine speed adjustment accessible from the back - possibly after a sticker or outer cover is removed. It may be marked with a couple of arrows and if you are lucky, with the proper direction for speed increase and decrease.

Without test equipment, the best you can do is a trial and error approach. Turn the screw just the tiniest bit in the appropriate direction. If this is not marked, use counterclockwise to slow it down and vice-versa.

Wait a week, then readjust if necessary.

If you have frequency counter with a time period mode, you can try putting it across the solenoid terminals and adjusting for exactly 1.000000 second. Hopefully the load of the counter will not affect the oscillator frequency.

With sensitive equipment, it may even be possible to do this without any connections by detecting the fundamental frequency radiation of the quartz crystal oscillator and adjusting it for exactly 32,768 Hz (most common).

However, keep in mind that the clock's quartz crystal accuracy required to gain or lose less than 1 minute a month is about +/- 1 part in 43,000 which may be better than that of your frequency counter's timebase. One alternative is to perform the same measurement on a clock that is known to be accurate and then match the one you are adjusting to that.

AC powered digital clock problems

Common problems include totally dead, missing segments in display, running at the wrong rate, switches or buttons do not work. (Also applies to the clock portions of clock radios.)

Note that these is often a battery - possibly just an 9V alkaline type for backup in the event of a power failure. If this is missing or dead, any momentary power interruption will reset the clock.

Although a totally dead clock could be caused by a logic failure, the most likely problem is in the power supply. The power transformer may have an open winding or there may a bad connection elsewhere. A diode may be defective or a capacitor may be dried up.

Often, the secondary of the power transformer is center tapped - test both sides with a multimeter on its AC scale. Typical values are 6-15 VRMS. If both sides are dead, then the primary is likely open. There may be a blown fusable resistor under the coil wrappings but a burnt out primary is likely. Although generic replacement transformers are available you will have two problems: determining the exact voltage and current requirements (though these are not usually critical) and obtaining a suitable regulatory (UL. CE, etc) approved transformer - required for fire safety reasons.

If the transformer checks out, trace the circuit to locate the DC outputs. These power supplies are usually pretty simple and it should be easy to locate any problems.

Missing segments in the display are most likely caused by bad connections. Try prodding and twisting the circuit board and inspect for cold solder joints.

A clock that runs slow on 50 Hz power or fast on 60 Hz power may not be compatible with the local line frequency since these clocks usually use the power line for timing rather than a quartz crystal. This is actually a more precise (as well as less expensive) approach as the power line frequency long term accuracy is nearly perfect. Sometimes there is a switch or jumper to select the line frequency.

Dirty switches and buttons can be cleaned using a spray contact cleaner.

Analog AC Motor Driven Clock Doesn't Run

The most common type uses a sealed rotor/gearbox inside a AC line powered coil. After 40+ years, even these reliable devices may stop running, often following a power interruption.

It's most likely gummed up lubricant but probably in good condition otherwise. The best option short of replacement (which may or may not be possible given its age) is to disassemble the gearbox and clean the gear-train and rotor bearings with degreaser, then lubricate the rotor bearings and gears with light oil. To get inside, file along the edge where it's joined, then glue back together.

Another option if you're lazy, which may not work as well, is to drill a tiny hole in from the side so it just breaks through, and squirt in some degreaser. Let it do its thing, blow it out, repeat a couple times. Then add some light oil and seal the hole. The problem with this approach is that it may not get to the rotor bearings - which are likely the main source of the problem.

In any case, DO NOT USE WD40 for the lube!!!! You'll just be doing it again in 6 months.

See Timepiece Workshop Tips and specifically Comments on Telechron Rotor Repair for some specific notes on dealing with the most popular types of movements.

The following sounds easy enough but I'm a bit skeptical as to it's chances of success and long term reliability:

(From: Jim Adney (jadney@vwtype3.org).)

The best cure for sticky electric clockworks that I've heard came from the USENET newsgroup for antiques. One person there suggested putting some rather heavy oil in a container and heating it up on the stove.

Drop the sealed clockworks in the hot oil and let it come up to temp. As it does, the air inside it will expand and bubble out. Wait for the bubbles to stop.

Remove the container from the heat and let it cool down with the clockworks still in it. As everything cools, the air in the clockworks will contract, pulling oil inside. Let it cool overnight and them pull out the works and wipe it off. Power it up and see if it wants to run.

Most of the time this will fix things, but you may want to let the works sit on a rag for a week to let excess oil seep out before you reinstall it.

Once you've oiled it this way, it's a good idea to run it for awhile in various positions other than the one where it spent most of its life.

Why is my $2 LED clock so much more accurate than the clock in my $2,000 PC?

Computer clocks use a crystal and are not tied to the AC line - after all, they have to keep time even when the computer is unplugged. Cheap digital clocks that plug into the AC line are extremely accurate - better than anything else you are likely to have access to short of the broadcast time signal.

The reason for this is that the power line frequency is referenced to an atomic clock somewhere and its long term accuracy is therefore maintained to great precision. Even the short term frequency stability is very good, changing by at most a small fraction of 1 percent due to variations in electric load affecting generator speed (U.S national power grid - isolated areas with local power generators could see much much wider swings).

These clocks may not keep good time if (1) the power line is very noisy, (2) there is a power outage, or (3) they are broken. Power line noise on the same circuit might confuse some clocks, however. This might happen with light dimmers or universal motors (e.g., vacuum cleaners, electric drills, etc.) on the same circuit.

Replacing batteries in digital watches

About the only type of service you can expect to perform is battery replacement but even this can save a few dollars compared to taking the watch to a jeweler. The typical watch battery will last anywhere from a year (alkaline) to 5 years (lithium). The most likely cause of a watch that has a dead or weak display, or has stopped or is not keeping proper time is a weak or dead battery.

The batteries (actually single cells) used in most modern watches (they used to be called electric watches, remember the Accutron?) are either alkaline or lithium button cells. Some are quite tiny. You will need to open up the watch to identify the type so that a replacement can be obtained.

How you go about doing this will depend on the watch:

1. Screws. If there are visible screws on either the front or rear, then removing these will probably enable the cover to be popped off. These will be teeny tiny star (sort of Philips) head type - use a precision jeweler's screwdriver with a Philips head tip. Immediately put the screws into a pill bottle or film canister - they seem to evaporate on their own.

   Note the orientation of the back: The piezo transducer of the audible alarm may make contact via tiny springs in a specific location. Take care not to lose the springs (or put them in a safe place) if they are not secured inside the watch.

2. Snap off back. This is probably most common. Look for an indentation around the edge. Using a penknife or other similar relatively sharp edged tool in this indentation or at any convenient spot if there is none. It is best to use the wristband mounting rod as a lever fulcrum if possible. The back should pop off. Note the orientation of the back before you set it aside so that you can get it back the same way.

   Same precautions as above.

3. Cover unscrews. The entire back may be mounted in a screw thread around its edge in which case you will have to somehow grab the entire back and rotate counter clockwise. An adjustable wrench with some tape to protect the finish on the watch may work.

If there is an O-ring seal (like on the space shuttle), be careful not to nick or otherwise damage it (you know what happens when these are damaged!).

Once the back is off, you will see a lot of precision stuff - though not nearly as much as in an old fashioned mechanical watch. DON'T TOUCH! You are interested in only one thing - the battery. Sometimes, once the back is off, the button cell will simply drop out as there is no other fastener. In other cases, one or two more teeny tiny screws will hold it in places. Carefully remove these and the button cell. Replace the screws so you will not loose them. Make a note of the orientation of the button cell - it is almost always smooth side out but perhaps not in every case.

Test the battery with a multimeter. The voltage of a fresh battery will be about 1.5 V for an alkaline cell and as high as 3 V for a lithium cell. A watch will typically still work with a battery that has gone down to as little as half its rated voltage.

Replacement batteries can be obtained from Radio Shack, some supermarkets, large drug outlets, electronic distributors, or mail order parts suppliers. Most likely, you will need to cross reference the teeny tiny markings on the old battery - places that sell batteries usually have a replacement guide.

Cost should be about $2.00 for a typical alkaline cell and slightly more for the longer lived lithium variety.

Note: some watches bury the battery inside the works requiring further disassembly. This is usually straightforward but will require additional steps and some added risk of totally screwing it up.

Install and secure the replacement battery and immediately confirm that the display is alive or the second hand is moving. If it is not, double check polarity. Sometimes, the back will need to be in place for proper contact to be made.

Replace the contact springs for the piezo beeper (if present). Where the back can be secured in more than one orientation, make sure it is the same as it was originally. If not, the audible alarm may not work as noted above. There is usually an obvious correct orientation based on labeling or some other means.

Repairing a watch electromagnet coil?

This is somewhat unlikely unless you touch or breath on the coil while changing the battery (almost - the wire is VERY thin) but I couldn't resist including it!

> "I have a 70's sonic oscillator watch (Omega 720) that has a bad magnet coil. The leads from the coil are apparently severed from the board. Is there anyone out there that could possibly repair it? (I don't know of any available spare parts."

(From: Jack Schidt (jack@wintel.net).)

I collect old Accutrons, and have seen this before. If you genuinely believe the coil itself is OK you can remove the coil, and under a magnifying glass attach a fine strand of wire to the fractured lead near the bobbin.

You can get this wire from an old ferrite loopstick, etc., Try to find the copper foil Litz type WITHOUT fabric inside- fabric burns easily.

Do both leads while you are at it. Prior to soldering, wind the new wire around a pin, to give it a small coil. This prevents breakage from happening again. Likely Omega forgot to do this when they manufactured the watch.

A light touch with a hot iron will remove the insulation on the existing magnet wire. Put a dot of epoxy at the solder joints to prevent more breakage. Tack the new wire to the coil body.

This is delicate surgery. If you cannot get at enough wire to solder, unwind a turn [if the break is on the outside wire]. If the break is on the inside lead- you may be screwed.

Lastly, these things are wound with #40 [sometimes smaller- check with gauge] wire, which is fragile, but obtainable. You can rewind the coil- but this takes time. Count the turns while unwinding.

I do not know of anyone who has a jig to rewind these things. Perhaps a search of the web would turn up something. Have you sent Mike Murray (www.accutronman.com) an e-mail? He may be able to help you. He regularly posts on the alt.horology newsgroup, and those people could help you as well. Perhaps rec.antiques.radio+phono could help. Old radios have IF coils that need to be repaired, and someone there may have a jig.

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Photographic Equipment

Note: For information on electronic flash operation and problems, refer to Electronic Flash Units and Strobe Lights.

Light meters

First check the batteries (if any). Self powered meters like the old Westons and their clones could also cause damage to the delicate meter movement if the light regulating lid was left open in bright light. Bad connections were also common. I have repaired the meter movements on these but it is not much fun. See the sections starting with: Analog Panel Meters for repair information.

Hand held light meters are subject to damage from being dropped.

Problems with internal light meters include bad batteries and corroded battery contacts, dirty or worn potentiometers.

Pocket camera repair

It seems that in the last few years, the amount of circuitry crammed into a compact 35 mm camera has grown exponentially. Auto-film-advance, auto- exposure, auto-film speed detection and loading, auto focus, auto-flash selection, auto-red-eye reduction - just about everything that could be put under computer control has been. Next thing you know, the photographer will be replaced with a auto-robot!

For the most part, modern cameras are very reliable. However, when something goes wrong, it is virtually impossible to attempt repair for two reasons:

1. The circuitry is so crammed into a tiny case that access is difficult and convoluted. Many connections are made with relatively fragile flexible printed cables and getting at certain parts means removing a whole bunch of other stuff.

2. Much of the circuitry is surface mount and many custom parts are used. Schematics are nearly impossible to obtain and with all the computer control, probably not that useful in any case. Most parts are not available except from the manufacturer and then possibly only to authorized service centers.

However, some problems can be addressed without resorting to the camera repair shop or dumpster.

If the camera is still under warranty, don't even think about attempting any kind of repair unless it is just a bad battery. Almost certainly, evidence of your efforts will be all too visible - mangled miniature screw heads and damaged plastic seams - at the very least. There are no easy repair solutions. Let the professionals deal with it.

If out of warranty and/or you don't care about it and/or you want an excuse to buy a new camera, then you may be able to fix certain (very limited) types of problems.

Getting inside a pocket camera

For anything beyond the battery, you will need to get inside. However, before you expend a lot of effort on a hopeless cause consider that unless you see something obvious - a broken connection, bent or dirty switch contact, or a motor or other mechanical part that is stuck, binding, or in need of cleaning and lubrication - there is not a lot you will likely be able to do. One exception is with respect to the electronic flash which is usually relatively self contained and simple enough to be successfully repaired without a schematic.

As with other consumer electronic equipment, getting inside may be a challenge worthy of Sherlock Holmes. In addition to many obvious very tiny screws around the periphery, there may be hidden screws inside the battery compartment and under the hand grip (carefully peel it back if that area is the last holdout). Also see the section: Getting inside consumer electronic equipment.

This is the time to make careful notes and put all the tiny parts in storage containers as soon as they are removed. If you never follow any of these recommendations for other types of equipment, at least do so for pocket cameras!

Caution: the energy storage capacitor for the electronic flash may be located in an unexpected spot way on the other side of the camera. Accidentally touching its terminals when charged will be unpleasant to say the least. Even if the camera is 'off', some designs maintain this capacitor at full charge. In addition, it may retain a painful charge for days - with the battery removed. Once you get the skins off of the camera (if you ever succeed), identify this capacitor - it will be about the size of a AA battery - and put electrical tape over its terminals.

Pocket camera problems

The following malfunctions may sometimes be successfully dealt with without an army of camera repair technicians at your disposal:

Caution: never open the back of a 35 mm camera anywhere there is light of any kind if there is a chance that there is film inside. If the camera is dead, there may be no way of knowing. Doing this even for an instant may ruin all of the film that has been exposed and two (usually) additional pictures. Opening the back of any other kind of roll film camera will only expose a few frames as the exposed film usually has a backing (120) or is inside a cartridge (110).

If a 35 mm camera failed with a roll of film on which you have taken irreplaceable photographs inside, the pictures can still be saved even if the camera never works again. First, wash your hands thoroughly to remove skin oils. Use a closet with a tightly fitting door (at night is better or stuff something in any cracks to block all light - it must be pitch black) for a darkroom. Open the back of the camera and carefully remove the film cassette. Gently pull the exposed film from the takeup spool (on the shutter release side of the camera). It should unwind easily. Avoid touching the film surface itself with your fingers (the edges are ok). Then, turn the plastic shaft sticking out of the film cassette clockwise to wind the exposed film entirely into the cassette.

(For items (2)-(4), you will need to get inside of the camera. See the section below: "Getting inside a pocket camera".)

1. General erratic or sluggish operation, weak display, camera pooped out during film advance or rewind. Most likely cause: the battery died.

Test the battery and/or try a new one. It is possible that the battery simply decided to go flat at an inconvenient time or that a replacement was defective. If possible, check the voltage on the battery while it is in the camera and the affected operations are performed. If the voltage drops substantially, there could be an overload - a motor that is binding or a shorted component. If the camera had been dropped, a mechanical problem is likely.

2. Flash inoperative or excess current drain - runs down batteries. Other functions may or may not work correctly. Most likely cause: a shorted inverter transistor. The electronic flash or strobe is usually a self contained module near the actual flash window but the energy storage capacitor may be mounted elsewhere - like the opposite side of the case. See the warning below - you could be in for a surprise!

3. Mechanical problems with focus, exposure, film advance, or rewind. Likely causes: binding due to damage from being bumped or dropped, bad or erratic motor operation, gummed up lubrication or dirt, or defective driver or control logic. Locate the motor for each function (right, good luck) and confirm that they spin freely and move the appropriate gears, levers, cogs, wheels, or whatever. If there is any significant resistance to movement, attempt to determine if it is simply a lubrication problem or if something is stuck. Test the motors - see the section: Small motors in consumer electronic equipment.

4. Auto-film-loading, film advance, or rewind do not operate at all or do not terminate. Most likely cause: defective motor or mechanical problems, dirty, corroded, or faulty sensor switches or bad controller. If there is no action or something seems to get stuck or sounds like it is struggling, check the battery and motor (see (1) and (3) above). Inspect the various microswitches for broken actuators, bent or deformed contacts, or something stuck in them like a bit of film that broke away from the roll. Dirt may be preventing a key contact closure. Sometimes, improper cable routing during manufacture can interfere with the free movement of a leaf type contact.

5. Exposure too light or too dark. Check the film speed setting and/or clean the contact fingers under the cassette that sense the film (ASA or ISO) speed. Clean the light meter sensor. Check the batteries, Look for evidence of problems with the lens iris and/or shutter mechanism. If the shutter speed can be set manually, see the section: Testing of camera shutter speed.

6. Automatic camera not responding to adjustments. Changing the diaphragm or shutter speed usually moves a variable resistor which is part of the exposure computer. If a single control has an erratic effect or no effect, its variable resistor is likely dirty or broken. If none of the controls behave as expected, there may be a problem in the actual circuitry that computes the exposure. There is little chance that you could repair such a fault. First, replace the batteries. Some of these systems will behave strangely if the batteries are weak.

Unless there is something obvious - the diaphragm control is not engaging the lever of the variable resistor, for example, and you care about the future health of your camera, my recommendation would be to take it in for professional service.

To successfully repair modern sophisticated compact cameras requires that you be really really experienced working on teeny tiny mechanisms, have the proper precision tools (e.g., good quality jeweler's screwdrivers, not just the $2 K-Mart assortment), bright light and a good magnifier, and a great deal of patience and attention to detail.

Testing of camera shutter speed

If you suspect shutter speed problems, there are several easy ways to measure this for your camera. The most accurate require some test equipment but you can get a pretty good idea with little or no equipment beyond a stopwatch (for slow shutter speeds - above 1/2 to 1 second and a TV (for fast shutter speeds - below about 1/60 of a second (NTSC 525/60).

Some of these approaches assume that you have access to the film plane of the camera - this may be tough with many highly automated compact cameras which will be unhappy unless a roll of film is properly loaded with the back door closed.

Note that the behavior of focal plane and leaf (in-the-lens) shutters is significantly different at high shutter speeds and this affects the the interpretation of measurements.

Some simple homemade equipment will enable testing of the intermediate shutter speeds.

1. Testing slow to medium shutter speeds - the use of a stopwatch is self evident for really long times (greater than .5 second or so). However, viewing or photographing the sweep hand of a mechanical stop watch or a homemade motor driven rotating white spot or LED can provide quite accurate results. Accurate timing motors are inexpensive and readily available. Mount a black disk with a single small white spot at its edge on the motor shaft and mark some graduations around its perimeter on a stationary back board. For a high tech look, use an LED instead. Use your creativity.

   Making measurements from the photographic images of the arcs formed by the spot as it rotates while the shutter is open should result in accuracies better than 1 or 2% for shutter speeds comparable to or slower than the rotation frequency of the motor. In other words, shutter speeds down to 1/10th of a second for a 600 rpm (10 rps) motor or down to 1/60th of a second for a 3600 rpm (60 rps) motor.

   At these speeds, focal plane and leaf shutters should result in similar results since the open and close times are small compared to the total exposure time.

2. Testing fast shutter speeds - view a TV (B/W is fine) screen on a piece of ground glass at the focal plane or take a series of snapshots of a TV screen (a well adjusted B/W TV is best as the individual scan lines will be visible).

   Note: If your camera has a focal plane shutter (e.g., 35 mm SLRs), orient the camera so that the shutter curtain travels across - horizontally (rather than up or down).

   If you are photographing the screen, take a few shots at each speed in case the timing of your trigger finger is not quite precise and you cross the vertical blanking period with some of them. This will also allow you to identify and quantify any variations in shutter speed that may be present from shot-to-shot.

   - For a focal plane shutter, you will see a bright diagonal bar. (The angle of the bar can be used to estimate the speed of the shutter curtain's traversal.)

   - For a leaf (in-the-lens) shutter, you will see a bright horizontal bar. but the start and end of the exposure (top and bottom of the bar) will be somewhat fuzzy due to the non-zero time it takes to open and close the shutter leaves. You will have to estimate the locations of the 'full width half maximum' for each speed.

In both cases, there will some additional smearing at the bottom of the bar due to the persistence of the CRT phosphors.

The effective exposure time can then be calculated by multiplying the number of scan lines in the bar at any given horizontal position by 63.5 uS (the NTSC horizontal scan time).

If you cannot resolve individual scan lines, figure that a typical over- scanned (NTSC) TV screen has 420-440 visible lines. If you can adjust your TV (remember this can be an old B/W set when knobs were knobs!) for underscan, about 488 or so active video lines will be visible.

If you have an oscilloscope or electronic counter/timer, fairly accurate measurements can be made at all shutter speeds using a bright light and a photodetector circuit.

3. Using an electronic counter/timer or oscilloscope. A gated 24 bit counter clocked at 1 MHz would permit (ideally) testing shutter speeds from 1/2000th second to 16 seconds with an accuracy of better than .2 percent. Of course in practice, the finite size of any photodiode and/or the finite open/close time of any shutter will limit this at high shutter speeds. Any resonably well calibrated oscilloscope will be accurate enough for shutter speed determination.

   Construct the IR detector circuit described in the document: Notes on the Troubleshooting and Repair of Hand Held Remote Controls. (Note that the fact that it is called an IR detector is irrelevant since the typical photodiode is sensitive to visible wavelengths of light as well.) Connect its output to the minus gate of your counter or the vertical input of your scope. Put a diffuse light source (i.e., light bulb) close to the lens so that it is not in focus. Position the detector photodiode in the center of the focal plane - mount it on a little piece of cardboard that fits on the film guide rails. Using this setup, it should be a simple matter to measure the shutter timing. Take multiple 'exposures' to identify and quantify any variations in shutter speed that may be present from shot-to-shot.

   - For a focal plane shutter, the time response will be the convolution of the photodetector area and the slit in the shutter curtain. The smaller the aperture of the photodiode, the less this will be a factor. Masking it with black tape may be desirable when testing fast shutter speeds. In simple terms, make the photodiode aperture narrow.

   - For between-the-lens shutters, the finite open and close times of the leaves will show up on the oscilloscope in the rise and fall times of the trace. The measurement on the electronic timer will be affected by its trigger level setting for this reason. However, since this photodetector is not linearly calibrated, the open and close times cannot be accurately determined from the waveform.

Here's an approach that finally represents a good use for your sound card:

(From: Jim Busse (busseja@yahoo.com).)

I thought I'd share a very easy way to measure the speed of a camera shutter using your computer.

1. Go down to your friendly parts store and get a photodiode. It really doesn't matter which one so long as it is small.

2. Put a current limiting resistor in series with the diode (100 to 500 ohms should work fine.

3. Paste the diode on a thin strip of cardboard sized so that the cardboard fits where your film is within the camera. The diode should be placed about in the center as seen from the front of the camera looking through the lens opening. This is not critical but the diode must be placed somewhere the film is exposed to the light when the lens activates.

4. Use thin wires and connect them to your microphone input on your sound card.

5. Close the camera, cock the shutter and point the camera at a light source.

6. If you have Wave Studio (comes with Sound Blaster), start to record the mic input and simply take a picture.

7. Look at the waveform of the picture. You can set the recording to 44 kB/s so you can easily measure 1/1000s, or 1/2000s exposure.

The whole setup costs a couple of dollars and gives you instant information. Of course it is difficult to adjust the exposure time for a camera but you can easily compensate using the exposure f-stop, (slow speed, larger opening, etc.).

Darkroom timers

Developing timers only provide a display or clock face (possibly with an alarm) while enlarging timers include a pair of switched outlets - one for the enlarger and the other for the safe light. These are usually self resetting to permit multiple prints to be made at the same exposure time setting.

Where the device plugged into a controlled outlet does not come on, first make sure these units are operational (i.e., the bulbs of the enlarger and/or safelight are not burned out and that their power switches are in the 'on' position. The problem could also be that one of these devices is defective as well.

Two types of designs are common:

1. Electromechanical - using an AC timing motor and gear train with cam operated switches controlling the output circuits directly or via relays.

   If the hands fail to move or it does not reset properly, the timing motor or other mechanical parts may require cleaning and lubrication. The motor may be inoperative due to open or shorted windings. See the section: Small motors in consumer electronic equipment. Where the timer appears to work but the controlled outlets (e.g., enlarger and safe light) do not go on oroff, check for a loose cam or bent linkages and dirty or worn switch or relay contacts. If the dial fails to reset after the cycle completes, it may be binding or require cleaning and lubrication or a spring may have come loose or broken.

2. Electronic - digital countdown circuits and logic controlling mechanical or solid state relays or triacs.

   Where the unit appears dead, test as with AC line powered digital clocks (see the section: AC powered digital clock problems). If the buttons have the proper effect and the digits count properly but the external circuits are not switching, then test for problems in the power control circuits. If the unit is erratic or does not properly count or reset, there could be power supply or logic problems.

Weird exposure meter problem of the year

Here is one for the photo album:

> "Ever since I bought the Mamiya 645 Pro 2 months ago, I've had exposure problems. I usually bring any new eqpt up to Twin Peaks (in SF) to test for lens sharpness, and overall function. Well my first shots from there were 2 stops overexposed, and the meter was reading wrong, so I returned the camera for repair, assuming it was broken out of the box. Mamiya went over it with a fine tooth comb, and could find nothing wrong with it. I got it back on Monday, and went up to Twin Peaks again. Same problem as before! The meter read 2 stops over! I cursed the techies at Mamiya, I cursed the product, I cursed MF, and then I decided to get scientific about it. So I took the camera off the tripod, and pointed it around at various things: all normal readings.
>
> I pointed the camera back at the scene I had just metered on the tripod...normal reading. I remounted the camera on the tripod ... 2 stops over. I removed the camera ... normal reading. I remounted the camera ... 2 stops over. Unbelievable. So that's when I started thinking about the RF and TV signals being transmitted from the big tower there, and how the tripod might act as an antenna, and cause a small current to enter through the ground socket and perhaps change the ground reference voltage. But it's a carbon fiber tripod! Still, I was on a quest.
>
> So I borrowed another 645 Pro from the store, and I took my 3 tripods up the hill. They were the Gitzo 1228, a Slik U212, and a Tiltall. All 3 tripods and both cameras exhibited this phenomenon, but to varying degrees. The Gitzo was off the most, anywhere from 1-3 stops. The other 2 did not affect the meter as much, at the most 1-2 stops. Funny thing is, the cameras did not even have to *touch* the tripod to have their readings affected! As I moved the camera closer, the meter would start overexposing by up to a stop, then jump even more once mounted.
>
> As a control, I then went halfway down the hill, and repeated the test. The effect was less, with the Gitzo giving 1-2 stops. I then went downtown, and tested again. No difference between on/off camera. I tested again when I got home. Again, no difference."

What you have described could indeed be due to RF interference. Metal and carbon fiber are both conductors so the construction of the tripods may not make that much difference.

How is it happening? This is anyone's guess but enough of a current could be induced in the sensitive electronic circuitry to throw off the meter. The ICs are full of diode junctions which can be rectifying (detecting) the relatively weak RF signal resulting in a DC offset. If this were the case and you happened to adjust the tripod height to be around 1/4 wavelength of one of the transmitters you *would* know it! :-)

Common problems with Kodak slide projectors

For service manuals and parts lists of newer/current model projectors, believe it or not, Kodak actually has a Web page at [Kodak: Slide Projectors Family Service Manuals](). (Though I don't know if they sell repair parts.) One source for some of the more common replacement parts in Kodak Equipment is [Micro-Tools (Kodak Parts)]().

(From: Olen Burkholder (burkhood@jmu.edu).)

I have worked on lots of these. Here is the likely problem.

If the advance/rev buttons do not work on either the remote or the projector but the select button cycles the mechanism, the probable cause is the nylon link is broken on the change solenoid plunger. If the mechanism doesn't cycle when pressing the select button, I expect the mechanism drive belt is broken. It is separate from the fan belt. The way to tell is to look and see if the main worm gear at the motor end of the mechanism is turning when the motor is running. If it is not, the belt is the culprit.

A note of caution. If you elect to disassemble the projector, Wrap the heat filter in a cloth. (The flat green lens in front of the lamp). If it is bare and laid on a flat surface, it can shatter spontaneously from internal thermal stresses. I know, I lost some this way. Also, Do not run the projector with the lamp burning and the case bottom removed. If you do, the thermal fuse will open within a minute or two and you will need to replace it as well (not an easy task and don't leave it out!). Also see the document: [Notes on the Troubleshooting and Repair of AC Adapters, Power Supplies, and Battery Packs]().

If you have never disassembled one of these, you might want to consider whether a 20 year old projector is worth the trouble. These things can be a real bear to work on without previous experience with this design.

(From: Johntneal (johntneal@aol.com).)

One source for plastic gears and parts for Kodak Carousel projectors is:

- [Fargo Enterprises, Inc.](), Vacaville, CA 95696.

Fil's notes on Kodak Carousel repair

In response to:

> "My IIIe slide projector does not advance the tray. When I push the switch the movement works, and I see the actuators moving (tray removed) but the tray doesn't advance. I just got this projector am I using it the wrong way or is it broken? Can someone tell me how to fix the advance mechanism."

(From: Filip "I'll buy a vowel" Gieszczykiewicz (filipg@repairfaq.org).)

I would try another tray first. Then, make sure you have aligned the tray and give it another try. Try both directions. Also, put a slide all by itself into the slot and see if the mechanism works from there.

I have fixed a few of the "Carousel custom 7xx/8xx[H]" series and they were most DEFINITELY *NOT* fun to work on. I would clean and lubricate first. Then, observe a *working* projector to see what moves where when. Timing is just about everything. At least in the 7/8xx series, there were broken plastic parts. Also, the AF gears break. I have yet to find a source for those.

Still, I get a feeling of accomplishment getting working an AF projector after paying $7.95 at a thrift store :-) They're worth just a *bit* more. :)

Screws hold the bottom of the case. Take them out and you should be able to lift the cover. Some of them have one slotted screw to change bulbs which also takes bottom off. Some have further assemblies that brace each-other - to take one out you have to take apart 1/2 of the projector. ARGH!

Avoid taking it apart. If you're not familiar and don't have similar models you can study, you'll most likely end up "screwed". I got lucky. The following week found another 800H in the store for $12.95. Bad bulb socket. Clean the optics in the AF versions! >

Slide projector autofocus

These systems are considerably simpler than their counterparts for cameras due to the very constrained nature of the problem. In fact, as far as I know, few if any actually do any more than attempting to maintain the lens at a constant distance from the surface of the film in the slide.

One way is to reflect a spot of light off the slide and adjust the lens so a photodetector coupled to the lens motion has that spot centered. It is really open-loop with respect to the actual focus of the lens - just maintains the position of the lens relative to the surface of the slide constant. In other words, it will maintain the wrong focus just as accurately if you don't set it properly to begin with!

On the projectors I have seen, slides covered with glass may not work properly since there is a strong reflection from the glass itself. They assume all your slides will be of the same construction. The idea is that the film itself may bow out or in and that is what it cares about. The older ones, at least, were far from perfect.

Where an autofocus slide projector doesn't autofocus, due to their simplicity, it should be possible to identify the faulty component. However, getting a replacement part for a 20 year old projector may be another matter. With non-use (how often do people use their slide projectors anymore?), gummed up lubrication in the motor that moves the lens or its drive train may be the most likely problem! However, there can always be bad connections and bad capacitors, photodetector, or something else. Of course, if an incandescent lamp is used to project the spot, it may just be burnt out!

If you were to implement an autofocus system today, there would be many options including maximizing edge or even film grain sharpness with a little scanner inside the projector! The displaced spot type systems were very simple and cheap using only a few components and no fancy processors.

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Motors and Relays

Small motors in consumer electronic equipment

A variety of motor types are found in audio and other electronic equipment. For the additional information on the specific types of motors used in VCRs and CD players, see the documents: "Notes on the Troubleshooting and Repair of Video Cassette Recorders" and "Notes on the Troubleshooting and Repair of Compact Disc Players and CDROM Drives".

Types of motors:

1. Small brush-type permanent magnet (PM) DC motors similar to those found in battery operated appliances. Such motors are used in cassette decks and boomboxes, answering machines, motorized toys, CD players and CDROM drives, and VCRs. Where speed is critical, these may include an internal mechanical governor or electronic regulator. In some cases there will be an auxiliary tachometer winding for speed control feedback.

   These are usually quite reliable but can develop shorted or open windings, a dirty commutator, gummed up lubrication, or dry or worn bearings. Replacement is best but mechanical repair (lubrication, cleaning) is sometimes possible.

   Also see the section: General tape speed problems - slow, fast, or dead.

   Additional info on these types of motors can be found in "Notes on the Troubleshooting and Repair of Compact Disc Players and CDROM Drives".

2. A low profile or 'pancake' brushless DC motor may provide power for a in some Walkman type tape players, direct drive capstans and general power in VCRs or tape decks. Since these are electronically controlled, any non-mechanical failures are difficult to diagnose. In some cases, electronic component malfunction can be identified and remedied.

3. AC induction motors - shaded pole or synchronous type used in inexpensive turntables. These motors are extremely reliable and are easy to disassemble, clean, and lubricate. Just do not lose any of the spacer washers on each end of the shaft and make notes to assure proper reassembly.

4. Miniature synchronous motors used in mechanical clock drives as found in older clock radios or electric clocks powered from the AC line, appliance controllers, and refrigerator defrost timers. These assemblies include a gear train either sealed inside the motor or external to it. If the motor does not start up, it is probably due to dried gummed up lubrication. Getting inside can be a joy but it is usually possible to pop the cover and get at the rotor shaft (which is usually where the lubrication is needed). However, the tiny pinion gear may need to be removed to get at both ends of the rotor shaft and bearings.

Motor noise in audio equipment

Of course you expect your audio equipment to be absolutely silent unless told to perform. Motor noise should not be objectionable. However, what if it is? There are several kinds of noise: rotating noise, vibration, and electrical interference:

If the noise is related to the rotating motor shaft, try lubricating the motor (or other suspect) bearings - a single drop of electric motor oil, sewing machine oil, or other light oil (NOT WD40 - it is not a suitable lubricant), to the bearings (at each end for the motor). This may help at least as a temporary fix. In some cases, using a slightly heavier oil will help with a worn bearing. See the section: Lubrication of electronic equipment.

For AC motors and transformers, steel laminations or the motor's mounting may be loose resulting in a buzz or hum. Tightening a screw or two may quiet it down. Painting the laminations with varnish suitable for electrical equipment may be needed in extreme cases. Sometimes, the noise may actually be a result of a nearby metal shield or other chassis hardware that is being vibrated by the motor's magnetic field. A strategically placed shim or piece of masking tape may work wonders.

If the noise - a buzz or whine - is actually coming from the audio output but only occurs with the motor running, the interference filter on the motor power supply may have failed. This is often just a capacitor across the motor terminals and it may be defective or there may be a bad connection.

Finding a replacement motor

In many cases, motors are fairly standardized and you may be able to find a generic replacement much more cheaply than the original manufacturer's part. However, the replacement must match the following:

1. Mechanical - you must be able to mount it. In most cases, this really does mean an exact drop-in. Sometimes, a slightly longer shaft or mounting hole out of place can be tolerated. The pulley or other drive bushing, if any, must be able to be mounted on the new motor's shaft. If this is a press fit on the old motor, take extreme care so as not to damage this part when removing it (even if this means destroying the old motor in the process - it is garbage anyway).

2. Electrical - the voltage and current ratings must be similar.

3. Rotation direction - with conventional DC motors, this may be reversible by changing polarity of the voltage source. With AC motors, turning the stator around with respect to the rotor will reverse rotation direction. However, some motors have a fixed direction of rotation which cannot be altered.

4. Speed - for tape players and turntables - this may not be feedback controlled. With a little care you should be able to determine the normal rpms of the motor. For example, with a cassette deck, knowing the tape speed (1-7/8" inches per second is standard), it is straightforward calculate the motor shaft speed based on simple measurements of pulley and capstan diameter ratios.

MCM Electronics, Dalbani, and Premium Parts stock a variety of generic replacement motors for tape decks, Walkmen, boomboxes, and CD players.

Relay basics

The ubiquitous electromechanical relay is a device that is used in a large variety of applications to switch power as well as signals in electrical and electronic equipment. Operation is quite simple: An electromagnet powered by an AC or DC coil pulls on an armature having a set of moving contacts which make or break a connection with a set of stationary contacts.

Most common relays can be characterized by three sets of parameters:

1. Coil - voltage; resistance, current, or power consumption; and whether it is AC or DC. For AC coils only, the VA (volt-amps) rating may be used instead of or in addition to power consumption due to the inductive coil. Typical coil voltages range from 5 V to 480 V (AC or DC) - and beyond. Current and power consumption depend on the size of the relay.

2. Contact configuration - number of sets of contacts and whether they are their type. The designation will be something like SPST-NO, DPDT, 4PST-NC, 6PDT, etc. The first two letters refers to the number of sets of simultaneously activated contacts (S=1, D=2, numbers are usually used for more than 2 sets of contacts). The second two letters refers to the contact configuration (ST=NO or NC but no common terminal, DT will have a common - there will be both an NO and NC terminal). Where contacts are ST, the last two letters indicate NO or NC. An almost unlimited number of variations are possible. Typical relays have anywhere from 1 to 6 or more separate sets of ST or DT contacts or a mixture of the two.

3. Contact ratings - this may be specified for a number of types of applications. For example: in amperes at a particular voltage for DC resistive loads, or in horsepower at various voltages for AC inductive loads. Like fuse ratings, these are maximum ratings and lower values are almost always acceptable. Small relays may be able to switch only a few hundred mA at 32 V while large industrial contactors can switch 1000s of A at 1000s of V. Even the contactor in your automobile's starter must control hundreds of amps to the starter motor.

The common (C) contacts connect to the normally closed (NC) contacts when the coil is unpowered and to the normally open (NO) contacts when the coil is powered.

Miniature and subminiature relays are used to switch phone line signals in modems, fax machines, and telephone answering machines; audio amplifier speaker protection circuits; multiscan monitor deflection components; and many other places.

Small relays control power in lighting equipment, TVs and other home appliances, automotive systems and accessories, and the like.

Large relays (often called contactors) are used for the control of central air conditioning systems (compressor and blower motors), all types and sizes of industrial machinery - as well as in the starter of your automobile.

Relay identification

A relay without a pin connection diagram can usually be identified with a multimeter and variable power supply - or by eye. Many have the critical information printed on the cover. However, for detailed specifications, referring to the manufacturer's databook (or WEB page) really is best!

(The following assumes a subminiature (DIP) relay. Lower coil resistances, higher coil voltages, and other variations may exist for larger relays.)

1. If the case of the relay is transparent or you can pop the top, examine the pole piece of the electromagnet. If there is a (copper) ring around half the pole piece, the relay coil is designed for AC (usually line frequency - 50 or 60 Hz) operation. An AC relay operated on DC will overheat very quickly but can be tested on DC.

2. Determine the coil pins. Use your eyeball if possible or your multimeter on the low resistance scale. For a small relay, the coil will most likely be a few hundred ohms. All other combinations of pins will be zero or infinity. If the resistance is under, say, 100 ohms, you may have an AC coil rather than a DC coil.

3. Power the relay from a variable DC supply (I am assuming it has a DC coil which is likely for a DIP relay. You can still do this with an AC coil but it will heat up quickly). Start at zero and increase the voltage until you hear the contacts close. This will probably be at around 3 volts (for a 5 V coil) or 8 volts for a 12 V coil - this will be roughly 60% of nominal coil voltage. If you do not hear anything, reverse the polarity of the coil and try again - you may have a latching relay. Alternatively, put your multimeter on the resistance scale across one of the pairs of pins that measured zero ohms as it is likely to be a NC set of contacts. This will change to infinity ohms when the relay switches.

4. Now that you can switch the relay on and off, you can use your multimeter on the resistance scale to determine which contacts are normally open (NO) and which contacts are normally closed (NC). (Normally here means unpowered.)

5. The power rating of the contacts can be estimated by their diameter (if they are visible). Rough current estimates (resistive loads): 20 A - 5 mm, 10 A - 3 mm, 5 A - 2 mm, 1 A - 1 mm. These must be derated substantially for inductive loads.

For latching relays, the polarity of the coil voltage determines whether the relay is switched on or off. In other words, to switch to the opposite state requires the polarity of the voltage to the coil to be reversed. Other types are possible but not very common.

Relay testing and repair

If the relay is totally inoperative, test for voltage to the coil. If the voltage is correct, the relay may have an open coil. If the voltage is low or zero, the coil may be shorted or the driving circuit may be defective. If the relay makes a normal switching sound but does not correctly control its output connections, the contacts may be corroded, dirty, worn, welded closed, binding, or there may be other mechanical problems.

Remove the relay from the circuit (if possible) and measure the coil resistance. Compare your reading with the marked or specified value and/or compare with a known working relay of the same type. An open coil is obviously defective but sometimes the break is right at the terminal connections and can be repaired easily. If you can gain access by removing the cover, a visual examination will confirm this. If the resistance is too low, some of the windings are probably shorted. This will result in overheating as well as no or erratic operation. Replacement will be required.

Relay contacts start out bright and shiny. As they are used, arcing, dirt, and wear take their toll. A sealed relay used at well below its rated current with a resistive load may work reliably for millions of cycles. However, this will be significantly reduced when switching high currents - especially with inductive loads which results in contact arcing. One speck of dirt can prevent a contact from closing so cleanliness is important. Excessive arcing can result in the contacts getting welded together as well.

The resistance of closed contacts on a relay that is in good condition should be very low - probably below the measurable limits on a typical multimeter - a few milliohms. If you measure significant or erratic resistance for the closed contacts as the relay is switched or if very gentle tapping results in erratic resistance changes, the contacts are probably dirty, corroded, or worn. If you can get at the contacts, the use of contact cleaner first and a piece of paper pulled back and forth through the closed contacts may help. Superfine sandpaper may be used as a last resort but this is only a short term fix. The relay will most likely need to be replaced if the contacts are switching any substantial power.

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Electromechanical Systems

This chapter deals with some of the specific issues relating to the types of electromechanical systems found in items ranging from high-tech toys like the Furby(tm) - the craze a year or so ago, (see Furby Autopsy for a most interesting look into how much can be done with a little bit of technology) to more traditional low cost robots. While similar in principle, the details of high quality industrial robots are quite different are beyond the scope of this document.

Electromechanical systems require a broad range of skills to troubleshoot because of the interaction of the software, electronics, and mechanics. While some problems like damaged mechanical parts after a mobile robot went down a flight of stairs will be obvious, others like the lack of response of a sensor could be due to many causes and a systematic approach must be taken to rule out each potential cause.

An electromechanical system consists of: motors and actuators, sensors, mechanical components (linkages, gears, belts and pulleys, etc), controller (microprocessor, program, and data memory, and its interfaces), power drivers, and power supplies - and software or firmware.

Motors and actuators

Two types of motors are commonly used in small robots: DC permanent magnet (PM) motors and stepper motors:

- Small PM motors are similar to high quality servo motors in how they work but are built as cheaply as possible. Direction of rotation and torque/speed are determined by the polarity and magnitude of the average voltage applied to them. Rotation is continuous (unlike stepper motors, see below). Speed can be quite high - 10s of thousands of rpm (revolutions per minute). Position feedback is needed where a system needs to move to a particular spot.

  They are found in all sorts of consumer electronic equipment, toys, and hand power tools. They are fairly reliable if run well within their ratings.

Problems with PM motors include:

  - Dirt or 'gunk' collecting on the commutator causing erratic operation or partially shorting the motor. Test with a multimeter.
  - Wear of the brushes if they are made of metal. This will result in erratic operation or a totally open motor.

  For typical toys and small robots, motor failures are probably less common than for motors used in applications like VCRs which may run for hours continuously.

- Stepper motors rotate in discrete steps as determined by the application of a multiphase waveform to their sets of field coils. They will hold their position with power removed (though with less torque then when power is on). Since movement is in discrete increments, except for an initial 'home' position reference, no feedback is required since movement to any position can be programmed by a known number of steps (assuming the rest of the mechanism has no slip). Common electronic equipment like printers and diskette drives used stepper motors as well.

  Problems with stepper motors include:

  - Open or shorted windings - check with a multimeter. However, a few shorted turns may not show up but result in overheating or speed problems.
  - Dry or worn bearing - shaft should rotate without binding though magnetic detents will be felt.
  - Demagnetized rotor - this may happen if the motor is disassembled or if it is driven with a much higher input than expected. Compare with a known good sample of the same motor. Weak or no evidence of detents compared to an identical good unit is one sign of this.

  CAUTION: Disassembling a stepper motor may result in demagnetization of the rotor when it is removed from the stator assembly. This is for all intents and purposes, irreversible at home. Low cost PM motors are generally not prone to this but some high quality servo motors may be rendered useless from disassembly.

- Solenoids are used where only 2 positions of some mechanism are needed as with a robot gripper. While motors require lubrication, many solenoids do not.

  Problems with solenoids include:

  - pen or shorted coil.
  - Dirt, damage, or gummed up grease from improper lubrication causing binding.

Sensors

Anything that detects some physical condition can be classified as a sensor. These include:

- Proximity and distance. These may be based on physical, optical, or sonic effects. A simple probe activating a microswitch will detect contact with a wall or obstruction. Optical proximity sensors send a beam out (typically from an IR LED) and detect any return reflections with a photodiode or phototransistor. Optical triangulation (which is used in many camcorders) and the Polaroid sonar module (used on their cameras for focusing) and sold separately can measure distance to 10s of feet with moderate accuracy.

  Problems can range from a crunched microswitch, dirt on an optical lens, electronic, interface, and buggy software.

- Angle. The most common type are probably variable resistors (pots or rheostats) for inexpensive devices like toys. Optical encoders or electromagnetic types are often used on higher quality equipment. Most computer mice (ironically, not the ones called optical mice!) use optical encoders.

  Problems include defective LEDs or photodiodes in the encoder (optical types) or bad coils or drivers (electromagnetic type).

- Speed. For the rotation of a motor or wheel, optical encoders are common with the actual speed calculated by software. A very simple 1 pulse per revolution may be sufficient for some purposes but more commonly, the A and B (quadrature) outputs of an optical encoder are interpreted to provide both angular position and speed.

- 1, 2, and 3-D imagers. These typically use CCD or CMOS camera with software to analyze the resulting data. A single line CCD array is sufficient for 1-D detecting contours or slowly scanning a scene to acquire a 2-D image. A pair of cameras can be used to acquire a 3-D information in the form of a stereo pair. Or, a laser line scanner in conjunction with a single camera to acquire 3-D information directly.

  Problems with any of these devices can range from a bad sensor (e.g., dead pixels, complete lines or, worse), control electronics, interface, or software problems.

Detailed testing is beyond the scope of this article but the basic procedure should be to attempt to localize the fault to the sensor, interface, or elsewhere by substitution if possible since that is easiest, or measurements of the sensor inputs and outputs. For example, for an optical encoder, check that power input is correct and then look at the A and B outputs to determine if they are good solid logic levels (where appropriate) as the shaft or wheel is rotated slowly by hand. Note that in many cases, problems with erratic counts from an optical or mechanical sensor producing A/B quadrature outputs is due to incorrect software or logic - there are many ways to get it correct enough to work under continuous rotation in one direction or the other but it takes more effort (a state machine approach) to work under conditions where the shaft is jiggling back and forth.

Testing of camera type devices can be much more complex requiring details documentation on the sensor and its electronics, a scope or logic analyzer, and a certain amount of luck!

Controllers

The intelligence in these systems is generally provided by a some form of programmable device. The simplest may use PICs - Programmable Interface Controllers - single chip micros with built in memory and interfaces.

More capable systems may use a higher performance microprocessor or multiple processors in a distributed architecture. There is no way to cover these in this article except to emphasize the importance of recognizing that the software/firmware bugs can manifest themselves in very peculiar ways. Also, note that motors and other electromechanical actuators result in an electrically noisy environment which is shared by the controller. Unless this is taken into consideration in the design of the system, problems like random lockups or reboots or just plain unreliable operation are almost assured. More below.

Power supplies

Almost all of the toys and small robot type devices are (or can be) powered by some form of batteries, possibly with DC-DC converters to generate multiple voltages from a single battery pack. Weak, dead, or improperly selected batteries must be near the top of the list of common problems with these and other portable systems.

Mechanics

Robots almost by definition include movement. Bearings and sliding parts can become worn, gummed up, or damaged. Rule number one has to be: Never force anything. If rotation of a shaft doesn't result in the expected movement, determine why. Perhaps you're turning it in the wrong direction and it's already at one end of its travel. Or, maybe something has jammed between gears.

Realize, however, that with many inexpensive devices like toys, everything is constructed as cheaply as possible - repair may simply not be possible if some key component has broken.

Fortunately, if properly lubricated when constructed and operated in clean environments, additional attention may never be needed. However, water, dust, dirt, and sand can require the need for frequent cleaning and lubrication. Rule number two is: "NEVER use WD40 as a lubricant!

- Sealed ball bearings should be replaced if they become excessively noisy or rough when rotated by hand. Disassembly, cleaning, and repacking may be possible but irreversible damage to the bearing surfaces (races) may already have occurred.

- Sleeve bearings (bushings) in motors may be lubricated for life or may need a periodic application of a couple of drops of light machine or electric motor oil. If dry or dirty, complete disassembly, cleaning, lubrication, and reassembly is advised if possible. Where excessively worn, replacement is the only option.

- Slow speed rotating and sliding parts should be lubricated with a light grease. If dry or tight, disassemble to permit the old gummed up grease and dirt.

Obviously, inspect for damage such as bent shafts or linkages, missing screws or cotter pins, etc.

Troubleshooting approach

Where a commercial product suddenly refuses to cooperate, mechanical or electrical problems are most likely. However, if you are attempting to troubleshoot a system you have built - and it uses a programmable processor - software/firmware problems must be near the top of the possibilities list, especially if it had worked before. Ask yourself: "What changed?" Has the broken function been tested since the last software change or download?

Some items to check when dealing with robotic systems:

- Test the power supply voltages. The most common problem is likely to be dead or weak batteries! Make sure the voltages hold up under load. Many types of motors draw a high current when starting and it decreases as the speed picks up. Thus, just checking the voltages while at idle isn't a sufficient test. In addition to unreliable movement, a dip in a critical power supply voltage may cause the system to reboot!

- Determine if the controller is booting properly. If you are designing a system, adding some diagnostic LEDs or a diagnostic terminal port will help emmensely. An in circuit software debugging facility is even better.

- Where only certain operations aren't working, attempt to determine what they have in common such as shared power supply voltages, an interface bus, or a block of program code. Power the relevant motors or actuators from an external source (AFTER DISCONNECTING THEM!) and see if the expect motion takes place. And/or activate them manually to assure there is no binding of parts or other mechanical problems.

- If you have spare parts or if parts like similar motors can be swapped, doing so can quickly confirm or rule out possible causes.

- With moving parts, bad connections due to flexing of cables or loosening of solder joints are quite likely. Problems may only appear when something is in a particular range of positions, or be more erratic.

- Erratic problems can also be caused by electrical interference between electromechanical actuators and sensitive logic or analog circuitry. For a commercial system, shields on cables may have become disconnected, cable routing may have changed, and power supplies may be marginal. When building your own robot, use separate power supplies for analog circuitry, digital circuitry, and actuators. Provide adequate bypassing (e.g., 0.1 uF ceramic caps on every chip as well as 22 uF electrolytic caps scattered around each circuit board. Add series L-C filters on next to the actuators. Use twisted pair or shielded cable for low level sensor and similar signals. And, not all commercial products: are designed properly!

- Don't jump to conclusions. With the combination of electronics, mechanics, and software, a trivial fault in one subsystem can result in a change in behavior in unexpected places.

Robotic and other electromechanical systems make great projects. In addition to the appear of seeing something other than electrons move and interact with its environment, the interdisciplinary nature of these devices result in an fun and rewarding educational experience, whether designing a robot from scratch, or repairing a high tech toy like a Furby(tm).

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Analog Panel Meters

Problems with Analog Panel Meters

While much new equipment uses digital readouts, there is still a lot of equipment out there with analog meters. And, for some applications, the continuously moving needle of an analog meter is superior to rapidly changing digits.

The actual mechanism of an analog panel meter is most often the "D'Arsonval moving coil meter movement". Meter Movement from Classic Simpson 260 VOM shows the assembly from a very popular series of analog volt-ohm-milliammeters (VOMs) with models dating from the 1950s and still being manufactured today. A closeup with parts labeled can be found in D'Arsonval Meter Movement Anatomy. A coil of fine wire wound on an aluminum or plastic frame is mounted on precision bearings within a strong magnetic field. The needle or pointer is attached to frame along with small balance weights at each 90 degree position. Some type of restoring force keeps the needle at the zero point when no current is applied. There are two common types of bearings: jeweled bearings with hair-springs (fine spiral wire springs similar to those in mechanical clocks and watches if you remember those) and taut-band suspension (the latter becoming more common in high quality movements). In general, if no hair-springs (or their remains) are visible, the unit uses a taut-band suspension.

With a DC current, a torque is produced which rotates the coil, frame, and needle to indicate the measured value. With a uniform magnetic field, the response is close to linear over 90 degrees. DC current is measured directly by passing it through the coil. Low resistance shunts may be used to increase the current range. DC Voltage is measured by putting a current limiting resistance in series with the meter. AC measurements are made by first rectifying the input. Where very low values are to be measured, a precision op-amp rectifier may be used.

More information can be found at: Integrated Publishing's Pemanent Magnet Moving Coil Movement Page.

Typical problems with these devices include:

- Burnt out coil from excessive overload.

  This usually is a terminal condition since disassembling and rewinding the coil is not really a home project. However, for some types, it's not totally impossible if there is no alternative.

- Bent pointer due to modest overload. Up to several times the full scale current, the wire of the coil may not be damaged but the point will whack into the end stop with such force that it may get bent - possibly quite significantly.

  It's usually possible to carefully bend it back in shape. Should the needle break off, a dab of Superglue(tm) may work for reattachment but the movement will need to be rebalanced. Or, replacement with a broom straw or other very thin, light, pointer. Avoid placing any stress on the frame/coil or bearings.

- Movement unbalanced. There are usually little wire coils used as weights at three 90 degree locations around the frame. These are designed to be rotated on their mounting pins to permit the movement to be balanced for all orientations. The "weights" may be gently pushed or pulled to change their position relative to the center of rotation.

Step 1: Set the zero with the meter sitting so the shaft of the movement if precisely vertical (so the weights have no effect). Then orient the meter so the pointer is horizontal with the two side-weights vertical (so they will have no effect) and adjust the bottom weight for zero. Go back and forth to fine tune.

Step 2: Adjust the side weights so changing orientation from horizontal to vertical doesn't change the position of the pointer. If the imbalance was caused by the reattachment or replacement of the needle, it should be sufficient to adjust the two side weights by the same amount as the bottom weight.

There is a more detailed description below.

- Sticky pointer - mechanical. The needle gets stuck at very specific locations as though it's hitting something. This is very often due to dust, dirt, flaking paint or rust, ferrous particles, or other debris that have found their way between the coil/frame and magnet yoke. However, first check that is isn't simply due to a static charge that has been built up on the glass or plastic faceplate from rubbing when cleaning or whatever. (See the next item.)

  It's usually possible to use a fine NON-MAGNETIC "probe" like a piece of nylon fishing line to sweep the area between the coil, magnet, and central core, of 'stuff'. If it's coated to be slightly sticky, total removal of the debris may be possible. But just moving it out of the path of the coil/frame - particularly the ferrous particles since they will stay put - may be enough. Take special care not to bend the hair spring (if used) or put any stress on the frame/coil assembly and bearings. In severe cases, it may be necessary to remove the magnet entirely and clean it separately. However, the most likely outcome of this would be damage to the pointer or hairsprings so it should be avoided if possible.

- Sticky pointer - static buildup. The pointer may get stuck or have trouble moving to certain locations and this may change over time. A static charge has built up on the faceplate either from rubbing or for other unknown reasons like a nuclear bomb going off in the vicinity. :) In most cases, careful cleaning of just the outside with liquid detergent, antistatic spray, or a clothes dryer anti-cling sheet should cure it. Even gently blowing on the faceplate with your breath to fog it may be enough to dissipate the charge. However, in severe cases, the faceplate will have to be removed and treated on the inside in a similar manner.

- Broken bearing pivot or hair spring (jeweled bearing). The tip of the shaft is ground to a very fine point and a severe physical shock cam break off the tip. The meter may still work but will be somewhat sticky.

  Carefully adjusting the bearings to be slightly closer together may help but there is no total solution.

- Bent hair spring. It's unlikely this would happen on its own but might occur during repair.

  These can usually be bent back into reasonable position.

- Broken hair spring. Again, not something likely to happen on its own.

  Careful resoldering may work but it's not easy. Note: Since the current passes through the spring, non-conductive adhesives can't be used.

- Broken taut band between frame/coil and suspension.

  No practical repair is possible.

- Broken taut band suspension.

  It may be possible to reconstruct or replace the piece to which the band is soldered assuming the band itself hasn't broken. More details below.

- Damaged or deteriorated meter scale.

  Some artistic talent may be needed, but these can be restored to at least be legible. Alternatively, a new scale may be hand or computer printed on a sheet of thin paper or plastic and glued on top of the old one. Clearance may need to be adjusted if there isn't enough space between the pointer and original scale.

- Corroded mirror on mirror scale meter.

  The scale can be removed so the mirror itself can be replaced or moved so a good section is exposed. If replacement is needed, a piece of aluminum foil may be adequate for anyone who isn't a real purist.

- Non-functioning backlight.

  These are either tiny incandescent lamps or LEDs. They are usually accessible but some disassembly may be required. But first make sure the driving circuit/power supply is working.

- Broken or cracked faceplate.

  For meters with glass plates, it is usually possible to remove the old glass and replace it with window or picture frame glass. If the original mounting clips or tabs don't work, use some small dabs of Epoxy or other adhesive to hold it in place. Rectangular meters are definitely easier to deal with in this regard than round ones - all that is needed is a good glass cutter (about $2).

  For plastic meters, a replacement is probably best but if there is no choice, it may be possible to "graft" on a new piece of plastic depending on how much is damaged.

When all else fails, replacing the entire meter or just the movement may be the only option. Many types of analog meters are still available new from electronics distributors. Older style and/or discontinued models may be found at surplus places, particularly those catering to amateur radio. Where a suitable meter can be found but it's scale is not appropriate, a new one can be drawn or painted, or created via software. One such program can be found under "Software" at: Jim Tonne's (WB6BLD) Web Site.

It's not impossible to rebuild a meter - just extremely difficult and time consuming. Here's a link to the Web site of someone who must have had way too much time on their hands and completely restored a TV-7 tube tester, meter and all. It's in german but the Altavista Universal Translator can do a good enough job to read it in

English and it's the pictures that really matter anyhow: TV-7 Tube Tester Restoration.

Balancing a Meter Movement

(From: Dave M. (dgmason@att.net).)

Pretty simple thing to do if you have deft fingers and a steady hand. If you have nervous hands, then it's dangerous to the meter for you to attempt it. It helps if you have a balance weight tool that fits the weight springs. This tool looks like a wire-wrap tool and make life much simpler with meter weights. A good, nonmagnetic tweezer with a knurled inner surface is a good alternative. If you resort to using needle nosed pliers, you risk permanent damage to the pivot and jewels. Be extremely gentle with the tool you use. And STAY AWAY from the hairspring. If you kink it or otherwise bend it out of shape, accuracy of the movement will suffer terribly.

OK, the caveats are out of the way.

First thing to do is to open the movement to allow easy access to the weights on the pointer. The typical D'Arsonval movement looks something like this:

```
      |
      |
      |
      |
      |
      |
   ---+---   <-- Side weights
      |
      |    <--  Tail weight
```

Each arm of the pointer, except for the pointer itself, normally has a weight screwed onto it. It will look like a coil of wire wound around the pointer arm. To balance the pointer, you adjust these weights in and out so that the pointer remains in the same place regardless of the position of the meter.

Balancing is done in two planes. First with the pointer vertical and again with the pointer horizontal. With the meter flat on the bench, adjust the meter's zero screw until it is exactly on the scale's zero marking. Next, with the pointer horizontal, adjust the weight on the tail (opposite the pointer) until the pointer remains in exactly the same position as when the meter is flat. Turn the meter so that the pointer is vertical. Twist the weights on the side arms so that the pointer is at exactly the same position as when the meter is flat. Repeat until the pointer remains in the same position regardless of position.

(From: Jim Adney (jadney@vwtype3.org).)

There are balance weights which look like little bent coil springs slipped over "spokes" which radiate out from the pivot point. These springs just have to be slipped in or out to change the balance. If, for example, the needle was shortened, you need to take the spring/weight that is 180 deg from the needle and either push it closer to center, or pull it completely off and shorten it.

You check your work by holding the meter AXIS horizontal and then rotating it about that axis. Examine it when the needle is horizontal and again when it is vertical.

The side-to-side balance is correct when the meter reads the same with the needle pointing straight up or down. The other axis is balanced when the meter reads the same with the needle pointing to either the left or the right.

Once this works, the meter should also read the same as when facing up.

Work carefully, and avoid putting any strain on the actual pivot.

Repairing a Taut Band Suspension

I was forced to attempt this repair after damaging the suspension in a Hastings CVT-16 thermocouple vacuum gauge controller. OK, I really didn't have to do it as replacements for the entire unit could be found relatively inexpensively on eBay but I considered it a challenge. Also, if I bought a replacement for the entire unit, I'd then have yet another set of electronics without a meter! (The meters used in these instruments are special low impedance devices so stock replacements would not work.)

The broken meter looks like the meter portion of TC Vacuum Gauge and Pump Protector. The adjustment knob is used to move the red set-point pointer (which is mechanically and electrically independent of the meter movement itself).

The problem occurred when I obtained a unit (not the one in the photo) that had a broken adjustment knob. In attempting to confirm that the set-point adjustment worked, I foolishly tried using a tool to turn what remained of the shaft behind the knob. Unfortunately, I didn't notice that the suspension for the front taut band is located behind the knob and unprotected. So, it basically got shredded. Can you spell "stupid design"?. :(If the knob's shaft was solid instead of hollow, there would have been no problem.

I normally consider damage to meter movement bearings to be non-repairable but as I said, this was a challenge. :) The first step was to confirm that enough of the band remained to attach to a new suspension. After removing the front cover and set-point mechanism, the extent of the damage could be seen. The suspension was just a formed piece of metal - something springy and the band was still soldered to its twisted remains. A quick touch of a hot soldering iron and the band was free. While it was completely intact, there wasn't much of it - perhaps 1/16 inch sticking up though the "cup" where the suspension was located. And, the band is extremely thin - perhaps 1 mil x 5 mils (1 mil = 0.001 inch).

To replace the suspension, I cut a piece of thin copper sheet into a shape that when folded over would fit in the cup. Thus, there was a top and bottom. An off-center hole was drilled and tapped for an 0-80 screw that would adjust the separation of the two "leaves". A 0.01" hole was drilled in the center of the top for the band to fit through with a larger clearance hole in the bottom. This contraption was filed so it would fit loosely in the cup.

My original plan was to mount an XYZ micropositioner above the meter with a gripper to hold the band to enable adjustment before soldering it to the new suspension. I even fabricated a wonderful little screw clamp to use as a gripper. However, the band tip is so darn short and thin that this proved to be unworkable. So, the folded suspension almost flat was placed in the cup with the band tip poking through its hole. This affair was held down with a piece of wire fastened to a convenient screw (to prevent the surface tension of hot solder from lifting it), and the band was soldered to the suspension. Next, the 0-80 screw was installed and tightened until the meter frame/coil came free, and then some to provide clearance. The suspension was then adjusted in position to center the frame/coil and in angle to set the zero on the scale with the zero lever centered.

This replacement is not as robust as the original since it's not very resilient. Any good whack in the direction toward the back of the meter would probably cause it to fail due to the inertia of the frame/coil but it does seem to work. Also, since the length of the free part of the band and its tension have changed, it is likely that the calibration will be slightly different.

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General Equipment

IC and hybrid power audio amplifiers

Note: troubleshooting of large audio amplifiers constructed with discrete output stages is left to a separate document. See: BIG Audio Power Amps.

The audio amplifiers found in small radios, Walkmen, portable cassette recorders, and other low power devices are often single chips with few external components. Obtain a pin diagram, test inputs and output(s) with an audio signal tracer and/or oscilloscope. A dead output where inputs and power are present usually indicate a defective IC - as does one that becomes excessively hot - assuming that the output is not overloaded.

Larger audio amplifiers may use ICs (up to 10 or 20 W) or hybrid modules (up to 100 W per channel and beyond). Purists may argue about the quality of the sound from these compared to discrete component designs but they are being used in many designs - at most price points (except perhaps the stratosphere of audiophile land).

Hybrids modules (called 'blocks' or 'bricks' by some) may be totally self contained requiring just power and line level inputs or may be just the final stage in an overall system including external amplifier circuitry which is effectively a power op amp - high gain with negative feedback. Failure of these bricks is quite common.

Note that testing of these op amp designs - whether discrete or brick based - can be very confusing due to the high gain and feedback. Intermediate signals in a working channel may look like power supply ripple and noise. In a dead channel these same points may appear to be normal or highly distorted audio depending on which stage you test. In addition, since extensive negative feedback is used, power supply ripple and noise is much less important significant and there may be substantial amounts of both in a normally operating amplifier.

One of the bricks may be shorted resulting in a blown fuse or overheating of other components. It is usually safe to unsolder each of the hybrids to determine if the other channel or at least other portions of the unit come back to life and without blowing fuses.

With stereo amplifiers, it is normally safe - and most effective - to swap components between the working and dead channels as long as you are sure there is no short circuit on the output. This is by far the quickest way to confirm a dead brick. (I would be a lot more reluctant to make this recommendation for a large audio amplifier constructed with discrete transistors in the final power stage as multiple cascade failures are possibly and likely if **all** defective parts are not located before power is reapplied.)

Amplifier noise caused by bad hybrid bricks?

There can be all sorts of sources for low level noise or static including bad connections almost anywhere, defective semiconductors, and erratic power amp modules. These are usually hybrid circuits - multiple devices mounted on a common substrate and interconnected via a variety of technologies. Think of them as entire subsystems encased in plastic.

Thus, hybrid bricks may have problems with noise especially considering that they may run hot and be abused by poor tastes in music (or at least high volume levels). Thermal cycling can take its toll on this kind of device. If you have eliminated other likely causes, replacing the brick would be the next step if the module is not that expensive - how much do you value your time and hair? Of course, if there are separate bricks for each channel, one channel is most affected, and the volume control does not affect the level of the noise, the choice is clear - swap. This will be relatively low risk in most cases. A hot air gun used carefully on the final modules might also be a good way of inducing or changing symptoms resulting from marginal connections or components.

Troubleshooting blown audio amps

(From: Andy Cuffe (baltimora@psu.edu).)

If it has IC's for the audio output you can just remove one of them. If the fuse still blows try removing the other one. If the fuse blows with both output ICs out you know there are problems in an other part of the unit, probably the power supply.

If it uses transistors instead of ICs you just need to check them with an ohmmeter. The bad ones almost always measure close to 0 ohms between at least 2 of the three pins. Once you find the bad pair try the stereo with them removed. You should get normal sound from the channel with the good transistors. To determine if there is more damage to the amplifier you can swap the good transistors into the damaged channel. Before you remove anything WRITE DOWN where they go because it's easy to get them mixed up. I strongly recommend that you don't bypass the fuse unless you don't want to fix it very much. I have seen a lot of repairable electronics ruined by this type of troubleshooting.

(From: Dakuhajda (dakuhajda@aol.com).)

Where one channel still works, on old amplifiers we commonly remove output transistors from both channels, place a 5 watt 100 ohm resistor across the base to emitter connection of every output transistor. Then bring the power supply up on a variac and measure all the voltages on each channel. With a working channel it should be a simple matter of making DC measurements to find the area of the problem.

(From: Wild Bill (kwag98@tcis.net).)

A lot of the diagnosis can be accomplished with a DMM. Either the diode check test or the ohmmeter will give you a direction to proceed in. Most of these comments are related to units with through-hole (components with leads) circuit boards.. not to boards which have lots of surface mount components on the foil side.

If you don't possess the skills, equipment and safe working habits required to perform the procedures, take the faulty equipment to someone that does. If you read the rest, you'll discover (and maybe understand) why technicians charge fees for their work.

For almost any bipolar-transistor-output-type amplifier testing, it's a progressive process. A good starting place is checking key components for opens and shorts:

- Bias resistors for open (infinite ohms).

- Transistors for shorts with the diode test.

- Ohms checks for the power transformer, standby transformer windings, and relay coils.

- Diode check for rectifiers, full wave bridge rectifiers and transistors.

- Capacitor testing should also be part of the diagnosis stage, particularly the large caps, but almost any one of them could prevent the amp from working, even partly.

Make notes of defective components, you can offer some help to someone else some day.

Before proceeding to the stage of disassembly, check for circuit board mounting screws that are intended to ground the board to the metal chassis. When these get loose, this can cause a lot of weird symptoms.

It's often necessary to start unsoldering parts since a 0.33 ohm bias resistor with a shorted transistor across it may appear to be normal. In most cases where there is no output, or the protection circuits are preventing the amp from powering up, you'll find several faulty components. Since the unit isn't powering up (or it keeps blowing fuses), you can find faults quicker (in my opinion) by checking key components without power applied. This method is also more economical since parts won't be repeatedly destroyed until eventually all of the faulty ones are replaced at once.

Many manufacturers utilize fusible and/or flameproof small wattage resistors to prevent catastrophic damage, and all of them should be checked. They might be blue, green or tan colored.. and often have values of less than 1 ohm, but when you see this type, check all of them.

When damaged output transistors are discovered, check the driver stage for that output.. it's often damaged too. Some driver stages use linear ICs.. if the pinout is known, compare resistance or diode check tests between all of them.

After a thorough check of key components, and faulty devices have been replaced, remove the line fuse and replace it with a 60 watt lamp.. everyone has a well-insulated lamp with alligator clips on it, right? The lamp will usually prevent destruction of components.

Instead of attaching speakers to the outputs (main or front L & R), use dummy load resistors. high power non-inductive (or no connections at all). The unit should be powered with an isolated variac. 40 VAC will probably be a good place to start making initial voltage measurements. You could also have an ammeter in series with the lamp, but the lamp gives a good visual indication.. brief light output followed by a barely visible glowing filament. If the lamp shows continuous light output (at this low variac setting), there is a major short somewhere near the power transformer. In that case, disconnect everything and resume ohmmeter tests. Check for components which may have gotten warm or hot.

If a dim glow is visible, don't rush to put a fuse in and attach speakers to power it up at full line voltage yet.. but instead, start making AC (transformer outputs) and DC voltage checks (full wave bridge rectifiers, plus and minus and branch circuit supplies). Check the individual supplies DC filtering and check for the presence of AC at all of the amp's outputs with a scope.

If all appears to be normal at reduced line volts, turn the unit off and increase the variac output to 60, make previous checks.. same for 80, 100 then 120. If dummy loads haven't been attached to the output terminals yet, turn the variac back down and repeat the previous procedure.. and check for heat at the dummy loads. With the volume control set low, there should be little heat.

For amps with rear and center channels, check the main channel L and R first, then turn down the variac and attach dummy loads to the other channels as you repeat the previous steps.

This seems like a lot of backing up and rechecking, but it is an economical method of accomplishing a thorough amplifier repair. Before connecting a repaired amp to the original speaker system, check the speakers and wiring.

Audio amplifier that blows one channel's output components

The situation is that after finding and replacing output transistors and other blown parts, the same thing happens again almost immediately or sooner.

(From: Mike Ross (mike.ross@juxta.mnet.pubnix.ten).)

Before you blow up any more parts insert some temporary current limiting resistors (i.e. 330 ohms 10W is okay) in series with each individual output transistor collector lead. If the transistors saturate then there is either a bias idle current or still yet an offset voltage problem.

Blown diodes and resistors in the bias voltage reference circuit could easily cause the outputs to self destruct. One common design problem is seen with the adjustment trimmer pot, in that if the wiper opens then it results in maximum idle current. Of course they should always be designed so that if the wiper opens then the idle current goes to minimum. This could be one cause. Good luck.

If all else fails, hurl it across the room a few times! :)

(From: Dave (gravman@idirect.com).)

Where one channel blows outputs, check the zobel network components. This is a capacitor (usually green mylar with values of .047 to .1 uF) connected in series with a low ohm resistor (2.7 to 8.2 ohm) BETWEEN the speaker line and common ground. I have seen a few amps with the same symptom and the cause was that capacitor blown OPEN! Cranking up the treble full at very high volume levels can cause this to occur. Even a nearby CB or HAM transmitter with lots of watts can inject into your unshielded speaker leads and blow that cap!

When that cap goes open circuit, the amp will oscillate at a high frequency beyond hearing range. I've scoped as high as 80 KHZ!

If those two components are OK, and you have definitely confirmed that all others are OK, leave the output transistors out, install a 100 ohm 5W speaker load resistor and power up the amp with a DC voltmeter in place. You should measure much less than +/- .6 volts DC across that dummy load. If the voltage is more, you've got a improperly installed transistor, bad bias pot, defective front end differential pair transistor(s), leaky/damaged bias diodes, etc. Check, double check, and re-check your components.

If the voltage is within proper range, connect a scope across the dummy load resistor, slowly increase input music or sine-wave. If you see a extremely blurred signal, shut down the amp and search for possible defective small pF value compensation capacitors in other parts of the circuit. You may have to pull each one and check/replace until you find the culprit. You may simply have a leaky/flakey transistor in there somewhere. You may also have a corroded/loose ground connection or bad solder joints too!

Do these tests, and see what you find. ALWAYS CHECK YOUR OWN WORK THREE TIMES BEFORE CURSING!!!

Audio amplifier that seems to have reduced power

(From: Jerry Greenberg (jerryg50@hotmail.com).)

The first step is to verify the voltages in the power supply for both the preamp and output stages.

I would also start by changing the main filter caps in the power supply to start. This is the only true way to test these...

The best way to test for such a problem is to feed an audio generator into the amp and put an 8 ohm dummy load for the speakers. Use a scope and go through it to see what is happening. Set the audio generator to a 40 or 50 Hz tone.

The test for the output stage is to turn up the volume with the scope across the dummy load to start. See and measure the amplitude of the waveform to determine the voltage P-P output. You should see where it is starting to distort the waveform, and back off about 5 to 10%. From that calculate the RMS, and then calculate the actual Power. If it is more than than the rated output of the amp you are overdriving it anyways...

Don't leave high volume tone into the dummy load for more than a few minutes at at time. This is hard on the unit for long periods of time...

Note* I have found many consumer amplifiers can only put out their rated power at 1kHz. Only the high quality ones can do it at all frequencies... At about 50 to 80 Hz most consumer amps will only put out about 50 to 70% of their rated power...

Comments on recurring audio amplifier failures

(From: Mark Kinsler (kinsler@adenine.frognet.net).)

The classic failure of output transistors in audio equipment is the collector-emitter short, which is typically caused by overcurrent, which is typically caused by someone short-circuiting the speaker wires together in an attempt to add or move the speakers, which is typically caused by someone being at a party and drunk.

(From: Tom MacIntyre)

Whenever someone brings an amp in for what looks like blown outputs, we try to talk them into bringing the speaker cables in, so the ends can be tinned properly. No extra charge, and maybe save them a few bucks from a few strands doing the short-circuit thing.

The only way to prevent a recurrence of the problem is to install fast-blow fuses in series with the speaker lines deep inside the receiver where the owner cannot find them.

They'll find them if they want to, but your point is well-taken.

(From: Phillip R. Cline (pcline@iquest.net).)

I used to work on high end audio stuff and when properly designed an amp can take a direct short at full power or any other level the volume may be set. Having said this I must qualify my statement. I did say I worked on high end stuff. This would not include the systems that appear to be a rack or component system but is in fact one big front panel molded to look like a group of individual components stacked on each other. This also doesn't include the vast majority of Japanese mid-fi stuff made and sold since about 1980 to the present. Most of that stuff use DC coupled amps and no speaker protection circuits or they use the infamous STK or SVI series of hybrid amp modules. These tend to be very unreliable and the output stages fail in these on a regular basis. Another problem is that often times there is now where near enough heat sink on the output devices and they overheat and fail. On one JVC amp that would be considered high end the engineers in their infinite wisdom decided to power one half of the bipolar supply going to the preamp op-amps through a panel lamp on the front panel. Guess what happens when the lamp opens up? Catastrophic failure of nearly all the semiconductors occurred when the lamp burnt out. This caused the speaker protection circuit to be effectively disabled and all the main power supply current fried everything including the woofers in the speakers due to a severe offset voltage present due to the lamp failure removing one side of the bipolar supply of the preamp section. Nice work on the engineers part.

When we got an amp with suspicious failure mode we always wanted to see the speakers to make sure that the owner didn't crank the amp up until it was clipping which would in some cases fry the crossover caps as well as the tweeters and mids and in more severe cases the woofers also thus rendering the speaker a very low value resistor which would in turn fry the amp. To prevent this we would sometimes have to increase the crossover caps voltage rating and we might even through a fuse in the speaker cabinet somewhere. That way when the fuse blew the customer had no choice but to tell the reason for the failure after being confronted with the evidence.

This kind of stuff is the primary reason for me leaving the repair business after the fact that most consumer audio and video stuff except TVs are made disposable.

Substituting Darlington transistors in audio amplifiers

(From Daan van der Veer (D.J.C.vanderVeer@stm.tudelft.nl).)

I have good experiences with the use of Darlingtons instead of normal output transistors in audio power amplifiers. The only problem is that you have to readjust the bias current of the bases of the drivers. Furthermore, reduced or increased frequency response is almost always corrected by the amplifier's feedback.

Readjusting the bias current is very simple with a scope and a sine wave generator, but could also be done with a simple voltmeter. And a computer is a very handy tool in diagnosing amps, if you have a soundcard, you can (mis)use it to measure a frequency response of any everyday amp (frequency response of most soundblaster compatible soundcards is 44 kHz). And with a very precisely tuned high quality notch filter you can even measure the THD of any amp, *real-time*. (This is very handy if you want to adjust output transistor bias current, to a minimum of crossover distortion).

Comments on power supply regulation in audio amps

(From: DangerDave (dangerdav@earthlink.net).)

I can't speak for all audio designers, but here are a few things I consider:

1. Differential output stages cancel in-phase sag/ripple

2. Regulation can add noise

3. Regulation adds complexity/reliability problems

4. Regulation adds cost

5. Other things are often more important than regulation to a predetermined voltage - e.g.; sag, ripple, stiffness, Zout. Letting the power supply DC output go as the mains voltage is usually good to within 5% or so, thus absolute regulation to a set-point voltage doesn't buy you much power headroom, and does create the possibility series regulators will overheat if the mains voltage rises. If the output stage is high power, the PS must supply high current, thus the overheating concerns under conditions of high mains voltage.

6. A little more complex argument - distortion products are determined by the order of the transfer functions of the subcircuits. The lower the order of transfer function, the lower the order of distortion artifacts. Under NFB conditions, the situation is more complex, as phase, gain, and bandwidth constraints interact with the PS's transfer function, to create multiplicative artifacts, leading to IM, TIM, and other spectral artifacts. You can easily create "loop within a loop" problems using servo'd voltage regulation. This topic really deserves more discussion. IIRC, Norman Crowhurst originally worked out multiplicative distortion mechanisms graphically in the 1950s and published them in Audio. Since that time TIM and other spectral distortion mechanisms have been further analyzed in AES and IEEE.

   Basically, a simple, low order PS transfer function may create fewer and lower order multiplicative artifacts (less objectionable distortion). The main thing is to keep the PS high in equivalent capacitance and low in Zout - e.g., an "ideal" voltage source. You don't need set-point regulation to accomplish this, and elimination of closed loop feedback voltage regulation usually makes the PS's transfer function lower order.

The simplest way to do this is giant caps in the PS. This is a popular approach among high end audio companies at this time. Some advertise "X uF of Capacitance" or "X Joules of Energy" A better approach is to use the new generation FET's, IGBT's, and other extremely low series resistance pass elements. Referenced to a stable voltage, the equivalent series output resistance of PS's so designed can be < 1 ohm, 20-20kHz, and no need to fill the box with giant (and expensive) caps. Reduces in-rush problems as well, so you don't add complexity/reliability problems with controlled ramp-up circuits, timed power-up schemes, and the host of ancillary circuitry required to keep breakers from triping. :) Equivalent transfer function and parts complexity can both be low, relative to servo'd NFB voltage regulation schemes.

Big topic. Interesting question. Hope I gave you a few insights.

Noisy or intermittent switches and controls

Symptoms include audible noise when rotating knobs, erratic operation of mode selectors, random changes in volume, switches, or controls that need to be jiggled or tapped to make them cooperate.

The causes are likely to be either dirt or wear.

First, try a spray control/contact cleaner - even the stuff from Radio Shack may make a remarkable difference iff (1) dirt is the problem and (2) you can get the cleaner inside the troublesome part.

DO NOT use WD40 or a similar product because aside from the flammability issues their use may result in rapid failure even if you get the immediate gratification often provided by these sprays. See the section: Why NOT to use WD40 on noisy controls.

Some types of contact and control cleaners can be used safely with low voltage circuits while they are powered but not always - read the label directions. Select a product that specifically states that is it safe for switches and controls.

Use the extension tube that comes with the spray can and snake it into or near any visible access holes. Operate the control or switch to help the cleaning action. Don't overdoe it - if you get to the right spot, a little is all that is needed.

Resist the urge to use sandpaper or steelwool (ack!) on switch or connector contacts. However, pulling a piece paper through a set of contacts or the occasional gentle use of a soft pencil eraser (e.g., Pink Pearl) may be helpful.

If this does not help - or only helps short term - the part may be worn. Sometimes, repair is possible (a slide switch with contacts that have loosened with use, for example) but replacement is better - if you can find an exact or suitably close match. See the section: Interchangeability of components.

Note that capacitor type frequency select controls may also be subject to noise as they are rotated. This may also be due to dirt/oxidation between the rotating part and the stationary connector. Some contact cleaner should help. For large variable capacitors with air between the plates, there may also be conductive slivers or dust that has found their way in between the plates - use a brush to remove these. Some plates may also have gotten bent somehow (e.g., if you were doing some other work in the area).

Why NOT to use WD40 on noisy controls

This may not apply to the resistive elements in all/many/most controls but why risk it?:

(From: Richardson (rchvid7@flash.net).)

Here are some facts after seeing the results first hand in an environment where Pro TV editors were using up controls in audio mixers manufactured by Shure Brothers. WD40 when used for the first time resulted in good operation for 5 days. After that time the controls started to deteriorate very quickly and were junk the next week.

The situation was clear after opening up the pots afterward. The carbon material was bonded to itself and to the phenol substrate by some chemical which became soft after being exposed to the hydrocarbon base of the WD40. It soon deteriorated to mush.

The use of LPS 1 did not cause such a dramatic failure of the surfaces but did not provide any improvement that lasted.

In the past we could get good results with Freon cleaning spray, but it is getting harder to get than the replacement controls.

In test pots the only way to get an improvement was to carefully remove residue and relubricate with a lubricant like Radio Shack "Gel Lube" or the latest Sony grease available for broadcast and pro use.

Resuscitating potentiometers

(From: Rene Zuidema (cps_rjz@cistron.nl).)

Often, pots are not really dirty, but the pot wiper just worn out the resistive layer. No amount of cleaning will solve the problem.

Just carefully re-bend the wiper contacts to follow another track alongside the damaged resistive material. If done well, the wiper will now track intact resistive material again. As new!

This specially works for servo's as used in RC cars / planes etc. In these applications the resistive track around the servo neutral position is worn out after some seasons of use.

(From: Paul Weber (webpa@aol.com).)

Disassemble the pot by carefully bending the tabs that hold the cover on (assuming this is a cheap consumer type pot). Inspect the works with a magnifying glass; find the fingers on the rotor that touch the resistor material. Using a needle or dental pick carefully bend the fingers out of the furrow they've worn in the resistor material. Objective is to make contact with an unworn area on the resistor material. Clean the whole thing with spray cleaner and re-assemble.

Overall resistance may be slightly changed due to the lost resistance material, but this is usually not a problem in consumer applications. Good luck!

General intermittent or erratic behavior

Any intermittent problems that cause random sudden changes in performance are likely due to bad connections, internal connectors that need to be cleaned and reseated, or dirty switches and controls. First, see the section: Noisy or intermittent switches and controls.

Bad solder joints are very common in consumer electronic equipment due both to poor quality manufacturing where cost reduction may be the most important consideration. In addition solder connections deteriorate after numerous thermal cycles, vibration, and physical abuse. Circuit board connections to large hot parts or parts that may have mechanical stress applied to them are most likely be suffer from hairline solder fractures (often called 'cold solder joints' when they result from poor quality soldering at the time of manufacture). However, since the solder is often the only thing anchoring these components, mechanical stress can eventually crack the solder bond as well.

To locate cold solder joints, use a strong light and magnifier and examine the pins of large components and components that are subject to physical stress (like headphone jacks and power connectors) for hairline cracks in the solder around the pin. Gently wiggle the component if possible (with the power off). Any detectable movement at the joint indicates a problem. A just perceptible hairline crack around the pin is also an indication of a defective solder connection. With the power on, gently prod the circuit board and suspect components with an insulated tool to see if the problem can be effected.

When in doubt, resolder any suspicious connections. Some device may use double sided circuit boards which do not have plated through holes. In these cases, solder both top and bottom to be sure that the connections are solid. Use a large enough soldering iron to assure that your solder connection is solid. Put a bit of new solder with flux on every connection you touch up even if there was plenty of solder there before.

In addition to soldering problems, check for loose or corroded screw type ground (or other) terminals, and internal connectors that need to be cleaned and reseated.

Need to turn up volume to get sound to come on

If at times, it is necessary to turn the volume way up or possibly to tap or whack the unit to get the sound in one or both channels to come on when the unit is first powered up, the speaker protection relay could be faulty. Receivers and audio amplifiers often include a set of relay contacts in series with each output to protect the loudspeakers from power-on and power-off transients as well as damage due to a fault in the audio circuits. However, these contacts may deteriorate after awhile resulting in intermittent sound.

While this set of symptoms could be the result of general bad connections or even dirty controls or switches, the relay is often at fault. This is exacerbated by switching the unit on and off at high volume levels as well as this may cause contact arcing.

To determine if the relay is at fault, either test it as outlined in the section: Relay testing and repair or with the unit on, very gently tap the relay to see if the sound comes as goes. If the relay is bad, you can try cleaning its contacts or replace with one that has similar electrical specifications as long as you can mount is somehow. Don't be tempted to bypass the relay as it serves a very important protective function for both the amplifier and your loudspeakers.

If it is not the relay, see the sections: "General intermittent or erratic behavior" as well as "Noisy or intermittent switches and controls".

Speakers take a while to come on

You turn on your stereo receiver and everything appears normal - display, tuning, signal strength, etc., but there is no sound. A few minutes later, just when you had entirely given up any hope, there is a click and everything is normal - until the next time you power down. The amplifier is taunting you - hehe, I will come on when I feel like it!

(Note that if it never comes on, then there could be a real problem that the protection circuitry is catching such as shorted components in one of the power amplifiers.)

This sounds like the signal to power the speaker relays is not being generated. The underlying cause could be a fault in the time delay or fault protection (overload) circuit.

It could be as simple as a bad capacitor. A first test might be to check for an audio signal at the input to the speaker relay. If there is signal almost as soon as you power it up, then trace back from the relay coil to see what type of circuitry is there. A schematic will probably be needed unless you find an obvious bad connection or dried up capacitor.

Amplifier clicking and shutting down on music peaks

(From: Frank Fendley (frank.fendley@datacom.iglou.com).)

It sounds like the protection circuit (usually a relay) is cutting in during louder music passages. This is caused by an imbalance in the amplifier circuitry, generally resulting in a DC offset voltage appearing on the output. The usual cause is a defective transistor(s), probably in the earlier stages in this case.

Of course, it could also be that you have 10 sets of speakers connected to the amplifier and all the volume levels turned to the stops - it is simply protecting itself from abuse! :-) --- sam.

Speaker outputs do not come on or shut off immediately

(From: Ronald Dozier (dozier@strauss2.udel.edu).)

The protection relay usually detects DC offset at the speaker terminals and then open's the speaker leads. Check for a DC offset > 100 mV or so before at the output, before the protection relays.

Leaky outputs are the first to suspect.

In most PP drivers the voltage between the bases of the output transistors should be about 2 Vbe or around 1.2 volts. 0V is definitely a problem. I have only seen one amp (mine) that used 4 Vbe. or about 3.2 volts. The voltage across the emitter resistors without a load are in the 0 to 20 mV range. This voltage should not increase appreciably over time and is set with the bias adjustment. Careless playing with the bias pot will result in output transistor destruction. It is best set with the aid of a distortion analyzer.

All resistors/transistors in the driver and output stage and in some cases the pre-amp are all suspect. The small valued ones like to change value. Compare with functioning channel.

Speaker thump - $2,000 amps versus PCs

(From: (filipg@repairfaq.org).)

Your stereo doesn't do this because it has a relay that doesn't turn on the speakers to the amp until AFTER it "thumps"! So, even a $2000 amp "thumps" it's just that there is a *provision* for that in the design. Altec has to compete with crappy brands that offer "200W" for $9.95... they can't afford to put in a $0.55 relay (*2 million units, you do the math for their total cost).

The reason they use the relay on the "speaker" side and not the "volume" side is so they can also have a "speaker protection" in the same deal - if you exceed some volume for too long, the relay will disengage the speakers, preventing their demise. You have not such worries so I suggest a small relay in the volume side of the speaker.

A 555 timer set for ~1 second will do nicely. Power it off the amp's power and set it to energize the relay after 1 second. The "thump" will still happen, but the volume will be "0". Put the relay in line with the wires to the volume control such that when it is not energized (i.e., amp off) it sets the volume at 0 and when energized (1 second after amp on) the pot controls the volume.

Problem solved.

BTW, your amp isn't technically "broken" - it's just designed that way. :-)

Determining power output of amplifier

You need a load resistor of a value equal to the ohms rating of the speakers you intend to use and a power rating sufficient to handle the maximum you expect the amp to put out for a short time at least. Then, all you need to do is drive it until just below clipping and measure the voltage. P=V^2/R. This really requires an audio signal generator but some music with a sustained high level might be sufficient to make measurements. Of course, unless you have an oscilloscope, you will have a hard time determining when clipping occurs without destroying a set of speakers in the process. :(

Strictly speaking, you need to do this simultaneously on both (all) channels as a weak power supply can also limit power output but that is for the advanced course!

Dead channels on front-end audio components

Unlike big amplifiers, these are not normally failures caused by abuse or high power components. This type of equipment includes preamps, cassette decks, CD players, tuners, etc.

First, eliminate the audio patch cables by trying a different set or swapping left and right at both ends. In addition, confirm that your amplifier is operating on all cylinders (or channels).

Assuming this does not turn up anything:

For a tuner, the problem is almost certainly very near the output - probably a bad connection, bad jack, or bad final IC or transistor stage. There isn't much between the demodulator and the line output.

For a tape deck, much more can be involved. First, clean any mechanical REC/PLAY mode and other switches with contact cleaner as dirty contacts may result in one channel dropping out. If this does not help, determine if the output of the tape head is making it to the toutput by touching the terminals on the playback head with a tiny screwdriver when in play mode - you should get a hum when you are on the appropriate signal wire. If there is none for the bad channel, then you will have to either trace forward from the head or backward from the output. If you do hear a hum in the defective channel, the tape head itself may be bad - shorted or open - very dirty.

Older tuners, receivers, premaps, tape decks, etc. used discrete transistors and circuit tracing was possible. Modern equipment relies on ICs but pinouts, at least, are generally available by checking a cross reference guide such as those put out by ECG, NTE, or SK.

Again, first eliminate bad jacks or cables -- and with tape decks - clean the REC/PLAY (and other) mode selector switches.

Repairing stereo headphone plugs/cables

This is only worth the time, effort, and expense if the original cost was substantial. It hardly makes sense to pay $2 for a replacement plug and an hour of labor to repair a Dollar Store set of headphones!

The most common location for broken wires is at the plug end due to repeated stress. Sometimes these can be repaired by pealing back the rubber boot, cutting, stripping, and soldering the broken wires end-to-end. However, in most cases, you will grow old attempting to do this successfully and replacing the plug is the desirable solution. Radio Shack or any real electronics distributor will have the required "1/8 inch stereo phone plug". If you don't want to solder, they are available with teeny tiny screw terminals.

Note: Sometimes the wires break at other locations so replacing the plug may not help!

There are a pair of shielded wires which need to be cut back to well beyond where the break took place (to expose undamaged wire), stripped carefully to expose the inner conductor and separate the outer braid/shield. This wire is really really thin and fragile so if you have trouble opening a zip-lock bag, leave the repairs to someone else. :)

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    ----.__________ ____ __
         __________ ____ __>
    ----'
           Collar  Ring Tip
            Gnd   Right Left
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- The Tip is the left channel (probably a color other than red like green, blue, or white. Check for continuity to the old plug if you can locate the broken end of the appropriate wire. Or momentarily touch a 1.5 V battery (NOT a 9 V - you could damage the headphones) between the inner wire and shield. You should get a click in the appropriate headphone.

- The ring is right (check as above or just assume it is the other one).

- The collar is common (both braids).

Equipment hums or buzzes

Assuming there are no other symptoms and the sound is coming from inside the unit and not the loudspeakers, this is probably simply due to vibrating laminations in the power transformer or motor(s) or nearby sheetmetal that is affected by the magnetic fields from the power transformer or motor(s). Most of the time, this is harmless but can definitely be quite annoying especially when one expects total silence from their audio equipment. If the noise is coming from any motors or their vicinity, refer to the section: Motor noise in audio equipment.

Sometimes, simply tightening the screws that hold the transformer or motor together or the mounting screws will be all that is needed. Placing a toothpick or piece of plastic in a strategic location may help. It is also possible to coat the offending component with a varnish or sealer suitable for electronic equipment but be careful not to use so much that cooling is compromised or getting any in bearings or locations that would interfere with rotating parts.

Dirty power - a light dimmer on the same circuit - may also result in increased magnetic noise. See the section: Dirty power and buzz from equipment.

If the hum or buzz is in the audio, there could be a bad filter capacitor in the power supply, other power supply problems, bad grounds inside the unit or general ground problems with external equipment, or other bad connections. Disconnect all external devices (except the speakers if you do not have a pair of headphones) and determine if the problem still exists. Proceed accordingly. Some Sony receivers are known to develop bad grounds internally and just tightening the circuit board mounting screws and/or resoldering ground connections will cure these.

Overloads can also cause a hum or buzz but would generally result in other symptoms like a totally or partially dead amplifier, severe distortion, smoke, six foot flames, etc.

If the problem is only annoying when the equipment is not in use, as a last resort (where no memory or clock functions run off the AC line), putting in an AC line switch may not be such a bad idea.

Dirty power and buzz from equipment

Power line waveforms that are not sinusoidal can cause buzz. Multiple devices on the same circuit (or even different circuits) can interact. A TV or other equipment may add to the problem since its switching power supply draws current only on part of each cycle.

Excessive voltage can also increase the 'magnetic noise' from motors and power transformers. This sound is a result of core or winding vibrations.

You need to check for both of these possibilities - a calibrated scope is best. DMMs and VOMs may not read correctly with non-sinusoidal waveforms.

Will line voltage fluctuations affect A/V equipment

When large applicances like air conditioners, refrigerators, and heaters kick in, there is often a momentary dip in line voltage (especially if they are on the same branch circuit) which is very visible on incandescent lamps but is it actually harmful to electronic equipment?

It really depends on many factors but a couple percent variation in voltage (which is probably what you are seeing) probably isn't going to affect your A/V equipment in any way. Most modern equipment includes internal voltage regulation so there could indeed be no detectable effects.

Note that the volt or two drop in the wiring isn't in itself dangerous since it is distributed over a large length of wire. For example, a 2 V drop with a 10 A load is only 20 W lost in the wiring which over 50 or 100 feet is negligible heating. However, if this just started happening with no changes or additions to the wiring - especially if it is erratic - it could be due to a bad connection which is potentially dangerous and should be checked out.

A line filter might be of some value if you are actually seeing or hearing interference when the offending equipment kicks in. However, if you can't detect it, don't worry about.

Note that a surge suppressor is basically useless for this sort of voltage fluctuation as it only kicks in with a very significant *increase* in voltage.

WARNING: If you are actually seeing your lights *brighten* when that equipment starts up, get your electric wiring checked out. This could indicate a loose Neutral connection and that can result in expensive damage to anything plugged into your residence's electrical system and a safety and fire hazard. See the document: Notes on the Troubleshooting and Repair of Small Appliances and Power Tools for more information on this and other wiring problems.

Identifying and correcting sources of interference

Although this is a rather special application, similar problems and solutions apply to other interference problems. Also see the section: Interference on AM radio band.

> "I am using a 12V DC to 110 VAC converter in my car, to run a small TV/VCR. It works fine. But the TV speaker is not very good.

> So I got one of those cassette adapters that has an audio cassette on one end, and a headphone jack on the other. I plug that into the TV, and the cassette slot on my car stereo. So then I can hear the TV sound on the car speakers, which are much better speakers.
>
> But now there is a lot of high frequency noise that way, on the car speakers. It is very irritating. A high frequency buzz of some kind. How can I reduce or eliminate that noise?"

(From Duncan (duncan@punk.net).)

First we have to figure out where it is coming from. The inverter is certainly a noise source, and without spending a large sum for a well filtered inverter you have to deal with the noise somehow.

One possibility is that the noise is on the 12 volt power supply going to your car stereo. To test for this, play a blank tape while running the TV and listen for the same noise. Fix with filters on the power leads of stereo and/or inverter, wire to a solid clean rail very close to the battery.

Another possibility is capacitive coupling between the TV, connected to the higher voltage side of your inverter, and the tape deck's playback heads. This might be alleviated by using a different, more isolated inverter or by using another method of getting the audio into the stereo system. FM modulators intended for portable CD players might work.

Another possibility is that the power supply of the television is not rejecting the higher frequency components of the inverter's signal. The fix here would be to add more capacitors and perhaps resistive or inductive filter elements inside the television. Check this by plugging headphones into the same jack and listening for the noise.

Still another possibility is that the noise you hear is part of the horizontal sync signal, which is not rejected well by all televisions. This causes a high pitched continuous squeal which is inaudible to some people. The only easy work-arounds here would be to try a different television or to turn down the treble or select Dolby-B on your car stereo. To test for this effect, try the same hookup in your house with your home stereo, cassette deck, adaptor cassette, and television.

Or just hook up your HiFi stereo VCR to the home stereo, move the whole mess into the car, and ignore the car stereo. Four of Radio Shack's little Pro-7 speakers with a Marantz 25 watt by four channel amplifier worked quite well for me, especially when combined with a hand-held LCD monitor :-).

Interference on AM radio band

This sort of problem is usually in the form of a buzz or hum at 60 Hz or 120 Hz (or 50 Hz or 100 Hz if your power is at 50 Hz). There may be a little of this on a small portion of the AM band but if it is excessive and interferes with even strong stations, then a remedy is needed! The following approach should serve to locate the source if it isn't obvious:

(From: Doug (dslosty@pipeline.com).)

First, turn off the main house breakers and listen on AM with a battery operated portable radio.

If the noise has disappeared, then you are generating the interference in your own home and its time to check out things like light dimmers, fluorescent lamps, touch-control incandescent lamps, motors, even cordless phones, etc.

If the interference is still present on the portable AM radio, with the breakers off, walk around the perimeter of the house and see if it's loudest near the electric service entrance.

If it is, walk up and down the street and try to see if the intensity varies (your neighbors will think you're weird - but what the heck!).

If the interference comes from outside of your home, it's time to call the electric utility company and ask to speak with one of their engineers. The electric industry is required by the U.S. FCC. to keep radio interference (RFI) to a minimum. They may try to stonewall you but if you persist, they will sent out an engineer with radio direction finding equipment to locate the source of the interference. If the source is a piece of equipment on a non-cooperative neighbor's property, you may have another problem - but - one step at a time.

I've been through this procedure several times. Last time, the electric company engineer tracked it to a broken and arching pole insulator.

As a former AM broadcast engineer (and current HAM radio operator), I've experienced this problem enough to know that while challenging, the interference source can always be found.

(From: Mr Fixit (mrfixit@cyberhighway.net).)

Radio Shack sells RF chokes. Label says "SNAP-ON FILTER CHOKES (2) cat. no. 273-104"

They open up and snap together over your wires. Very simple to install and come with comprehensive instructions.

With a little experimentation you can see if you need it on your power cord, on the speaker wires or both. (these wires can act as antennas for certain frequencies of RFI)

I use them all over my house on phones, TV's, stereos, computer speakers etc to block out RFI from my CB base station and vis-versa.

BTW: if you happen to have any unneeded computer monitor cables laying around, the oversize collar near the end is a RF choke. I had a couple so I cut the covering and slid them off the cable. I put them onto our cordless phone base unit antenna as an experiment to see if it would reduce the ever-present buzz it had. To my surprise, the buzz disappeared with no loss of signal strength.

(From: Dan Hicks (danhicks@millcomm.com).)

An even better idea is to put these chokes on the RF **generators** in your house. I'm not sure if it's "code" to install them on permanent wiring, but it should be safe to do so so long as you are reasonably careful. And it's easy to install them on any plug-in devices that appear to cause problems.

Internal fuse blew during lightning storm (or elephant hit power pole)

Power surges or nearby lightning strikes can destroy electronic equipment. However, most of the time, damage is minimal or at least easily repaired. With a direct hit, you may not recognize what is left of it!

Ideally, electronic equipment should be unplugged (both AC line and phone line!) during electrical storms if possible. Modern TVs, VCRs, microwave ovens, and even stereo equipment is particularly susceptible to lightning and surge damage because some parts of the circuitry are always alive and therefore have a connection to the AC line. Telephones, modems, and fax machine are directly connected to the phone lines. Better designs include filtering and surge suppression components built in. With a near-miss, the only thing that may happen is for the internal fuse to blow or for the microcontroller to go bonkers and just require power cycling. (Unplug the unit from the wall for a couple minutes and see if that will reset it.) There is no possible protection against a direct strike. However, devices with power switches that totally break the line connection are more robust since it takes much more voltage to jump the gap in the switch than to fry electronic parts. Monitors and TVs may also have their CRTs magnetized due to the electromagnetic fields associated with a lightning strike - similar but on a smaller scale to the EMP of a nuclear detonation.

Was the unit operating or on standby at the time? If was switched off using an actual power switch (not a logic pushbutton), then either a component in front of the switch has blown, the surge was enough to jump the gap between the switch contacts, or it was just a coincidence (yeh, right).

If it was operating or on standby or has no actual power switch, then a number of parts could be fried.

Many devices have their own internal surge protection devices like MOVs (Metal Oxide Varistors) after the fuse. So it is possible that all that is wrong is that the line fuse has blown. Remove the case (unplug it!) and start at the line connector. If you find a blown fuse, remove it and measure across the in-board side of fuse holder and the other (should be the neutral) side of the line. With the power switch off, this reading should be very high. With the switch on, it may be quite low if the unit uses a large power transformer (a few ohms or less). For example (assuming power transformer operated supply):

- Small AC adapter - 100 to 500 ohms.
- Large AC adapter - 10 to 100 ohms.
- VCR - 15 to 30 ohms.
- Cassette deck or CD player - 25 to 100 ohms.
- Stereo receiver or amplifier - .5 to 10 ohms.

Some may be outside these ranges but if the reading is extremely low, the power transformer could have a partially or totally shorted primary. If it is very high (greater than 1 K ohms), then the primary of the power transformer may be open or there may be blown thermal fuse under the outer insulation wrappings of the transformer windings. This may be replaceable but don't just bypass it (except for testing). See the document: Notes on the Troubleshooting and Repair of AC Adapters, Power Supplies, and Battery Packs.

If the unit has a switching power supply (the AC input doesn't go to a power transformer but gets rectified and filtered first), see the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies.

If the resistance checks out, replace the fuse and try powering the unit. There will be 3 possibilities:

1. It will work fine, problem solved.

2. It will immediately blow the fuse. This means there is at least one component shorted - possibilities include an MOV, line filter capacitor, transformer primary.

3. It will not work properly or still appear dead. This could mean there are blown fuses or fusable resistors or other defective parts in the power supply or other circuitry. In this case further testing will be needed and at some point you may require the schematic.

Use of surge suppressors and line filters

Should you always use a surge suppressor outlet strip or line circuit? Sure, it shouldn't hurt. Just don't depend on these to provide protection under all circumstances. Some are better than others and the marketing blurb is at best of little help in making an informed selection. Product literature - unless it is backed up by testing from a reputable lab - is usually pretty useless and often confusing.

Line filters can also be useful if power in you area is noisy or prone to spikes or dips.

However, keep in mind that most well designed electronic equipment already includes both surge suppressors like MOVs as well as L-C line filters. More is not necessarily better but may move the point of failure to a readily accessible outlet strip rather than the innards of your equipment if damage occurs.

It is still best to unplug everything if the air raid sirens go off or you see an elephant wearing thick glasses running through the neighborhood (or an impending lightning storm).

Surge Suppressor/UPS cascading

(From: Fred Noble (f-noble@suttondesigns.com).)

A large number of users still seem confused about the use of a Surge Suppressor in line with a UPS. The general rule is, do NOT plug a surge suppressor INTO the OUTPUT of a UPS that produces a non-sinewave output that exceeds 5% Total Harmonic Distortion (or THD) when the UPS operates from battery supporting any load under any ambient conditions. Do NOT plug a Line Conditioner or other type of filter into the UPS either.

You can plug a UPS into a well grounded surge suppressor, but this is not always a good idea, especially when we are talking about various 'low cost' surge suppressors of questionable electrical integrity. We constantly hear of low-end surge suppressor recalls for safety reasons, with several recent recalls ordered by the U.S. Consumer Product Safety Commission, for example, http://cpsc.gov/cpscpub/prerel/prhtml97/97078.html. A cursory search using the keywords 'surge arrester consumer recalls' with the Excite engine reveals several such recalls.

If the surge suppressor you plug the UPS *into* is electrically 'safe' you are still extending the ground path with such a cascading arrangement, which, on balance, may not be wise. The UPS should provide Surge Suppression energy ratings of 480 Joules or more. Then, you probably wouldn't require the additional upstream surge suppressor at all. This does not mean that you shouldn't also have a surge suppressor installed at the MAINS or the branch panel, however. We are only talking about the extra, stand-alone, AC protection devices.

This is also not to say that you should not provide additional surge suppression for your modem or UTP connections!. This you must do, and a low cost device that is also a *high quality* device, should be used. These devices are designed specifically for the protection of DC electrical surges and they are not used in series with a UPS anyway.

Lightning, surge supressors, and telephone equipment

(From: aa-2@deltanet.com@deltanet.com)

Nothing will stop a good lightning strike, but there are things you can do to put the odds more in your favor.

For telephone line protection, the place to start is where the phone line comes into your house. Locate the protector and verify you have a good ground close to it. Next, replace the standard carbon protector elements with gas tubes. These often look like large brass hex bolts with no wires attached, but the exact design will vary. Carbon protectors operate rather slowly; gas tubes ionize very quickly and carry large amounts of current. You may have to shop around your local telco supplier to find these. Strictly speaking, these are on the telco side of the demarc and you're not supposed to fool with them, but if you won't tell, I won't either. Or you could call your local telco and ask for the gas tubes...

Then add your store-bought protector inside. Make sure it has a good ground, too. It can't hurt, and it might help. But the best place to try and stop the lightning is before it enters your house.

Paul's Notes on Power Line Connected Devices

The most common of these are so-called "wireless" intercoms and X10 appliance controllers.

(From: Paul Grohe (grohe@galaxy.nsc.com).)

The "Wireless" intercoms actually send 220 to 250 kHz signals across the power line. They pump about a volt or two into the line - then receive in the millivolt range. Obviously - the power line is NOT a good transmission medium.

They worked fine years ago when most loads were mostly inductive (lamps, motors, transformers, etc).

Nowadays, there are loads that essentially place small value capacitors across the line - most notably power strips and newer electronic equipment with switching supplies (Computers, TVs, VCRs, compact fluorescent lamps, etc). These "small" caps essentially short out any high-frequency noise on the power line. To make things worse, switching supplies and CFL bulbs run in the 40 to 80 kHz range, and can spray harmonics well into the 200 kHz range. Some channels will get knocked out by poorly filtered switching supplies or CFLs.

Also, both intercoms need to be on the same service "leg". The majority of (US) homes are fed by a 120-0-120 feed. Half the home is on one leg, and the other half is on the other leg to "balance" the load. Even two outlets in the same room may be on different legs. The kitchen usually has the most of these "mixed" outlets.

If the intercoms are on opposite legs, the signal has to traverse the transformer to get to the other leg. Obviously, with the inductance of the pole transformer and long power feed, the signal rarely makes it back.

BTW: If the intercoms work better if a 220 VAC load, such as an oven, drier or stove is turned on - then they are defiantly on separate legs.

X-10 remote controls also face a similar problem. Do a search on X-10 wireless controllers - there are many FAQs about signal problems and what causes them. There are devices that allow the X-10 signal to "bridge" between the two lines. Essentially a high-voltage, low value capacitor that must be professionally installed at the breaker box.

One thing I have found is to NOT plug the Intercom/X10 device into the *same* outlet as a filtered outlet strip or TV/VCR/Computer/CFL. Instead, pick an outlet *between* the sending unit and the electronic loads.

Think of "loads" as capacitive, and power line as slightly inductive - and you'll see why.

As an alternative to power-line carrier - Radio Shack sells intercoms that use the phone line as the carrier - RS# 430-0483. Of course, they need a phone line too - but the performance is *much*, *much*, *much* better than the power line units.

I originally tried the usual 'power line" intercoms - but encountered many problems with noise/interference from the computer and compact fluorescent lamps. I happened across a pile of some older-model phone-line intercoms at Goodwill and gave them a try - they worked perfectly with NO interference at all (although if you have DSL using "Microfilters" at each phone - you cannot use these intercoms or you must split off DSL at the phone box).

The best they can do is to try other outlets - even if it means extension cords. Otherwise, they will have to switch to an "alternate" means since the power line is unusable. I have seen RF "intercoms" somewhere (900 mHz?) - so there are some available. But if phone lines are available at the locations they wish to use - then I would highly recommend the phone-line intercoms.

Equipment dropped or abused

I have heard of someone fighting off a would-be mugger with a tape deck but this is generally not a recommended practice. However, once it happens - your cassette deck fell off its shelf or you prized walkman fell from your hang glider (ok, maybe that will be too much even for miracles) - what should you do?

Overall, electronic equipment - especially portable devices - are quite tough. However, falling or being beaten in just the wrong way can do substantial and possibly not immediately visible damage.

If you take it in for service, the estimate you get may make the national debt look like pocket change in comparison. Attempting to repair anything that has been dropped is a very uncertain challenge - and since time is money for a professional, spending an unknown amount of time on a single repair is very risky. There is no harm is getting an estimate (though many shops charge for just agreeing that what you are holding was once a - say - tapedeck!)

This doesn't mean you should not tackle it yourself. There may be nothing wrong or very minor problems that can easily be remedied.

First, unplug the unit even if it looks fine. Until you do a thorough internal inspection, there is no telling what may have been knocked out of whack or broken. Electrical parts may be shorting due to a broken circuit board or one that has just popped free. Don't be tempted to apply power even if there are no obvious signs of damage - turning it on may blow something due to a shorting circuit board. If it is a portable, remove the batteries.

Then, inspect the exterior for cracking, chipping, or dents. In addition to identifying cosmetic problems, this will help to locate possible areas to check for internal damage once the covers are removed.

Next, remove the covers and check for mechanical problems like a bent or deformed brackets, cracked plastic parts, and anything that may have shifted position or jumped from its mountings.

Carefully straighten any bent metal parts. Replace parts that were knocked loose, glue and possibly reinforce cracked or broken plastic. Plastics, in particular, are troublesome because most glues - even plastic cement - do not work very well. Using a splint (medical term) or sistering (construction term) to reinforce a broken plastic part is often a good idea. Use multiple layers of Duco Cement or clear windshield sealer and screws (sheetmetal or machine screws may be best depending on the thickness and type of plastic). Wood glue and Epoxy do not work well on plastic. Some brands of superglue, PVC pipe cement, or plastic hobby cement may work depending on the type of plastic.

Cycle the the mechanism and check for free movement of the various moving parts.

Inspect for any broken electronic components - these will need to be replaced. Check for blown fuses - the initial impact may have shorted something momentarily which then blew a fuse.

There is always a slight risk that the initial impact has already fried electronic parts as a result of a momentary short or from broken circuit traces and there will still be problems even after repairing the visible damage and/or replacing the broken components.

Examine the circuit boards for any visible breaks or cracks. These will be especially likely at the corners where the stress may have been greatest. If you find **any** cracks, no matter how small in the circuit board, you will need to carefully inspect to determine if any circuit traces run across these cracks. If they do, then there are certainly breaks in the circuitry which will need to be repaired. Circuit boards in consumer equipment are almost never more than two layers so repair is possible but if any substantial number of traces are broken, it will take a great deal of painstaking work to jumper across these traces with fine wire - you cannot just run over them with solder as this will not last. Use a fine tipped low wattage soldering iron under a magnifying lens and run #28 to 30 gauge insulated wires between convenient endpoints - these don't need to be directly on either side of the break. Double check each connection after soldering for correct wiring and that there are no shorts before proceeding to the next. Also see the section: Repair of printed circuit board traces.

If the circuit board is beyond hope or you do not feel you would be able to repair it in finite time, replacements may be available but their cost is likely to be more than the equipment is worth. Locating a junk unit of the same model to cannibalize for parts may be a more realistic option.

Once all visible damage has been repaired and broken parts have been replaced, power it up and see what happens. Be prepared to pull the plug if there are serious problems (billowing smoke would qualify). Determine if it appears to initialize correctly - without shutting down. Play a garbage tape to determine if there are any problems that might damage the tape. Listen carefully for any evidence of poor tracking, tape speed instability, or weak or muddy audio that might indicate that tape path alignment requires further attention. Listen as well for any unexpected mechanical sounds that were not there before.

Very likely, the unit will be fine, you can replace the covers, and now find a more secure spot for it to prevent this sort of event in the future. Maybe hang gliding is just not for you!

Decayed glue in electronic equipment

Larger components like electrolytic capacitors are often secured to the circuit board with some sort of adhesive. Originally, it is white and inert. However, with heat and age, some types decay to a brown, conductive and/or corrosive material which can cause all sorts of problems including the creation of high leakage paths or dead shorts and eating away at nearby wiring traces.

The bottom line: Most of the time, this stuff serves no essential purpose anyhow and should be removed. A non-corrosive RTV or hot-melt glue can be used in its place if structural support is needed.

(From: Richard Rasker (r.e.rasker@student.utwente.nl).)

Are you repairing somewhat older Japanese (Yamaha, Nikko, etc.) equipment, but the problem seems very obscure? Then maybe this may interest you:

In some amplifiers and other equipment, the supply capacitors and other large pcb-mounted devices are secured in place by a type of gluelike substance, that after several years causes corrosion to all metal parts that it touches; eventually, the metal connections (like component wire leads and wire bridges) will fail.

The substance in question is a dark yellow rubber-like compound, coloring brown and turning rather hard on the places where damage is done to other components. The only solution is to scratch it away completely and replace all components affected.

I've already repaired five amps where this turned out to be the cause of trouble - with very vague symptoms, like a missing ground reference to an endstage, an on-board controller that wouldn't start up, etc. The first time it took me forever to find, so if this posting will make even one repair easier for someone, I'm already happy.

Hope this makes life a (little) bit easier for all those people out there trying to repair stuff, instead of throwing it away :)

P.S. My theory about this process: I think that the substance used is a rubber compound with an excess of sulfur, which will very slowly react with oxygen and moisture to form corroding chemicals (like sulfites). If anyone has a better theory (or the correct explanation), please let me know.

(From: Jake Gray (jake79@hotmail.com).)

I have found in a lot of electronical gear and more recently in my monitor. The glue has been designed mainly to hold leads and wires in place, also to hold capacitors in place.

It eventually soaks up the moisture from the air, giving it a conductive effect and the places that it is located don't like having a conductor across them. And, as time goes on, the glue seems to carbonize and become an even better conductor.

Just keep and eye out for it, it is like a creamy colour and remove it ASAP.

With many appliances, especially those with many IC's, I have found that with the removal of the glue, they work fine.

Repair of printed circuit board traces

In most cases, a functional repair - using wire to bridge the breaks soldered to conveniently located pads - is all that is needed. This will be at least as reliable as the original foil wiring if done properly. However, there are those times when a complete restoration is desired:

Note: If the original cause was chemical corrosion rather than mechanical, ALL of the offending material must be removed and/or neutralized before any sort of reliable repair can be attempted!

(From: MKILGORE (mkilgore@aol.com).)

Yes, you can repair damaged/lifted conductors and pads on circuit boards. If you would like to repair the damaged area professionally, track repair kits are available from sources such as Pace. These repairs once completed are almost undistinguishable from the original work. Damaged pad replacement - Using a scalple or Xacto knife follow the run attached to the pad back to a point where it is still firmly secured, at a 45 degree angle, cut the trace loose and remove it from the board and discard. Scrape any solder mask from the end of the trace back about 3 trace widths, and clean the area with an ink eraser, then tin the area. Select a pad with trace from the kit (various sizes are included) position it in place of the damaged run and form it so it follows the contour of the board to the 45 degree angle cut and rests on top of the original trace by about 2 trace widths. Now prepare a small amount of two part epoxy and flow it on the board where the replacement conductor will lie, do not get any on the tinned conductor. Lay the replacement conductor in place and allow the epoxy to dry, this can be speeded up with a heat lamp. Once dry simply apply flux to the joint and solder the two pieces together. If this was a plated through hole, or strength is an issue, the kit contains eyelets which can be installed through the board. --- However, if the trace you wish to repair is merely lifted you can simply use the epoxy and secure it back in place.

Circuit repair where a pad has been lifted due to mechanical stress

This might be the case where someone tripped over the AC adapter cord of a walkman or laptop computer thus ripping the jack from the circuit board.

(From: KIRTO (Kholson@cris.com).)

As you will see in the following, I recommend using something other than the pad to get that strength.

I suggest you provide mechanical connection between the jack and the board so that the jack can't move with respect to the board.

Techniques include a wire strap over the component near the back and soldered to the board like you see on crystals or adhesive under the jack like you see on large caps in midboard.

Another possibility is to put a rubber bumper atop the jack so that the front cannot tip inward when it's in the case. A stick-on foot might be a start, with whatever 'foot surgery' is needed to fit.

If the jack has a rim near the front (like a std keyboard connector) you might be able to put triangular braces on either side of it with adhesive and some stiff rubber or plastic.

I have seen this problem happen when someone trips on a cord and thus pulls the connected jack at a sharp angle with high force. Warn the customer about this possibility, and suggest using an extension cord on the power adaptor.

(From: Hank Sievers (textax@aol.com).)

The best way that I can think of is to bend down whatever part of the leg extends through the board and bridge with a heavy bare wire and plenty of solder to as much of the nearest part of the trace (scraped to the copper, of course) as you can. Then, for good measure put a drop of magic glue or some silcone sealant where the leg comes through the hole. Should be stronger than the original.

I am a charter member of the the 'down-to-the-component-troubleshooting fraternity', since I am naturally curious and fortunate enough to have the time, since I am retired. However, I can see where it is often important to the bottom money line, not to spend too much time on a repair and so replace the entire unit. Time is money also!

Boombox or other equipment went to the beach (sand and/or surf)

A (former) relative took your boombox to the beach this summer and now it has sand or perhaps salt in it. Or, maybe you could not resist "sing'n in the rain" and a big bus went by without slowing. Now neither of the tape decks will play. Can this possibly be fixed? Will it be worth the effort?

Unless this is a really expensive sophisticated unit, I doubt whether it will pay you to take it anywhere for repair. Furthermore, as with equipment that has been dropped or physically abused, few repair shops will be inclined to touch the job. They really don't like challenges of this sort.

That leaves you!

If saltwater was involved in a significant way, you can probably forget it. Without immediate attention, saltwater corrosion can set in very quickly and attacks electronic components, circuit board traces, cable wiring, and mechanical parts. The only thing worse is damage caused by forgotten, leaky batteries.

Although it is probably too late, the first thing to do when electronic equipment gets wet is to remove the power source - switch it off and pull the plug or remove the batteries if possible. Don't be tempted to apply power until you have determined that it is completely dried out. If power was on when the 'incident' took place, then electronic damage may have already resulted which will not be apparent until after cleaning, drying, and lubrication.

The following description assumes a dual cassette boombox. Adjust as appropriate for your patient:

If the tape decks are totally dead, you may have serious electronic or corrosion which will make any salvage unlikely. If they sort of move (or even twitch a bit) but the sound is erratic, weak, fluttery, etc. then there may be hope. (Of course, if it got wet, you should not have done this test until everything was cleaned and dried!)

NEVER use strong solvents for any cleaning. These may attack plastic parts or cause internal damage to electronic components.

Mechanical intensive care:

1. Remove the tape decks. This will be a pain but otherwise you will not be able to get at everything. Make as many as drawings as needed so you will be able to reassemble.

2. Make a drawing of the belt routing, remove the belt(s), wash and dry them, label and set them aside.

3. Use a soft brush (like a paintbrush) to dust out as much sand as possible. Hopefully, you can get it all this way. A vacuum cleaner with a wand attachment may prove handy to suck out sand. Don't use high pressure compressed air - it will just spread the sand around. Any grease or oil on which sand has collected will need to be totally removed and replaced with fresh lubrication.

4. If there is evidence of salt (remember, I said forget it...but), you will need to wash it off. Yes, wash it. Keep water out of the motors. Use low pressure compressed air (a blow dryer on low heat should be fine) to dry so that it does not rust. Ditto if it is still wet with contaminated liquid (we won't say where this came from), wash with fresh water to remove all traces of it as quickly as possible. A final rinse with 91% or pure isopropyl alcohol will decrease drying time and should not damage mechanical assemblies. Degreaser may be used if it is safe for plastic and rubber parts.

   Lubricate all bearing points with a drop of light machine oil - electric motor oil, sewing machine oil, etc. (Never never never WD40). Lubricate gears, cams, and sliding parts with a light plastic safe grease.

5. Replace the belts and reinstall the tape decks.

Electronic intensive care:

1. Remove the circuit boards and label the connectors if there is any possibility of getting them mixed up. If the circuit board(s) are soldered to the rest of the equipment, then you will have to improvise.

2. Wash with water and dry thoroughly. This does work. I use it routinely for degunking remote controls and rubber membrane keypads, for example. The most important objective should be to get corrosive liquids off the components and circuit traces as quickly and completely as possible. A final rinse with isopropyl alcohol will decrease drying time. However, there is a slight risk of damage to sensitive electronic components should some be trapped inside. Moisture will be trapped in controls, coils, selector switches, relays, transformer cores, connectors, and under large components like ICs. Pat dry, then use warm air from a hair dryer (or heat gun on low) to completely dry every nook and cranny. DO NOT operate until everything inside and out is thoroughly dry.

3. Inspect for damage due to short circuits including blown fuses, fried components, and melted traces. These will need to be repaired or replaced.

4. Use spray contact cleaner on the switches and control cleaner on the user controls and adjustment pots. DO NOT turn the internal adjustments without precisely marking the original positions - else realignment will be needed. Exercise the user controls to help the cleaning process.

Once everything is reassembled, power the unit up and see what happens. Be prepared to pull the plug or pop the batteries if there are serious problems. Attempt to play a garbage tape to determine if there are any problems that might damage the tape. Look and listen for any abnormalities which may require additional attention. There could still be electronic faults not repairable without schematics and test equipment.

Obviously, this description is very simplistic. The important thing is to get every last grain of sand, salt, and other contaminants off of the mechanisms quickly.

Similar comments apply to equipment that went for an actual swim - you dropped your portable CD player in the toilet. The most important objective is to clean and dry it as quickly as possible and then relube any motor and other bearings. Use your judgement as to the severity of the dunking in terms of how deeply the liquid penetrated. Surface moisture will not hurt anything as long as it is dried up quickly. If you left it soaking on the other hand....

As noted above, moisture may collect inside certain electronic parts and it is essential that these be dried completely before attempting to apply power to the unit. If you do not, at best it will not work properly and you may do additional serious damage due to short circuits.

For the mechanics, the same applies though this is trickier since certain parts need to be lubricated and these may not be readily accessible or obvious. Don't be tempted to overdo the lubrication either - too much is worse that too little.

For high tech devices like CD players, some parts of the internal optics or shielded DC-DC convertors may be impossible to access and clean of scum.

Salt water salvage

(From: John Baker (jbaker@flash.net).)

I have repaired equipment that has been soaked in salt water and it depends on what type of components it has on the boards. If they have any batteries on them, get them off as soon as possible. transformers are usually good for rusty paperweights. Get the boards out of the salt water and into fresh water ASAP. I have not found any chemicals that will remove the salt deposits and leave the traces. The best bet is to use a small nylon brush along with a chemical called Flux Off-nr, there are several types of Flux-Off, get the one that does not harm plastic parts, it is not as strong but it workes just as well in this case. From there it takes a lot of time. Use the brush and remove all salt deposits, try and get under all components, especially IC's. Most components can take being under salt water with no damage, it is the batteries and metal that cause problems.

Fil's notes on rescuing soggy equipment

(From: Filip "I'll buy a vowel" Gieszczykiewicz (filipg@repairfaq.org).)

Greetings. I've recently had the opportunity to rescue several rather expensive electronic units after the owner flipped the canoe and spilled the beans, so to speak.

The dead units were: a Casio solar-powered calculator, a car-alarm key ring transmitter, a 10-satellite GPS unit (yowser!), and some smaller items.

Note: GPS unit was waterproofed and did not suffer much.

Solution (sorry, pun) was: purchase 1 gallon of distilled water, disassemble the units and submerge the PCBs (and keypads and displays) in containers. The devices were left soaking for more than 20 minutes. Then, they were removed and dried with a hair dryer (and fan for less expensive items).

Results: excellent. All items have been brought back to life. Some *did* require purchase of new (rather expensive) Lithium batteries but that was a small price to pay.

Hint: It is highly useful to have a brush to clean the area between ICs' pins after 10+ minutes of soaking. This helps to remove any minerals that are not as soluble in water as others. This is more of an issue if the items came in contact with flood-stage stream than a sinkful of tap water. :-)

Observation: devices that were "on" at the time of the dunking were the most damaged and required the most time to soak. Batteries had to be replaced since they *all& started to leak.

REALLY cleaning electronic equipment

The following is probably excessive for most needs and should be used with caution since there are some types of components which will not take kindly to forced hot water cleaning. In addition what is mentioned below, mechanical assemblies like motors and solenoids should be removed and dealt with separately. And, of course, any moving parts that are left in place should be thoroughly dried as soon as possible and then lubricated with the proper oil or grease.

(From: Gray Frierson Haertig (gfh@haertig.com).)

I have had excellent results cleaning electronics in the dishwasher. I try to do a bit of disassembly so that as much of the instrument is exposed as possible. If you can separate chassis from electronics, so much the better. I have generally avoided putting unpotted transformers and inductors and the such through the wash. I either hand clean those boards or dismount the sensitive item. Mechanical parts can be run through the whole cycle, if your water is reasonably soft. A second rinse cycle doesn't hurt. The electronics should not go through the heat dry cycle. They should be thoroughly flushed in deionized or distilled water after they come out of the washer to prevent mineral and salt deposits. Then go after it with a blow dryer set to low heat, or if you're blessed with sunshine, smear on the cocoa butter and let them work on their melanoma.

Reviving old (antique) equipment

If you have a true antique - really old, and valuable, you should refer to the extensive literature available on this subject. The following applies more to that 30 year old record player/amp found in the storage loft of your garage during spring cleaning.

Common problems relate to two types of components: vacuum tubes (valves for all of you on the other side of the lake) and capacitors (paper and electrolytic type). Push all the tubes down in their sockets as well - they will work their way loose with non-use and vibration. However, thorough cleaning of all socket and switch contacts, and controls will almost certainly be needed.

WARNING: the voltages inside tube type equipment can exceed 400 V - and contact with that can be real painful not to say dangerous. AC-DC type sets are not isolated from the power line. (In some really old equipment, even the chassis may be tied to one side of the line). This could also happen as a result of a shorted component. The electrolytic capacitors can hold a charge for quite a while. Read, understand, and follow the recommendations in the document: Safety Guidelines for High Voltage and/or Line Powered Equipment. Use extreme care when probing or even touching anything. This isn't 5 V logic!

Vacuum tubes:

It is not possible to fully test vacuum tubes without proper equipment but the inspection and tests below will find most bad tubes but will not pick up weak tubes. As a side note, when a repair shop replaced tubes, perhaps 20% of the tubes they replaced were actually bad (I know because the local TV repair shop's trash can was a favorite hangout on pickup day and nearly all the tubes I scrounged tested perfectly good on a real tube tester once they were washed of coffee grounds and cigarette ash!) Whether this represented legitimate preventive maintenance or just IPM - Increased Profit Margin, I really do not know.)

1. Look for a silvery metallic spot somewhere inside the tube. This is the getter and is there to remove the last traces of gasses. If you see this, the vacuum is intact. If it is milky white or red, the tube has lost its vacuum and is dead-dead.

2. Use an ohmmeter to test for filament continuity. The nice thing about tubes (aside from their cheery glow) is that you can see inside (at least for the ones with a glass envelope) and locate the filament connections by tracing from the pins - it will be the whitish fine wire in the center of each of the tube sections. (The filament is almost always pins 3 & 4 on a 7 pin tube, 4 & 5 on a 9 pin tube, and 2 & 7 on an 8 pin tube.)

3. You can check for inter-element shorts (but not at normal operating conditions) with a VOM or DMM. For glass tubes, even without a tube manual, you should be able to deduce which elements are supposed to be isolated by visual examination.

Now, just jump into your time machine, back about 20-30 years should do it (remember?) when every corner drugstore and TV repair shop had a tube tester. There is, of course a good chance that your local TV repair shop still has one (if they can find it under an inch layer of dust) and it may even work.

Capacitors and resistors:

If you just dug this thing out of the attic, it is very likely that electrolytic capacitors have dried up and paper capacitors have turned leaky. Professional restorers will often install modern replacements for all of these capacitors without even testing the old ones. To maintain the authenticity of the vintage equipment, they may actually remove the guts of the old capacitors and mount the new ones (which are much smaller anyhow) inside the original cans.

Old carbon resistors can absorb moisture and change value. If your measurements do not agree with their marked rating based on their tolerance, consider replacements. However, if within, say, 20 %, for now, leave them alone.

Sockets, switches, and controls:

Vacuum and/or use a small paintbrush to remove dust, spider webs, dead insects (and anything larger).

Remove each tube (or transistor) one at a time and use contact cleaner on the sockets. Tubes are usually keyed against incorrect installation. However, for transistors, make sure which way they go! You don't want to make a mistake. Use contact cleaner on all the switches and exercise them to help the contact cleaner do its job. Use control cleaner on all the potentiometers and rheostats and rotate them back and forth to help clean the track. Put a drop of oil into the bearings of any non-enclosed (multiplate) variable capacitors. Lubricate mechanical dial pointers, pulleys, and and other similar mechanical parts.

Testing (use an isolation transformer with AC-DC line connected sets):

Much of this old equipment had schematic diagrams pasted to the cover - really handy if the paper hasn't totally disintegrated.

Turn on the power but be prepared to pull the plug in a hurry if, for example, a capacitor should decide to blow up (this shouldn't be a problem if you replaced them all unless some electrolytics are in backwards).

It is probably best to use a Variac to increase the voltage gradually. In fact, this will help to 'reform' old electrolytic capacitors that have developed excessive leakage. However, by 'gradually', we may be talking hours or days to reform capacitors! I would still recommend replacement even if this appears to work.

Do the filaments light up? If your equipment has a power transformer, the filaments are probably wired in parallel, so if one tube is out, that tube is bad (or its socket). If they are all out, then the power transformer or AC line input is bad.

If it is an AC-DC set like a table radio, then the tube filaments are wired in series. If one is bad, they will all be out. Get out your ohmmeter, pull each tube, and check it for filament continuity.

Assuming the filaments check out - all sections glowing (for metal tubes, feel the case for warmth after a few minutes though this won't guarantee that all sections are alive) when power is applied:

WARNING: It is possible for metal cased tubes to develop a short between one of the high voltage electrodes like the plate and the metal case. Test with a voltmeter before grabbing one of these and keep that other hand in your back pocket!

Check for DC voltages out of the power supply. There will be big filter capacitors - check across those. Watch out: we are talking several hundred volts and BIG capacitors - ouch.

With no signal, check plate voltages on the various stages - there should something. If you measure 0, then a plate resistor or coil could be open or the tube may be shorted.

The rest is just basic troubleshooting. Think of the vacuum tubes as oversize high voltage depletion mode FETs (field effect tubes, why not?). This is not much different than modern equipment except for the bites the relatively high voltages can take out of your hide.

There are some links in Sam's Neat, Nifty, and Handy Bookmarks to vacuum tube information and troubleshooting.

Additional comments on old equipment restoration

(From: Carl Ratner (artdeco@bway.net).)

A good place to post problems is rec.antiques.radio+phono. There are often discussions there about fixing vintage electronic gear.

Many long books have been written about fixing old radios! If you don't want to do a lot of reading and learn a lot of theory, here are some practical tips: First, give the radio a thorough physical inspection with the power disconnected. Use your eyes and your nose. Look carefully for broken or disconnected wires, charred components, damaged insulation, etc. If you see wax dripping from a transformer or if it smells burnt, there has been an overload of some sort that will need to be identified. If the set has an internal antenna, make sure that it is connected. If an external antenna is required, connect a long piece of insulated wire, say 15 feet, and lay it on the floor. Old sets will play very weakly or not at all if the antenna is missing. Always replace the power cord if it is deteriorated.

In radios of 1930s vintage, it's very likely that all wax paper capacitors, as well as the electrolytic capacitors, are bad. First thing to do is replace all the wax paper ones with modern mylar types. If you have the tall metal can electrolytics, you can put modern ones under the chassis (the new ones are tiny). However, you must disconnect the old ones from the circuit... don't bridge the new ones across the old. Be sure to observe polarity of electrolytics. You may leave the old cans in place to retain original appearance. BTW, the old square mica capacitors seldom need to be replaced unless the cases are cracked open of they have other obvious damage.

Even if some of the old wax paper capacitors are still good, they are likely to fail within a few days if you start using the set. I've restored hundreds of old radios and have learned this from experience. Get them all out of there and save yourself a lot of trouble.

You should also check the value of all the carbon resistors in the set. They tend to go high or open with age. Replace the bad ones with modern equivalents (same resistance and wattage). You may have to disconnect one side of a resistor when testing it, as the associated circuitry can cause a low reading. However, if a resistor reads way too high, you don't have to bother disconnecting it for testing as it is definitely bad.

Your set should start playing quite well after you change all the capacitors and possibly some resistors. You noted that you had changed the tubes, and I'll assume that all the replacements are good. Tubes don't fail nearly as often as people would expect, however, and it's possible that the set's original tubes were OK. Once you get the set working, you can substitute the old tubes one at a time to see if the set continues to play. Then just keep the good ones as spares.

Set still dead? If you have a multimeter, check the B+ voltage. The audio output tube's plate connection is a good place to do this. This can be 250-350 hundred volts in a transformer set, so work with care. If B+ is absent or some very low value, you have a problem in the power supply. (If you tell me the tube numbers in your set, I can give you some of the pinouts for testing) If the rectifier tube is known to be good, and you have already changed the electrolytics, then you may have a bad power transformer (large black box, usually near a back corner of the chassis. These are hard to find nowadays and very costly. I'm assuming here that you don't have a B+ short somewhere else in the radio. You will know about that because something will be smoking if such a short exists!

There are other components that can fail. Inspect the speaker for physical damage. You can test the voice coil and field coil for continuity. Replace if open. A modern permanent magnet speaker can be substituted for an old field coil speaker, but a power resistor of abut 1500 ohms, 20 watts must be added to replace the field coil. Dirty volume controls and band switches can cause noisy, weak or intermittent sound too. Clean them with a good spray cleaner such as Deoxit D5. Avoid the "tuner cleaner" that is sold at Radio Shack. It is worthless for fixing old radios.

As a final step, your set may need an alignment. This consists of adjusting all the tuned circuits to factory specifications to obtain the best possible performance from your set. You need a signal generator and an output meter to do this properly. It is strongly recommended that you do not twiddle any screwdriver adjustments on the IF transformer cans or elsewhere in the set unless you know exactly what you are doing. Misadjustment will cause the set to play very poorly or not at all.

End of short course in fixing old radios.

(From: R. G. Keen.)

1. Use a battery or ohmmeter to verify that the speaker clicks when electricity hits it.

2. Disconnect the output transformer primary and use the battery on the primary to verify that it makes the speaker click, albeit faintly.

3. Power the amp. verify that the plate(s) on the output tube(s) are sitting slightly below B+, and that cathode is near ground, grid more negative than cathode.

4. Touch a probe to the grid of the output tube, listen for a click in the speaker. No click means that the output tube or it's surrounding circuitry is bad.

5. Assuming that (4) worked, go one tube back up the signal chain at a time, touching grids and listening for clicks. When the clicks stop, that tube or the circuitry around it is bad.

6. When you find the bad one(s), measure all the resistors and check the capacitors for leakage. Measure the tube pin voltages for plate high, cathode low and grid less than cathode. sub in a new tube.

7. It could be an open volume or tone pot between stages. Also a bad solder joint. remelt and touch with a bit of rosin core solder every joint in the bad stage.

(From: John Mitchell (j.b.mitchell@qmw.ac.uk).)

Get a hold of the "The Amp Book" (or something like that) by Aspen Pittman. It's stuffed full of dozens and dozens of tube amp schematics plus other info on mods servicing etc.

Capacitors in old equipment

(From: George R. Gonzalez (grg@umn.edu).)

I used to repair mostly oooold radios from the 1930s and 40s. Now I'm doing more of the newer stuff, including test equipment and stereos from the 60s and 70s. Here's my rundown of what needs replacing capacitor-wise:

- 1920-1935: Radios have non-polarized paper-oil filter caps. These are usually in very good shape. You maybe have to replace 5% of them.

- 1935-1950: At least half the electrolytics have dried out. Some of the others will reform, the rest are too leaky to use. About 80% of the wax- covered caps are leaky, although this depends on how dry the radio was kept.

- 1950-1970: 80% of the black and blue-green bakelite caps are very leaky. About 30% of the electrolytics have dried out. One exception, the Sprague 350Ds look nice on the outside, but about 80% are dried out, leaky, or shorted, especially those with date codes before 1970. Those bakelite-cased electrolytics sealed with black, yellow, or red goop are almost all leaky or dried out.

I think I'm going to stock up on small electrolytics, as those seem to only have a 30-year life, even in the cooler-running more modern equipment.

Tube amp Web sites

Sites with tube amp design, troubleshooting, info, links:

(From: Duncan Munro (postmaster@muffy.demon.co.uk).)

- Duncan's Amps
- Triode Electronics Area 51

(From: Jan B. Jensen (jbj@lif.dk).)

- AMPAGE Schematics
- Pat's Tube Schematics
- Guitar Special Effects/Tube Stuff
- Bob's Music/Vacuum Tube Audio/Electronics Page

TV/VCR combos

These hybrids which include both a TV and VCR (and sometimes other stuff as well) seem to combine the worst of all possibilities. Although, in principle, the idea of a combination TV/VCR sounds good - no cabling to worry about, ease of use, compatibility assured, the result may be less than meets the eye. While TV/VCR combo units do include both a TV screen and a VCR transport, very often there is only a single shared tuner so that viewing and recording of different programs is not possible unless one is from an external baseband video source (assuming there is a suitable input jack) like - you guessed it - a VCR or laserdisc player.

If either the TV or VCR poops out and needs repair, the entire unit may be unusable either because of shared circuitry or because the whole thing is in the shop. Construction quality tends to be shoddy and some designs are poor to begin with. Finally, as if this is not enough, servicing is difficult and painful because everything is crammed into a single compact (at least that is a good feature!) unit.

Refer to the appropriate documents for your particular problems.

Boomboxes and compact stereo systems

These combine a stereo receiver and a single or dual cassette deck, and/or a CD player or changer, and a pair of detachable speakers, into a single unit. Most are fairly portable but larger boomboxes and compact stereos may require a forklift to move any great distance.

While the individual subsystems - CD player for example - are usually relatively self contained electrically except for a common power supply, mechanically, everything tends to be jumbled together - even on units that have an outward appearance of separate components. Both cassette transports are usually driven from a single motor. Getting at the CD player may require removal of both cassette decks, audio amplifier, and power supply. Working on these is not fun. As usual, take careful notes as you disassemble the unit and expect it to require some time just to get to what you are after. Be especially careful when removing and replacing the individual modules if printed flex cables are used for interconnections.

Refer to the relevant sections on cassette transports, loudspeakers, and power supplies for problems with these units. Refer to the document: Notes on the Troubleshooting and Repair of Compact Disc Players and CDROM Drives for CD specific problems.

Since these do get abused - bumped, dropped, dunked, etc., bad connections, and other damage is very common. See the sections: "General intermittent or erratic behavior" as well as "Noisy or intermittent switches and controls".

Design to discourage repair

Here is a description of the pain involved in attempting to get at the CD player part of a Garrard boombox. Sadly, this is all too typical of 'Getto Blaster' construction.

(From: BELJAN E (lvpy67c@ix.netcom.com).)

I managed to get the whole Garrard mess disassembled (this thing is a major pain to service). The CD mechanism is removable, but just try it. This boombox has all sorts of modules: main board, display, cassette, radio, power supply, and CD are all separate. The problem is the way it is designed you simply cannot reach all the connectors to get the CD player out. If I could get the CD player out, I could disassemble it and find the solution. By the way, voltage to CD section appears OK. I would not have been able to find loose connections had there been any. I put it back together, CD still dead, everything else still works. It is convenient to service only if you intend on replacing the entire mechanisms (possibly Garrard's motive?). If I really needed to, I could simply detach the CD mechanism and replace it. I wouldn't bother. I see they now have Garrard Boombox with Dual CD players, and one with all sorts of features, one with detachable speakers and so on. This is a mystery, with the voltages OK, it would seem that there would be a loose connection, but none are visible (remember I cannot get the whole thing out).

I say this thing is a pain to service, here is why:

1. You must have an 8 inch long thin phillips screwdriver to disassemble it.

2. You must remove the cassette player to reach the Display.

3. You must remove the display to reach the switches.

4. You must remove the switches to reach the CD mechanism.

   An interesting note: the display modules are connected to the CD mech, along with the headphone module, they work fine.

5. you must unscrew the CD player from behind, then attempt to slide it forward, while it is connected to the main board from behind with white push on connectors. You get it halfway out, careful now, you don't want to damage the Cassette deck, which is connected somewhere out of visibility.

6. Once you slide it forward, you must try to loosen the slide on connectors without dropping the whole mechanism on the main board. (you need 6 hands and screwdrivers to try to do this.

7. On top of all that, the Whole Front of the unit is hanging there, connected also out of site

This unit is incredible. Truly incredible. It is easy to replace whole components, but servicing?

Panel lamps out

In the old days, this was due to the failure of easily replaceable and widely available miniature incandescent lamps. Even today, may displays are not LEDs as you might think but LCDs with backlighting provided by - you guessed it - incandescent lamps. Unfortunately, they are rarely easily replaceable and or as widely available.

This will be particularly likely if the display color is anything but the most common for LEDs - red. You might find green LEDs but will not likely find orange and certainly not blue or purple. LEDs would not be orange because the additional cost of orange LEDs would not translate into increased sales of boomboxes (or whatever). Blue LEDs are very expensive and purple ones do not exist.

The bulbs are replaceable. Getting at them may be easy or require entirely disassembling the unit. Soldering may be required as the manufacturer saved a nickel by not providing a socket. They may be tiny and special - try places like MCM Electronics for replacements.

If they are really red LEDs or vacuum fluorescent displays, then the most likely problem is a bad connection or other physical damage.

Adjusting station/channel settings on tuning dials

So 95.7 MHz comes in a 100.1 MHz on the dial.

Don't touch any of the trimmers on the tuning capacitor! They didn't magically change their settings. Just move the pointer on the dial cord to match a known centrally located station. If it is glued, you may have to carefully break the bond between the pointer and the dial cord. Then put a drop of household cement to fix its position when you are satisfied with the adjustment. Only if the ends of the dial are way off frequency should you consider anything beyond this mechanical fix.

Caution: Be careful! Should you accidentally cut the dial cord or have it pop off of the pulleys, you will have a much bigger job ahead of you. In this unfortunate circumstance, see the section: Repairing a broken dial cord or tuning gang wire.

Repairing a broken dial cord or tuning gang wire

With age, use, or through some mishap, it is inevitable: your analog dial no longer works because the string that runs between the tuning knob, variable capacitor, and dial indicator has broken. How does one repair it?

The simple answer is: very carefully! :-)

Demonstrating your skill in stringing dial cords is one of those rites of passage that has (thankfully) pretty much disappeared :-). Usually, it succumbs to a bit of logical thinking and carefully placed bits of tape to keep the entire mess in place until the last knot is tied!

These are a royal pain - especially if you do not know the original routing. In this case, some of it is going to be by trial and error. Some of my learned-the-hard-way tips:

1. Major electronics distributors will actually be able to supply dial cord material without making too much of a face though they may have to go into a dusty old bin to locate it!

2. Start at the variable capacitor pulley. Tie your favorite knot and secure it with some semi-flexible adhesive like Duco Cement(tm) or windshield sealer.

3. Route the cord around the appropriate idlers and the tuning knob shaft.

4. As a default, 3 turns on the tuning knob shaft seems to be common. If there isn't enough space for 3 turns, use 2 turns. If it slips with 3 turns, use 4 turns.

5. If in doubt about the direction, determine which way it will end up turning the variable capacitor.

Clockwise rotation of the tuning knob should increase the channel frequency by decreasing the capacitance - plates separating.

6. Use bits of electrical tape or putty to keep the cord from popping off of the idlers, etc., until you have it firmly attached to the spring on the other side of the variable capacitor pulley.

7. Once you are happy with the routing, pull it tight enough to stretch the tensioning spring about half-way. With the cord held in place with your finger, confirm free and smooth movement throughout the entire tuning range.

8. Tie the cord off and seal it as in (1) above.

9. Install the dial pointer - it usually just clips on. Tune a known station and slide the pointer along until it lines up with the correct frequency. Use a dab of sealer to keep it from wandering off.

Congratulations! You are done. Hopefully, only 3 or 4 iterations were needed. Now, if you need to do this again, it will be easier! And, your supply of tuning cord will probably last centuries.

One more gotcha: Don't attempt to solder circuitry near a dial cord - get your iron near it and the stuff often used melts instantly - much fun! Push it out of the way or shield it with something.

Revival of dead or tired remote control units

There are two types of problems with hand held remote controls: they have legs of their own and they get abused or forgotten. I cannot help you with walking remotes.

Where response is intermittent or the reliable operating distance is reduced, first check the batteries and battery contacts. If some buttons are intermittent or dead, than the most likely cause is dirty or worn contacts under the rubber buttons or on the circuit board.

If there is no response to any functions by the TV or VCR, verify that any mode switches are set correctly (on both the remote and the TV or VCR). Unplug the TV or VCR for 30 seconds (not just power off, unplug). This sometimes resets a microcontroller that may have been confused by a power surge. Confirm that the remote has not accidentally been set to an incorrect mode (VCR instead of TV, for example). If it a universal type, it may have lost its programming - reset it. Make sure you are using the proper remote if have multiple similar models.

Test the remote with an IR detector. An IR detector card can be purchased for about $6. Alternatively, construct the IR detector circuit described in the companion document: Notes on the Troubleshooting and Repair of Hand Held Remote Controls.

If the remote is putting out an IR signal, then the remote or the TV or VCR may have forgotten its settings or the problem may be in the TV or VCR and not the hand unit. The following is just a summary - more detailed information is available in the companion document: Notes on the Troubleshooting and Repair of Hand Held Remote Controls.

Problems with remote hand units:

All except (1) and (2) require disassembly - there may be a screw or two and then the case will simply 'crack' in half by gently prying with a knife or screwdriver. Look for hidden snap interlocks.

1. Dead batteries - solution obvious.

2. Corroded battery contacts, Thoroughly remove chemical deposits. Clean contacts with pencil eraser and/or sandpaper or nailfile.

3. Broken connections often between battery contacts and circuit board, possibly on the circuit board - resolder.

4. Bad resonator or crystal - replace, but diagnosing this without an oscilloscope may be tough. Broken connections on resonator legs are common.

5. Dirt/spills/gunk preventing keys from operating reliably. Disassemble and wash rubber membrane and circuit board with water and mild detergent and/or then alcohol - dry completely.

6. Worn or corroded contact pads on circuit board. Clean and then use conductive Epoxy or paint or metal foil to restore.

7. Worn or dirty pads on rubber keypad. Clean. If worn, use conductive paint or metal foil to restore.

8. Cracked circuit board - can usually be repaired as these are usually single sided with big traces. Scrape off insulating coating and jumper breaks with fine wire and solder.

9. Bad LED. If IR tester shows no output, remove LED and power it from a 9V battery in series with a 500 ohm resistor. If still no output, replace with readily available high power IR LED. Otherwise, check driver circuits.

10. Bad IC - if it is a custom chip, forget it! Failure of the IC is usually quite unlikely.

    (The following is from Duane P Mantick:)

    An awful lot of IR remotes use IC's from the same or similar series. A common series comes from NEC and is the uPD1986C which, incidentally is called out in the NTE replacements book as an NTE1758. A lot of these chips are cheap and not too difficult to find, and are made in easy-to-work-with 14 or 16 pin DIP packages. Unless you have no soldering or desoldering skills, replacement isn't difficult.

There are a large variety of universal remotes available from $10-$100. For general TV/VCR/cable use, the $10 variety are fine. However, the preprogrammed variety will not provide special functions like programming of a TV or VCR. Don't even think about going to the original manufacturer - they will charge an arm and a leg (or more). However, places like MCM Electronics do stock a variety of original remotes - prices range from $9 - $143 (Wow $143, for just a stupid remote! It doesn't even have high definition sound or anything exotic). The average price is around $40.

Problems with keypads or touchpanels

Most common are moisture problems followed by physical damage:

Very often, a little overzealous cleaning results in moisture trapped inside a not quite perfectly sealed membrane keypad or touchpanel.

First, of course, dry off the exterior as best you can. Any moisture that seeped inside may be difficult to remove without surgery - which is definitely not something you want to undertake as the long term reliability will be compromised.

I would recommend waiting a while - a week may be required - for it to totally dry out. You could also try confirming across the touchpad contacts with an ohmmeter that there is still low resistance (even 10s of K ohms may look like a button press). It is nearly impossible to speed up this process without subjecting the device to conditions that may harm the device - heat and/or vacuum. You possibly try something like isopropyl alcohol in the hope that it will displace the water and dry quickly. I do not know if this will be safe in every situation, however.

Of course, it is also possible that are other problems but I have seen these things take a very long time to dry out.

However, significant damage - a membrane type touchpad is punctured - may require replacement unless you can repair the internal wiring. The connections are usually made with flex-cables which are difficult or impossible to repair. See the section: Repairing flexible printed cables. Damage to any membrane buttons may result in stuck buttons or improper operation of other buttons.

Repairing flexible printed cables

It seems that more and more consumer devices from pocket cameras to laptop computers are being built with miniature multiconductor flexible printed cables. Very often one or more traces to develop hairline cracks due to repeated flexing. In addition, damage from moving circuit boards and modules during servicing is all to common.

Needless to say, repairing any kind of flex cable is a real pain!

Caution: many devices like calculators have printed cables that use a material that will not take solder and are glued rather than soldered at their ends - the logic board and LCD panel, for example. Repair of problems with the cables is virtually impossible. Take great care when working inside of devices with this sort of cabling to prevent damage to the cables or their termination.

With types like these in particular where soldering is not possible at all, the use of conductive paint, conductive Epoxy, or the stuff in a windshield defrost heater repair kit are worth trying.

For the metallic conductor types, I have succeeded by carefully scraping the plastic off with an Xacto knife and then soldering fine wire (#30 gauge wire wrap for example) to the traces. This presumes that the conductors on your cable will even take solder. I then cover up the joints with a flexible sealer for electrical and mechanical protection.

However, you need to make sure that the wire you use can be flexed or that the joint is set up in such a way that the wire does not flex much - else you will just end up with broken wires pretty quickly.

Soldering from end point to end point if possible may be preferable. Even going to only one endpoint would reduce the risk of immediate damage and reliability problems in the future.

With multiple traces broken or damaged, you are probably better off replacing the cable entirely.

Where the break is near one end and the equipment will be happy with a cable that is slightly shorter, it may be possible to cut off the bad part, carefully scrape the insulation from the appropriate side exposing a new set of contact strips to go in the socket.

(From: Steinar Botten (sbo@nera.no).)

I just fixed an electronic kitchen scale where the glued-on flex cable had begun to come loose from the LCD display, causing some of the segments to grow faint and disappear, while others showed when they shouldn't. In my first attempts I used conductive paint, but I couldn't get the viscosity right so that the paint didn't spread and short-circuit some of the connections. So I removed and discarded the flex cable and cleaned the tracks on the PCB where the cable had been attached. I searched through my collection of IC sockets and found one type with "fork-type" contact springs that could be removed from the socket and that fit snugly over the glass edge of the display. The spacing of the contact points of the display left just enough room for insulation (I used linen thread because the subsequent soldering would have melted plastic tape) between the contact springs. After having fixed the display back on the PCB with double-sided tape I soldered fine copper wire between the springs and the PCB. And voila, the display was OK again.

Some ASCII art might make things clearer, here is a side view of the LCD display:

```
          ___
         ! ! !
         ! ! !
         ! ! !
 contact !_! !
  side --> ! !
          !! !!
          !!_!!
          !___! <-- contact spring from IC socket
          !
          !
```

Obviously, this probably wouldn't work on a pocket calculator because of the size of the contact springs.

(From: Bob/Brad (santek@mb.aibn.com).)

On some displays, the ribbon cable is fastened to the display by a heat activated adhesive, called a "heat seal" for obvious reasons. Once you take the old one off it must be replaced with a new one. In my experience you cannot try and reattach it never works. There is a special tool made for doing this (attaching cable to display) that consists of an iron with a bar on the end (like a T), once seal is lined up you press bar onto tape for a second or two and its done, but its a one shot deal. I used to do quite a few when I worked for a company that repaired pocket organizers, lots of fun!!

Comments on soldered flex cables

(From: Ken Bouchard (bouchard@ime.net).)

These are the leading cause of problems for me! I repair camcorders for a living, and all too often have seen these flex cables fall off the PCB, or are so delicate in construction that they fall away from the PCB.

In many cases during repair stage, I often touch up the soldering with a low heat iron, while pressing down on the soldered to PCB area of the cable, with a flat plastic blade, enough to re-flow the connection. Then I take and apply some general purpose glue around the cable to get it to adhere better to the PCB and prevent tearing. Of course the consumer never should encounter a problem unless the camcorder is dropped, and the case splits open and rips the connectors away from the PCB.

Sony is infamous for having connectors fall off the boards. Many brands of camcorders are infamous for having connectors that mate 2 boards together break away from the PCB. It is a very bad situation because the boards they work with are very expensive to replace. For the cost of a simple piece of flex cable and 2 insertion force sockets, it is amazing they are cheap and choose to mate the boards together directly, knowing that failure is just around the corner!

Most commonly the CCD board or camera assembly is mated to the video (main) PCB in this fashion and it is very sad when they break due to stress. This is one reason that the consumer should never ever attempt to repair delicate items like this.

The best you can hope for in dealing with these is to never attempt to repair the flex cable by soldering to it, etc. That is asking for future problems at best...

Don't 'tin' the ends of the cable either, you simply melt and distort it so that it will no longer get a good connection into the socket. Only clean it possibly with denatured alcohol if needed - otherwise replace it.

Also do not stress them, you soon discover how easily they rip!

About elastomer ('zebra stripe') connectors

Remember that first (or last) digital watch you took apart? Remember how a little piece of rubber fell on the shag carpet and you thought: "What the heck, that can't be anything important". Remember how the watch's display never worked again? Well, you lost the connector that linked the LCD panel to the logic board.

Elastomer or 'zebra stripe' connectors are used to attach LCD panels to the logic board and interconnect multiple boards on digital watches, calculators, pocket computers, and many other modern gizmos. It seems as if every cheap and many not so cheap gadgets now uses this connector technology.

They can shift position, become dirty, and lose pressure due to warpage or damage to the plastic retainers. Very often, a weak display or missing segments can be traced to a problem with these 'zebra stripe' connectors. Equally often, disassembling, cleaning all parts with alcohol, drying, and reassembling will return the device to (better than) new condition. When installing, make sure the striped edges are against the circuit traces if there is any ambiguity.

Of course, it isn't that the zebra stripe shifts position a small amount - by its nature this should not matter. However, if the display shifts with respect to the circuit board contacts or the zebra stripe material becomes twisted or angled, poor and/or erratic connections will result.

(From: Spehro Pefhany (speff@gold.interlog.com).)

These are conductive elastomer connectors made from alternating layers of conductive (carbon filled) and insulating silicone rubber.

There are also lower resistance versions with embedded wires, but they are not used for LCD displays because the series resistance doesn't matter for LCD's.

Alignment to the PCB is critical as is even pressure, so they tend to be used only in high volume applications where a metal stamping or plastic molding is used to hold all the parts in place.

Identifying wiring on an auto radio/cassette

So you want to use your old car stereo as a boombox but don't have the connection information. Here is what I would do:

Locate the power - there will be a +12 switched and possibly a +12 unswitched for channel memory. At least one may be obvious if has an in-line fuse. Use an ohmmeter if necessary. Once you have found the power connections, power it from your 12 V power supply. Keep the volume way down and use the balance and fader controls to identify the speaker connections. There will be either 2 pairs of wires or more likely 4 pairs for front and rear speakers.

Ray's notes on plastic part repair

(From: Raymond Carlsen (rrcc@u.washington.edu).)

I recently had to repair a power supply for a camcorder. It was dropped. Parts of the case were broken, and the circuit board inside was cracked. Board repair was easy. I glued the PC back together with superglue and soldered across the broken traces with jumper wires.

The plastic case presented me with more of a challenge. Two little "ears" held the front end cap on the unit with small screws. The ears were broken into several pieces and could be heard rattling around inside the case. I could glue them back together, but the results have, in the past, been unreliable at best.

I decided to try and reinforce the plastic. I often melt solid hookup wire across a break (on the inside, where it doesn't show) with a soldering iron to strengthen a glued area, but these tabs were so small, any heat would warp them and the case would not fit back together. What to do?

I noticed once that when Superglue gets on ordinary notebook paper, it gets hard as a rock. It is difficult to tear, but is flexible enough to bend a little without breaking. Since one side of the little plastic ears were essentially flat, I superglued a strip of paper on each ear. The glue partially melted the plastic and made a good strong bond. After the glue set up, I trimmed the edges with an Xacto knife and poked holes in the paper for the mounting screws. The finished repair is stronger than the original product. The paper reinforcement is thin enough that there was no problem fitting the front back on the case.

Putting equipment into long term storage (Self-Stor, etc.)

Electronic equipment is happiest if kept in the same type of environment that humans like - moderate temperatures, low humidity. What if you are forced to store equipment for months or longer in a non-environmentally controlled space like a public storage facility?

Recommendations:

1. Find some long lost relatives who will store the electronics for you in a heated space.

If this is not possible:

2. Seal each piece of equipment in a thick plastic bag along with a pack of dessicant to keep it dry (that silica gel stuff you always throw away). This will preferably be in the original packing box (and include all cables, accessories, and manuals, so they won't get lost.)

Moisture is more of a problem than the absolute temperature (within reason) or temperature fluctuations. Therefore, avoiding the totally damp and dingy dungeon of a medieval castle is definitely desirable.

Dealing with a kit that was assembled by someone else a long long time ago

When you purchase a commercial piece of equipment, it is assumed that the construction has been done properly. This may not always be the case but it is more likely when a million of something is manufactured than a hand soldered kit possibly assembled by someone who barely knew which end of the soldering iron to hold!

I picked up a Heathkit DMM at a garage sale for next to nothing that had apparently never been quite completed. The problem turned out to be a defective rectifier in the power supply. However, everything else including the soldering was perfect. For kits, this may be the exception :-(. The original owner must have given up when the DMM didn't power up properly - and had no DMM to debug it with!

(Portions from: jmccarty@sun1307.spd.dsccc.com (Mike McCarty)

1. Look for improperly soldered joints. Kits often are soldered by people with, shall we say, less than completely optimal soldering skills. I have looked at kits I assembled when I was a teenager, and can't believe the joints were really that bad.

2. Clean any switches or other moving contacts with some good TV tuner cleaner.

3. Vacuum out any dust which may have accumulated. I prefer that to using compressed air, but you may use that also; be careful of compressed air which may come out with a high static charge.

4. Reseat socketed components and any boards with edge connectors. If the contacts look oxidized, clean them with a soft pencil eraser and/or contact cleaner. Look for loose spade connectors as well.

5. Check for loose screws or other fasteners and tighten if necessary.

6. Jiggle wires and look for corrosion/fatigued wires especially where flat ribbon type cables are used

7. Where something is more than 10 years old (in particular), it may be a good idea to check and/or just replace any electrolytic capacitors which may be drying out.

8. Replace any primary batteries after thoroughly cleaning the battery contacts. Depending on age and previous use types may also be bad as well. Discharged lead-acid types more than a year or two old are likely hopeless. However, I have found some NiCds that were quite old and perfectly fine.

9. Finally, if the equipment had possibly never been operational (i.e., you found the cover still in its protective plastic bag!), check ALL components for proper location and direction before applying power. Of course, it may already be too late if there was a part installed incorrectly and the original owner attempted to power it up.

Cleaning exterior surfaces

I usually start with soap and water or mild detergent. If this does not work, rubbing or 91% medicinal alcohol, 'Windex', and then, WD40 are tried. All of these are usually safe for plastics though some paints or printing may be affected - test on an inconspicuous area first. Scouring powder and/or sandpaper is only used as a last resort! :-) However, in some cases, where there is serious discoloration due to heat and ozone, these may prove somewhat effective...

One or more of the following will probably work even for tough tobacco smoke/tar buildup (also more in the next section, below):

(From: Terry DeWick (dewickt@esper.com).)

I have found plain household ammonia works well especially since it is cheap, if not available I use '409' or 'Fantastic' cleaners.

(From: Ralph Wade Phillips (ralphp@gcstation.net).)

'Scrubbing Bubbles' bathroom cleaner (Dow is the brand I use) works better than anything else I've found yet, besides chucking the case.

Be sure to follow with a decent Windex-like cleaner - the residue from the Dow cleaner will cause you to gasp every so often for the next six months!

(From: Joe (joeb@viaduct.custom.net).)

Go to SAM'S and get a jug of 'ENTNT'. Mix it in a spray bottle with water (I like about one part ENTNT to four parts water) and enjoy watching the nasty brown yuck drip off the monitor. Finish the job with windex to remove the residue from the ENTNT. The ENTNT is safe on plastic, but test it on painted surfaces first.

Eliminating tobacco smoke smell from electronic equipment

Of course, the best way to avoid this hassle is to not subject your equipment to second-hand smoke. However, where you picked up something at a garage sale or flea market, you its previous habits may have been out of your control!

CAUTION: Where an oven is suggested for drying, make sure it's temperature can be set low enough to avoid melting plastic and damaging sensitive electronic components!

(From: Hapticz (hapticz@email.msn.com).)

First, unplug it. then open it up as much as possible. get a spray bottle of Fantastic and cut the strength in half with water.

Put the thing over the kitchen sink and spray away. let it sit for a minute and watch the yellow nicotine crud slither out. repeat if necessary you shouldn't even have to do any scrubbing.

Avoid getting the stuff into inaccessible dial spaces, water spots are inevitable.

Then, and this is very important, use the sink spray to thoroughly, very thoroughly, rinse any hint of cleaner out. (it is NaOH, most all cleaners are)

Shake it off, spin it around, whatever, to remove excess water.

Heat your oven to 140 degrees F. put in oven for 2 to 3 hours. use some kind of metal cookie sheet between it and the oven elements to avoid radiant melting.

If it's got a lot of plastic, lower the heat to 120 and leave for 4 to 5 hours.

Hair dryers work well if you're willing to stand around for 2 hours.

It sounds weird, but it has worked very well for me on many items.

(From: Jerry Greeberg (jerryg50@hotmail.com).)

In the high end service industry boards are washed when serviced if the need arises.

You can use a mild soap. At home Fantastic will do the job for getting rid of cigarette stains and grimy dirt on boards. You will have to rinse them very well with water afterwords.

You can dry your boards in an oven at about 120 to 150 degrees F. But your home oven may be a bit too intense for this. The upper element tends to come on too strong at times because your oven was really made to work much higher.

You can shake off the boards and let them dry under some 60 watt lamps for a few days. Make sure they are not too hot on the boards. Do not exceed about 160 degrees F. average, or you can cause some damage.

It is very important that you let these boards be properly dried before putting the power back on them.

As for the case and non electronic pieces, you can also wash these... These must also be very dry before assembling. A drop of water on the electronics will cause you a lot of grief, and possible damage, if the power is turned on with wetness present.

I would say that you can do a mild cleanup by just blowing the boards off with forced air, and then gently cleaning things with Q-Tips, paper towels, and isopropyl alcohol.

It is extremely important that you do not disturb any trimmer adjustments, or devices that effect the alignment of the boards. you will never be able to get these adjustments back to their proper positions yourself without the proper test gear and facility setup.

You can take the case apart and wash all the non electrical parts with dish soap and water. Also these parts must be properly dried before assembling.

(From: John (jberenyi@tacisp.com).)

Well I tried it. Took the radio completely apart and soaked the boards with Scrubbing Bubble foam spray. Wow does it make aluminum shine and strip that nasty crap off the boards. A final clean with Windex and a clean rinse with distilled water is the final touch. Then I used compressed air to get most of the water removed. Next I got a cardboard box to put all the equipment in to and hooked up a 100 watt bulb and thermometer. I baked everything for 2 days at 130 degrees. Sure looks nice and works great!

When glue is more than glue

(From: Jim Leone (jim.leone@paonline.com).)

I have two words (no they are not plastics --- sam): Resistor Glue.

A lot of today's electronics manufacturers, before the printed circuit board goes through the flow solder machine, use a certain type of glue to hold down large components like heatsinks, electrolytic capacitors, and resistors. After 2 to 3+ years of life, bonded to a high temperature component, this glue turns conductive!!!!!!!

One blatant example of this is the Viewsonic (however many other manufacturers use the same type of stuff) 4e Model 7033 computer monitor where the 86VDC main rectifier on the switching supply has it's pins coated with this 'Resistor Glue'. When the monitor was new the glue has a tan color and kind of feels like really dried up chewing gum. You know, the kind that has been under a desk for 1 year. After about 2 years, the color has changed to a darker brown; it could be almond to dark walnut colored. Now you should be able to easily remove it by scraping it away with an Xacto knife, and it will crumble away.

However, in equipment left on 24 hours a day in moderate to high heat environments this glue takes on a more carbon hue. Typical units have holes burned right through the circuit board and others are left with carbon scarred 'divits' on the board that must be gouged out to keep the supply from arcing across.

On one hand, an optimist might say that this is a result of engineers who's goal was to get the product out before the deadline at the end of the month.

But on the other hand, a pessimist could say that this is a result of blatant planned obsolescence

Grounding of computer equipment:

While electronic equipment with 3 prong plugs will generally operate properly without an earth ground (you know, using those 3-2 prong adapters without attaching the ground wire/lug), there are 3 reasons why this is a bad idea:

1. Safety. The metal cases of computer equipment should be grounded so that it will trip a breaker or GFCI should an internal power supply short occur.

   The result can be a serious risk of shock that will go undetected until the wrong set of circumstances occur.

2. Line noise suppression. There are RLC filters in the power supplies of computer and peripheral equipment which bypass power supply noise to ground. Without a proper ground, these are largely ineffective.

   The result may be an increased number of crashes and lockups or just plain erratic wierd behavior.

3. Effectiveness of surge suppressors. There are surge suppression components inside PC power supplies and surge suppression outlet strips. Without a proper ground, H-G and N-G surge protection devices are not effective.

   The result may be increased hard failures due to line spikes and overvoltage events.

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Specific Problems and Repairs

Classic ATT Touch Tone phone will not dial properly

Most electronic equipment over 20 years old would be history but many of these are still around and in service for a couple good reasons: They are very reliable, almost indestructible, and still have a solid feel rarely duplicated in modern phones. Typical symptoms are: Everything works fine except erratic or no dialing. For some buttons, dial tone would not go away. For others, tones would be accepted but will be erratic and result in incorrect digits. Certain digits may sound weak, wavery, or single frequency (rather than the proper DTMF dual tones).

(Note that this is not the same as the situation where the phone does not dial at all - there are no tones of any kind generated. In this case, the wires to the phone may simply be reversed - old ATT touch tone phones will not dial out if they are but will work in all other respects. Modern phones generally don't care about phone line polarity.)

While the internal wiring of these old phones is intimidating, the basic tone dialing circuitry is an amazing example of simplicity. About the only things that fail yet still permit some tone generation are the pot core coils that determine tone frequency. Therefore, this is the first thing to check.

There are two cores which each consist of two halves glued together. Breaks seem to be a common problem due to both the age and the brittle cement used on some revs of this model phone, and probably, as a result of rough treatment when hanging up the handset, or dropping or throwing of the desk phone.

These cores must be aligned before being glued back together. In addition, there is an adjustment plug which may need to be tweaked. I align by ear as follows: Put a known good tone dialing phone and the bad phone on the same phone line. Momentarily depress the hook switches to silence the dial tone. You will now have about 25 seconds before the nice polite operator recording tells you how to make a call. Depending on which core is bad, depress either an entire (same) row or column of buttons on both phones. (Adhesive tape is handy to hold down the buttons unless you have four hands.) By depressing the entire set of buttons, you are disabling the other tone generator so you hear a pure tone. Without turning the fine adjustment plug (assuming it was not disturbed; if it was, set it mid-range or the same as the one in the other core), rotate the loose core top until a zero beat is obtained. As your rotate the core, you will hear the pitch change. As it approaches the correct setting, you will hear the tones beat against each other. When you are set correctly, the pitches will be equal and the beat frequency will go to zero. Mark the position of the core with a pen or pencil and then glue with Epoxy or other general purpose adhesive (around the outside - not on the mating surfaces as this will affect the tone frequencies). After the glue sets, confirm and adjust the plug core if needed. These cores use a strange triangular core tool - I made mine by filing down an aluminum roofing nail (do not use a ferrous material).

These classic ATT Touch Tone phones are virtually indestructible. However, broken cores (or actually, just broken joints on the cores) are common but easily repaired once you know what to look for. Setting the tones by referencing a known good phone seems to be a very reliable technique as the zero beat permits an adjustment to better than .1%. Note that if the reference phone is a more modern (and flimsy digital one), then pushing multiple buttons may not work as it does with the old analog models. Setting the frequency using the normal dual tones will work - it is just not as easy.

ATT classic dial phone will not dial

I know, you haven't seen one of these in years, but I just had to throw this in.

Most likely it was dropped - these phones simply do not seem to fail any other way. When dropped, assuming there is no obvious damage, a little plastic stop inside the dial mechanism which is on a pivot flips the wrong way. This normally prevents dialing pulses from being generated when the dial returns to its home position but when flipped, prevents dialing totally. It is real easy to flip it back into place.

About those old battlewagon phones

(From: Author Unknown)

I got a hold of a couple of old rotary dial AT&T 500 sets with the old non-modular cords for both the coiled cord and wall cord. Man, I love these old clunkers because no one likes to steal them and they last just about forever. The reason they work well is that where I put them the people mostly just answer the phone so the dial doesn't make any diff. And since they are so big and clunky they tend to stay in one place.

I took the wall cord off and cut a hole in the back for the modular jack that I got over at Fry's for under a buck. They make it a whole lot easier to change the cord. But I haven't been able to find the same kind of jack for the four pin coiled handset cord. I also got some of the rubber ducky shoulder rest thingies over at Radio Shock, and before I put them on I decided to clean off the handle of the handset with rubbing alcohol. Man was I in for a surprise.

I started rubbing on the handle with a cotton ball and some alcohol, and all the paint started coming off. What a MESS. After I used a lot of cotton balls and rubbing alcohol on the whole handset, I got off most of the paint, but the screw on covers for the receiver and transmitters were different colors than the original beige, one was PINK! Weird. So now I have an even uglier rainbow phone! Cleanest phone in the neighborhood, though.

One of the phones looked like someone dropped something really heavy on it and the dial was loose from the base. So I had to drill out the rivets on the base and replace them with screws. Feels a whole lot better now. On another 2500 set, I had to take the touch tone pad apart and go in the bathroom and wash out all the dried up coke sugar goop that was in it, so now the buttons don't stick anymore. I had to take the keys out, but I couldn't remember which side the * and # went, so I had to cheat and peek at another phone. I also found out that the weird screws that hold the base to the cover are some odd screw thread like a #7 - 18 tpi.

One interesting thing is that the 500 and 2500 sets are made to compensate for the loop length. They have varistors inside, and they do a decent job. But it seems to me that the newer electronic phones don't do such a good job of this.

One thing I thought was really strange was the sticker on the bottom of the 2500 set. This is a AT&T 2500MMG set, and the sticker on the bottom says:

"WARNING: USE FOR BUSINESS SYSTEMS ONLY OR YOU RISK AN ELECTRICAL SHORT CIRCUIT"

I kind of think this is a put-on, since the phone works okay on a POTS line.

Jerrold 400 Cable Converter Problems

The following may also apply to other models of similar vintage (e..g, 440).

The most common symptoms for these cable boxes relate to their not staying on or acting erratically when the buttons are pressed. The causes are usually quite simple:

1. Cold solder joints around the power supply regulator ICs (on chassis heat sink).

2. Dried up main filter capacitors - two large electrolytics in power supply on main board.

Be careful disassembling the main board from the chassis as at least one of the regulator ICs clipped to the side of the chassis is insulated from this heatsink and the insulation is easily damaged.

One cause of a totally dead converter is a blown thermal fuse in the primary of the power transformer. It will be buried under the outer wrap inside the transformer, between the bobbin and core, or molded into the bobbin, but may be repairable. Test by jumpering around it. But for safety, install a replacement.

Original Nintendo console erratic or dead

While the original Nintendo game machine is a couple of generations out of date, many are still in use. And, hey, kids usually don't care.

The most common problem with these units is a worn or dirty cartridge connector. In this case, the red power/status light will continue to flash even after the RESET button is pressed with a game cartridge in place. Replacements are available for about $9 from the sources listed at the end of this document.

First, try another game cartridge - the one that is not working may just have dirty contacts or may be defective. Clean the contacts with a Qtip moistened with water followed by isopropyl alcohol. (The water will remove the sugar from the candy that may have made its way onto the connector.)

To get inside, you first remove the 6 screws on the bottom and then about 12 screws which fasten the circuit board and shield to the bottom of the case. (Note: there are two screws which are longer and silver colored - make sure they get back to their original location when you put everything back together.) Once all these screws are removed, the black connector can be slid off the edge finger on the circuit board Inspect these connections - they just may be a bit corroded or dirty. Use contact cleaner and/or a pencil eraser and see if that makes any difference. Use contact cleaner on the dual rows of fingers that connect to the game cartridge as well. A dental pick can be used to gently spread the fingers apart ever so slightly and thus improve the connection when the cartridge is inserted.

Even if this only makes a slight improvement - you can press down on the cartridge and the machine will respond to the RESET button - you have confirmed that the connector is indeed the problem. In many cases, just this cleaning will result in reliable operation for a long time to come.

Replacement connectors are under $10 from places like MCM Electronics and Dalbani.

Repairing Texas Instruments TI-5X calculators

I have them up through TI-57 so I don't know if the following applies to models higher than this (TI-58 and TI-59).

If it hasn't been used for a while (like 15 years?) then the NiCds are likely deader than a door nail and will not accept a charge since they are totally shorted. Bad NiCds is very likely all that is wrong with the calculator.

If your calculator has a pack that plugs in inside the back with 2 AA NiCds and some circuitry, then it is the same.

First crack open the pack by using a butter knife or similar instrument at the catches along the seam. You will see a pair of AA NiCds and a small circuit board. This is a DC-DC convertor which boosts the 2.4 V of the NiCds to about 10 V to operate the logic of the calculator.

Inspect the circuit board for corrosion and other obvious damage. Unless the calculator was stored in a damp area, it should be fine. The batteries will probably have crusty white stuff on the positive ends. They are bad. Don't even bother trying to zap them.

As a test, you can do either or both of the following:

1. Get a large electrolytic capacitor (e.g., 10,000 uF at 10 V) and put it in in place of the batteries. Observe polarity. Try out the calculator using the TI charger/adapter. Operations will be a bit flakey but should basically work (the capacitor, no matter how large, apparently will not substitute for the NiCds).

2. Unplug the TI battery pack and set it aside. Find a 9 V power supply or a 9V battery. Connect this to the red and black wires coming from the logic board connector which went to the battery pack. NOTE: the wire color coding is backwards on at least some of these. Black is positive for some reason. However, nothing disasterous happens if you connect it backwards as far as I can tell since I was testing it backwards for quite a while until I caught on. And, I thought TI was a real company!

If these tests are successful, the calculator is likely fine and you just need a new set of AA NiCds with solder tabs to make it as good as new.

Or, if you don't need the authenticity of a genuine TI form-and-function rechargeable battery pack, use a 9V AC adapter, 9V Alkaline, or 9V NiCd battery and charge it externally.

Some information (with photos) on battery packs for various TI calculators can be found at Datamath.org - Battery Packs. You'll find what you just read there as well. :)

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Service Information

Determining belt type and size

Belts are normally specified by their cross section - square, flat, round, and their inside circumference (IC). The IC is used since it is virtually impossible to accurately measure the diameter of a belt.

Assuming you cannot locate an actual part number, determine the type of belt; square, flat, or round. If you do not have the old belt, this is usually obvious from the pulleys. Most small belts (as opposed to V-belts on 1 HP shop motors!) used in consumer electronic equipment are of square cross section though flat types are sometimes found in the main drives of VCRs, cassette/tape decks, and turntables (remember those?). Measure or estimate the thickness.

The IC is always specified with the belt fully relaxed. This can be measured by hooking the old belt on one end of a ruler and pulling it just tight enough so that it more or less flattens out. Read off the length, then double it for the IC. Get a new belt that is 5% or so smaller to account for the old one be somewhat stretched out. Of course, if the belt broke, measurement is real easy. Or, if you do not care about the old belt, just cut it and measure the total length.

If the old belt decomposed into a slimy glob of jellatinous black goop or is missing, you will need to use a string or fine wire around the appropriate pulleys to determine the IC. Reduce this by 10-25% for the replacement. Very often the match does not need to be exact in either thickness or length - particularly for long thin belts. A common rubber band may in fact work just as well for something like a tape counter!

However, there are cases where an exact match is critical - some VCRs and belt driven turntables or tape decks do require an exact replacement for certain drive belts but this is rare.

Some parts suppliers make determining replacement belts very easy with the PRB system in which the part number fully codes the shape, size, and thickness.

Making custom length rubber belts

The following will probably work for most drive belts except for those which are critical for accurate speed control in devices like cassette decks and turntables.

(From: Melissa & Jim (mgkepner@facstaff.wisc.edu).)

3M and Eastman make cyanoacrylate adhesives (super glue) that are specially made for making custom O-rings from linear stock. This seems to be exactly the same problem you are approaching. These glues work very well and produce a joint as strong as the base material, but without the need for the needle and thread. The joint can be made almost invisible. The only hard part is holding the pieces aligned while the glue cures, but in this case that is only seconds.

I have used a machinists steel V-block for this, but one of the O-ring manufacturers sells a plastic tool for exactly this purpose. In the US, I would check at a bearing supply house; they often carry O-ring supplies as well.

Rubber or elastic bands as drive belts?

It is 3 AM, you have finally removed the last of the 38 screws to access the tape transport in your Suprex Never-Forget model X4123 answering machine and what do you fine? A broken belt, of course! What to do?

As a test at least, a common elastic band may work. The recordings will likely have terrible wow and flutter but this will at least confirm that there is nothing else broken. In a pinch, this free solution can be left in place until a proper replacement arrives. This should work for many types of devices - CD players, VCRs, tape decks, etc. - where grooved pulleys are used and the belt is not called on to provide a great deal of power.

Identifying and replacing SMT devices

See the document: Surface Mount (SMD) Transistor/Diode Cross-reference. If this does not list your device or it is so fried that no markings survive, you can usually use some educated guesswork to select a suitable replacement. SMD types can usually be replaced with normal devices since there is usually sufficient space. If there are any other SMD parts with the identical marking, you should be able to determine pinout (e.g., BCE for transistors - see the document: Basic Testing of Semiconductor Devices) and replace with a general purpose non-SMD type. I doubt that the specifications of parts used in telephones or modems are critical. Even if there are no identical device, if you can determine the voltages on the pins, you may be able to guess the type. The worst that will likely happen if you are wrong is to blow your replacement device - anything that this will do the rest of the circuitry has already been done.

Interchangeability of components

The question often arises: If I cannot obtain an exact replacement or if I have a VCR, tape deck, or other equipment carcass gathering dust, or I just have some extra parts left over from a previous project, can I substitute a part that is not a precise match? Sometimes, this is simply desired to confirm a diagnosis and avoid the risk of ordering an expensive replacement and/or having to wait until it arrives.

For safety related items, the answer is generally NO - an exact replacement part is needed to maintain the specifications within acceptable limits with respect to line isolation, X-ray protection and to minimize fire hazards. However, these components are not very common in audio equipment or other consumer devices (other than TVs, monitors, and microwave ovens) except for possibly in their power supply.

For other components, whether a not quite identical substitute will work reliably or at all depends on many factors. Some designs are so carefully optimized for a particular part's specifications that an identical replacement is the way to return performance to factory new levels.

Here are some guidelines:

1. Fuses - exact same current rating and at least equal voltage rating. I have often soldered a normal 3AG size fuse onto a smaller blown 20 mm long fuse as a substitute. Also, they should be the same type - slow blow only if originally specified. A fuse with a faster response time may be used but it may blow when no faults actually exist.

2. Resistors, capacitors, inductors, diodes, switches, trimpots, lamps and LEDs, and other common parts - except for those specifically marked as safety-critical - substitution as long as the replacement part fits and specifications are met should be fine. It is best to use the same type - metal film resistor, for example. But for testing, even this is not a hard and fast rule and a carbon resistor should work just fine.

3. Potentiometers - user knobs usually control one or more of these. There are four considerations in

locating a suitable replacement: resistance, and taper, power rating, configuration, and mechanical fit. Configuration refers to the number of ganged pots, concentric knobs, etc. Matching this from your junk box may prove to be the toughest challenge! Many of the controls for audio equipment use what is known as an 'audio taper'. This means that the resistance change with knob rotation is not linear but is designed to produce a uniform incremental change in perceived volume, for example. Replacement with a linear taper pot will squish all of the effect towards one end of the range but it will still work. If measuring the resistance of a (good) potentiometer with its wiper set in the middle results in significantly different readings from center to each end, it is most likely an audio taper pot (though some other weird taper or other peculiarity is possible).

4. Rectifiers - many are of these are high efficiency and/or fast recovery types. Replacements should have equal or better PRV, If, and Tr specifications. For line rectifiers, 1N400x types can usually be used.

5. Transistors and thyristors (except power supply choppers) - substitutes will generally work as long as their specifications meet or exceed those of the original. For testing, it is usually ok to use types that do not quite meet all of these as long as the breakdown voltage and maximum current ratings are not exceeded. However, performance may not be quite as good. For power types, make sure to use a heatsink.

6. Switching power supply transistors - exact replacement is generally best but switchmode transistors that have specifications that are at least as good will work in many cases. See the documents: "Notes on the Troubleshooting and Repair of Television Sets", "Notes on the Troubleshooting and Repair of Computer and Video Monitors", and "Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies" for more info.

7. Audio and erase heads - may be possible if the mountings are reasonably compatible. However, there could be other unknowns like coil impedance and drive requirements. The connectors are not likely to be similar either. There are usually significant differences in head configuration and mounting arrangement between 2 head, 3 head, and autoreverse cassette or open reel tape decks.

8. Motors - small PM motors may be substituted if they fit physically. Make sure you install for the correct direction of rotation (determined by polarity). Capstan motors - especially the direct drive type - are probably not interchangeable. However, generic speed regulated cassette drive motors are available.

9. Sensors - many are sufficiently similar to permit substitution.

10. Power transformers - in some cases, these may be sufficiently similar that a substitute will work. However, make sure you test for compatible output voltages to avoid damage to the regulator(s) and rest of the circuitry. Transformer current ratings as well as the current requirements of the equipment are often unknown, however.

11. Belts, tires, and pinch rollers - a close match may be good enough at least to confirm a problem or to use until the replacements arrives.

12. Mechanical parts like screws, flat and split washers, C- and E-clips, and springs - these can often be salvaged from another unit.

The following are usually custom parts and substitution of something from your junk box is unlikely to be successful even for testing: SMPS (power supply) transformers, interstage coils or transformers, microcontrollers, other custom programmed chips, display modules, and entire power supplies unless identical.

Why are there parts missing from my equipment?

It is not uncommon for parts to be missing from production equipment due to design changes or field mods. Thus, it may not mean anything. Inspect the solder pads - if they look the same as all the others, it was probably never installed in the first place. Of course, that could have been a manufacturing omission as well. Parts just don' jump ship without leaving evidence behind!

Don't be tempted to add a part just because there is an empty spot. In some cases, like the RCA TV that would tend to blow HOTs if the power failed, that would be a really bad idea and complicate your troubleshooting.

Whole blocks of circuitry are often left unpopulated on lower priced models. You didn't pay for those features. Sometimes, this can work to your advantage enabling you to upgrade to a fancier model for the cost of the parts.

Web resources

Radio Shack has a nice web resource and fax-back service. This is mostly for their equipment but some of it applies to other brands and there are diagrams which may be useful for other manufacturers' VCRs, TVs, CD players, camcorders, remote controls, and other devices:

- Radio Shack Product Support

Since Radio Shack does not manufacture its own equipment (I can tell this doesn't particularly surprise you!) - they are other brands with Realistic, Optimus, or other Radio Shack logos - your model may actually be covered. It may just take a little searching to find it.

Some general references

Here are some suggested titles that might be found in your local public library or a technical bookstore.

1. Troubleshooting and Repairing Electronic Circuits
   Robert L. Goodman
   Second Edition
   TAB Books, Inc., 1990
   Blue Ridge Summit, PA 17294-0214

2. Small Electric Motors
   Rex Miller and Mark Richard Miller
   Second Edition, 1992
   MacMillan Publishing Company
   866 Third Avenue
   New York, NY 10022

3. Repairing Quartz Watches
Henry B. Fried
American Watchmakers Institute Press, 1988
Cincinati, OH
ISBN 0-918845-06-8

4. Readers Digest Fix It Yourself Manual
The Readers Digest Association, 1996
Pleasantville, New York/Montreal
ISBN 0-89577-871-8

5. The Complete Guide to Digital Audio Tape Recorders including Troubleshooting TIps
Erik S. Schetina
P.T.R. Prentice Hall,
Englewood Cliffs, NJ 07632
ISBN 0-13-213448-9

6. DAT - The Complete Guide to Digital Audio Tape
Delton T. Horn
TAB Books, Inc., 1991
Blue Ridge Summit, PA 17294-0214
ISBN 0-8306-7670-8 (hardcover), ISBN 0-8306-3670-6 (paperback)

7. Troubleshooting and Repairing FAX Machines
Gordon McComb
Tab Books, a division of McGraw-Hill, Inc., 1992
Blue Ridge Summit, PA 17214
ISBN 0-8306-7778-X (hardcover), 0-8306-3778-8 (paperback)

8. Complete Guide to Home Entertainment Equipment - Troubleshooting and Repair
John D. Lenk
Prentice Hall, Inc., a division of Simon and Schuster, 1989
ISBN 0-13-161001-5

9. Understanding Telephone Electronics
Fike and Friend

10. Installing Telephones
Radio Shack
Catalog number: 62-1060

11. All Thumbs Guide to Telephones and Answering Machines
Gene B. Williams
TAB Books, Inc., 1993
Blue Ridge Summit, PA 17294-0214
ISBN 0-8306-4435-0 (paperback)

This one is very basic but does cover the most common problems and has illustrated instructions for general telephone wiring, adding extensions, answering machine cleaning, rubber parts, simple electronic problems, etc.

And, for that older audio equipment (including record changers):

12. Repairing Home Audio Systems
 E. Eugene Eckland
 McGraw-Hill Book Company, 1962
 Library of congress catalog number: 61-18021

Recommended parts suppliers

For general electronic components like resistors and capacitors, most electronics distributors will have a sufficient variety at reasonable cost. Even Radio Shack can be considered in a pinch.

However, for consumer electronic equipment repairs, places like Digikey, Allied, and Newark do not have the a variety of Japanese semiconductors like ICs and transistors or any components like tape heads or belts.

See the document: Major Service Parts Suppliers for some companies that I have used in the past and others that have been recommended. Also see the documents: Troubleshooting of Consumer Electronic Equipment.

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-- end V3.30 --

Notes on the Troubleshooting and Repair of Video Cassette Recorders

Version 3.17

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Working on VCRs entails a number of personal risks: electrical, mechanical, as well as the possibility of irreversible damage to the equipment and loss of irreplaceable recordings due to improper repair or adjustment.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Introduction

Entertainment - then and now

Think back past 25 years. You went to the theater to see a movie. You watched TV programs when they were broadcast (there was no cable, remember?) or you missed them. TV studios and industry had video recording equipment but it was expensive and cumbersome. Little did you realize at the time, but after some false starts, the modern video revolution was about to be born. Are we better off? Whatever you decide, there is no going back. You may be able to leave your VCR's clock flashing 12:00 but you cannot escape the impact that this technology has had on so many aspects of your life.

The video cassette recorder is a wonderful example of extremely complex precision technology that has been made affordable through mass production. In general, it is usually quite reliable. Treat a modern VCR with a bit of respect and it will provide trouble free service for a long time. Unlike a TV where the power circuits take their toll on circuit components, the electronics in VCR are generally quite reliable and rarely fail. Most VCR problems are mechanical - dirt and dust in the tape path, deteriorated rubber parts, dried lubrication, wear of precision parts including the spinning video heads, and abuse caused by rocks, toys, and peanut butter and jelly sandwiches.

Scope of this document

This document was developed specifically for the troubleshooting and repair of VCRs using the VHS format. However, most of it also applies to Beta, 8 mm, 4 mm (DAT), and the industrial U-Matic formats as well. The basic tape related problems found in camcorders are also likely to be similar to those for full size VCRs. However, due to the miniaturization and difficulty in accessing internal parts of these units, troubleshooting and repair are generally much more difficult.

Note: Links to all the diagrams and photographs referenced from this document can be found in Sam's VCR FAQ Files.

VCR repair

Note: for VCR emergencies that just cannot wait, the solution may be found in the document: VCR First Aid and you may not need to read further. VCR First Aid deals with the half dozen or so acute VCR problems that may tempt you to throw something through the window - or worse.

Even if you are a technoklutz who lets your kids change the light bulbs in your house and would never consider tackling any actual repair or internal maintenance of your VCR, some basic awareness of the principles of video recording and the likely causes for common problems will enable you to intelligently deal with the service technician. You will be more likely to be able to recognize if you are being taken for a ride by a dishonest or just plain incompetent repair center. For example, did you know that one of the most dreaded of problems - the tape eating VCR - can often be remedied by a thorough cleaning and a 50 cent rubber tire?

This document will provide you with the knowledge to deal with over 85% of the problems you are likely to encounter with your VCRs. It will enable you to diagnose problems and in most cases, correct them as well. First and foremost are the techniques for cleaning of the tape path and replacement of rubber parts like belts, tires, and the pinch roller - the solution to many common problems with VCRs. With minor exceptions, specific manufacturers and models will not be covered as there are so many variations that such a treatment would require a huge and very detailed text. Rather, the most common problems will be addressed and enough basic principles of operation will be provided to enable you to narrow the problem down and likely determine a course of action for repair. In many cases, you will be able to do what is required for a fraction of the cost that would be charged by a repair center.

Should you still not be able to find a solution, you will have learned a great deal and be able to ask appropriate questions and supply relevant information if you decide to post to sci.electronics.repair. It will also be easier to do further research using a repair text such as the ones listed at the end of this document. In any case, you will have the satisfaction of knowing you did as much as you could before taking it in for professional repair. With your new-found knowledge, you will have the upper hand and will not easily be snowed by a dishonest or incompetent technician.

Repair or replace

While VCRs with new convenience features are constantly introduced, the basic function of playing a tape has not changed significantly in 25 years. Even the introduction of HQ about 15 years ago does not represent a dramatic improvement. Therefore, unless you really do need a quick start transport, a real-time counter, index search, or the like, repair may not be a bad idea. The older VCRs are built much more solidly than the $100 models of today. Even high-end VCRs may be built around a poorly designed transport and flimsy chassis. Many older VCRs - for example 10 year old Panasonic models (and their clones) can be kept functional - nearly indefinitely, it would seem - at minimal cost. The consensus of those in the business is generally that most newer VCRs are built to last through the warranty and then either be too expensive to repair or simply impossible to repair. However, there are still millions of middle age to older VCRs out there whose life could be greatly extended with a little tender loving care. If you buy a $79 K-Mart special, you get what you pay for. Don't expect it to last more than a year or so. However, if you have something that is a few years old, it may be well worth the effort to keep it going. As already noted, newer VCRs don't have significant picture or sound quality - they are just more cheaply made to optimize the manufacturer's bottom line.

If you need to send or take the VCR to a service center, even a simple repair could easily exceed half the cost of a new VCR. Service centers may charge up to $50 or more for providing an initial estimate of repair costs but this will usually be credited toward the total cost of the repair (of course, they may just jack this up to compensate for their bench time).

If you can do the repairs yourself, the equation changes dramatically as your parts costs will be 1/2 to 1/4 of what a professional will charge and of course your time is free. The educational aspects may also be appealing. You will learn a lot in the process. Thus, it may make sense to repair that old clunker so the kids will have their own VCR or you will have a convenient means of copying tapes (legally, of course).

BTW, if you ARE one of those individuals (and there are bucket loads) who doesn't bother (or doesn't know how) to set the clock on your VCR, there is a solution - at least the next time you need to purchase a new VCR. These machines search for a TV station that includes the time code in its transmission format (it is in the vertical blanking interval should you care) and automagically sets the VCR's clock from that information. There - no more flashing 12:00! Many VCRs have this feature nowadays.

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Video Recording Technology

Helical scan video recording

Modern VCRs - both consumer and professional - are based on what is known as helical scan recording. The main technological challenge that confronted the designers of early video recording machines was achieving the necessary bandwidth - several MHz - to faithfully capture the high frequency video signal. The first such machines ran normal audio tape past stationary recording heads at high speed - 10s of feet per second - in an attempt to solve this problem. Needless to say, the mechanisms were complex, a finite length of tape could only record a few minutes of video, and the heads wore out almost as quickly. If anything - anything at all - went wrong with the tape transport, you were up to your eyeballs is spilled tape. An alternative technology was clearly needed.

Prior to practical video tape recording, the only way to preserve a TV show was to use special equipment that essentially made a film of it off of a video monitor. The quality of such recordings was not very good, editing was difficult, the film needed to be developed so playback was not immediate, and of course, the film could not be erased and reused.

The first successful commercial video tape recorder was introduced around 1956 with the Ampex Quadplex - a $50,000 machine using 2 inch open reel tape and a high speed spinning head with 4 pickups rotating across the tape. This event revolutionized commercial broadcasting. However, this technology was much too complex, cumbersome, and expensive for consumer use and has a number of technological disadvantages as well.

For a consumer video tape recorder to be successful it was felt that the following three major hurdles had to be overcome:

- Tape loading had to be simple and foolproof using a cassette - none of this open reel stuff.
- A cassette had to hold at least an hour of color video.
- The cost to the consumer had to be less than $1000 (1970's dollars!) for the machine and perhaps $20 per hour for the tape.

The rotating heads of the Quadplex machine provided the needed tape-head speed to achieve sufficient video bandwidth. However, the transport was much too complex for a consumer machine. Another disadvantage was that since a video frame consists of many adjacent tracks on the tape (16), special effects like stop motion as well as forward and reverse search were not possible without a frame store. While this would not be out of the question today, the cost of such a device in the 1950's would necessitate the consumer taking out a second mortgage to pay for it. Finally, the 2 inch wide format required too much tape for achieving a cost effective 1 hour program time and made the design of a manageable cassette an impossibility. A separate room would be needed to house a modest size video tape library!

Helical scan overcomes most of these problems. See: Helical Scan Video Head Assembly. Rather than scanning across the tape, the tape is wrapped a bit over 180 degrees around a rotating drum at a slight angle. Thus, successive tracks are written diagonally across the tape and can thus be much longer than the width of the tape as in the Quadplex. The tape, therefore can be rather narrow. The first helical scan tapes used a 1 inch format but narrower tape soon followed. The most common formats today are forms of VHS (and Beta) at 1/2", and 8 mm (mostly used for portable applications in camcorders and data storage.) 4 mm tape is used for high quality audio (DAT) as well as data storage.

VHS video

Most of the following discussion unless otherwise noted applies to the VHS format. Beta, which preceded VHS into the marketplace and which has all but disappeared for consumer VCRs is actually a somewhat better system technologically with superior picture quality. Physical tape format is similar to VHS but differs in the details. However, Sony's licensing practices with respect to Beta made it inevitable that VHS would triumph in the marketplace. Too bad in some ways. The 8 mm format, used mostly used nowadays in camcorders, is also helical scan but there are no separate audio and control tracks - they are part of the video track.

Each VHS track corresponds to 1 field of the interlaced video format. See: VHS Tape Format. Generally, two heads opposite each other on the rotating head drum are used. One rotation of the drum corresponds to a complete video frame with heads designated A and B for the even and odd fields respectively. What this also provides is the ability to easily implement a variety of special effects including freeze frame, and fully variable speed forward and reverse motion with a recognizable and in many cases, quite clear picture. With relatively minor restriction, this becomes as simple as moving the tape forward or backward or keeping it stationary.

For a not too terrible ASCII diagram and additional discussion, also see the section: VHS physical tape format

(Camcorders and other compact systems may use 2 pairs of identical heads where the opposing pairs are separated by 270 instead of 180 degrees. Physically, there are 4 heads spaced equally around a drum 2/3rds the size of the normal VHS drum. However, successive head in the sequence is 270 degrees apart. In other woeds, if the heads are numbered 1,2,3,4, they are used in the order: 1,4,3,2,1,4... This permits the use of a smaller, lighter video drum but the recorded format is identical.)

The A and B heads are not identical either. Their azimuth angle differs being +6 degrees for one and -6 degrees for the other. See: VHS Video Head Pair Azimuth Angles. This is one of several techniques used to minimize crosstalk between adjacent tracks. Azimuth angle is how far the head gap is from being perfectly perpendicular to the direction of tape-tape motion. For example, a head with an azimuth such as / will ignore most of the information recorded with an azimuth of \.

Note that the head gap - the distance between pole pieces - is on the order of 1 um - 1/25,000 of an inch. As a point of reference, a human red blood cell is about 7 um in diameter and an average sheet of typing paper is about 100 um in thickness. The gap is filled with a nonmagnetic material to prevent it from getting clogged and to force the magnetic flux out of the head structure and into the tape magnetic coating. This remarkably fine spacing is necessary to achieve the multimegahertz video bandwidth.

Actual tape motion for a VCR is remarkably slow. To someone familiar with audio decks, the tape in a VCR even at SP speed (the fastest) seems to be crawling along. Their first reaction is often one of: "there must be something wrong as the tape is moving sooo slooowly." Nope, just amazing technology. The SP speed of a VHS VCR corresponds to a linear tape speed of only 1-5/16 ips - slower than for an audio cassette deck (1-7/8" ips). EP speed is 1/3 of this - 7/16 ips. However, the effective tape speed as seen by the video heads is over 15 feet per second due to the spinning video head drum.

The luminance (Y) and color (C) components of the composite video signal are recorded differently. Luminance, which is in effect the black and white picture with all the high resolution components but no color, is frequency modulated on a carrier at around 3.4 MHz. The deviation is about 1 Mhz and the maximum frequency recorded on a VHS tape is a little over 5 Mhz (Beta is slightly different and S versions of Beta and VHS extend some of these to achieve higher bandwidths. The color signal is separated from the composite video and is amplitude modulated on a 629 kHz carrier. This is called the color under' system. The 'U' in U-Matic, a very popular industrial VCR 3/4" format (which predates Beta and VHS and is still in use) stands for this.

VHS audio

Sound for the VHS format is not merged into the video signal on the tape. For non-HiFi VHS VCRs, a separate stationary tape head is responsible for the audio signal. Due to the very slow tape speed, audio quality is not even comparable to a cheap audio cassette player even at the SP speed. VHS HiFi overcomes this by FM recording of the audio signal deep in the tape (recorded by a separate set of HiFi heads just before the video information), actually buried under the video information. The left and right audio channels are recorded in separate frequency bands - centered around 1.3 and 1.7 Mhz respectively. The azimuth angles for the HiFi audio heads are +/- 30 degrees which minimizes crosstalk between the recorded HiFi audio and video information.

Since the head-tape speed for the VHS audio track is the same high rate as for the video track and exceeds that of a typical audio cassette deck by a factor of more than 100, VHS HiFi audio reproduction - frequency response, signal to noise ratio, and dynamic range - is excellent and approaches that of a CD. In fact, using a T120 video cassette in EP (SLP, 6 hour) mode simply to record stereo music (with the video ignored or blanked) is extremely cost effective. What other media/technology will store a 6 hour concert with nearly perfect reproduction for under $2? (Note: if you do this, some VCRs will require some kind of video input to maintain stable tape speed. You can just ignore the video portion on audio playback.)

There are two disadvantages to VHS HiFi, however: (1) there may be some degradation of video quality due to unavoidable interactions with the buried audio, and (2) it is not possible to rerecord (dub) only the audio without disturbing the video. The only way to do this without copying the video to another tape would be to read out the video and hold it temperorily in a double buffered frame store for subsequent recording back onto the tape after the new video was laid down. However, this would put the video 1 frame behind where it was thus complicating the situation. So, audio dubbing simply isn't supported.

Beta and 8 mm audio

Like VHS, Beta has both linear and HiFi audio but in that system, the HiFi audio signal is actually recorded and played back via the video heads and uses a portion of the frequency spectrum to fit it in with the video information.

With 8 mm, there is no separate linear audio track - all audio is HiFi using the spinning video heads.

More information on video formats

See the following for additional information on these and other video formats.

- Tomi Engdali's Video Recording Formats Page.
- Leopold's Home Video Formats Page.

VCR servo systems

Linear tape motion and head drum rotation must be precisely synchronized during record, play, and special effects play modes. The general functioning is similar for all but the source of the basic reference signal differs for play and record. Some of the specific relationships may differ depending on the specific VCR design.

Record: reference signal is vertical sync pulse from video input:

- Head drum rotation is phase locked to vertical sync pulse so that appropriate head (of the A-B pair) is in contact with the tape during the appropriate video field.
- The speed of the capstan which moves the tape through the transport is also locked to the vertical sync pulses so that the selected linear tape speed (SP, LP, EP) is maintained.
- Control pulses (30 Hz for US NTSC) are recorded along the bottom edge of the tape by a stationary control head.

Play: reference signal is timing pulse derived from quartz oscillator:

- Capstan rotation speed is locked to a 30 Hz pulse derived from a precise quartz crystal oscillator. Head drum rotation is phase locked to the control pulses now being read off of the tape by the Control head.
- The tracking control is used to adjust the relative phase of the head drum with respect to the control pulses. This permits the head path across the tape to be aligned with the actual recorded tracks.

Video special effects

For CUE (fast play forward) and REV (fast play reverse), the capstan speed is phase locked to a multiple of the control track. Since the video heads are crossing multiple tracks during these modes, some noise bars are unavoidable. At SP speed, special wide or dual azimuth heads are required to minimize this degradation. Thus, only 4 head VCRs can play SP tapes at fast speeds with minimal noise. With EP speed, the tracks actually overlap and a normal video head is wide enough to pick up enough signal from adjacent tracks to produce a mostly noise free picture. Due to the way adjacent tracks line up with LP speed, most of these special effects cannot be used due to serious tearing of the picture. The sophisticated processing needed for proper support at LP speed is generally not included in modern VCRs due to the apparent lack of interest in the LP speed (recording support at LP speed seems to be absent in more and more newer VCRs though they will all play back LP tapes at normal playback speed).

Really slow speed is usually implemented as a variable frame advance with the tape fully stopping between frames. Special sets of video heads provide the best quality. Freeze frame (PAUSE) uses the same set of heads. As with CUE and REV, acceptable picture quality is provided even with a 2-head VCR for EP speed recorded tapes. In all cases, picture quality can be further improved through the use of a digital frame store.

Note that the servo systems in consumer VCRs are rarely precise enough to implement the kind of instantaneous forward or reverse frame advance that is present in high performance (and high cost) editing decks having jog shuttle knobs with instantaneous and precise response.

For more information on VCR and related technology

The books listed in the section: Popular books on VCR maintenance and repair include additional information on the theory and implementation of the technology of video recording and VCRs.

Philips/Magnavox used to have a very nice on-line introduction to a variety of consumer electronics technologies. Although their site has disappeared - and even people who work for them have no clue - I have now recovered several of the articles including those on TVs, VCRs, camcorders, satellite reception, and connections. See the Introductory Consumer Electronics Technology Series.

Also check out:

- The How Stuff Works Web site has some really nice introductory material (with graphics) on a variety of topics relating to technology in the modern world. Of relevance to this document are articles on VCRs (including the tape cassette), motors, remote controls, etc.
- The Video Cassette Recorder (U. Dayton CPS460 notes).
- An Introduction to VCRs is really only a summary but it does include some diagrams which may useful.
- EE498 Final Project: Disassembly and Inspection of a VCR includes some descriptions, photos, and diagrams which may be helpful, or at least amuzing!
- For some information on helical scan audio and data recording, see: Sprague's Technical Library.
- Tim Stoffel's Videotape Systems Theory includes history as well as some of the newest digital formats.

- NTSC Television Tutorials by Williamson Labs has many diagrams with a bit of text on their site. It looks like they are really trying to sell stuff including a CDROM but the graphics are worth checking out. While this is more of a TV site, there are some slides with VCR related information.

- Ronald's VCR Knowledge Page includes many nice diagrams of VCR basics and scope photos of video signals for normal, CUE/REV, and still frame operation.

On-line tech-tips databases

A number of organizations have compiled databases covering thousands of common problems with VCRs, TVs, computer monitors, and other electronic equipment. Most charge for their information but a few, accessible via the Internet, are either free or have a very minimal monthly or per-case fee. In other cases, a limited but still useful subset of the for-fee database is freely available.

A tech-tips database is a collection of problems and solutions accumulated by the organization providing the information or other sources based on actual repair experiences and case histories. Since the identical failures often occur at some point in a large percentage of a given model or product line, checking out a tech-tips database may quickly identify your problem and solution.

In that case, you can greatly simplify your troubleshooting or at least confirm a diagnosis before ordering parts. My only reservation with respect to tech-tips databases in general - this has nothing to do with any one in particular - is that symptoms can sometimes be deceiving and a solution that works in one instance may not apply to your specific problem. Therefore, an understanding of the hows and whys of the equipment along with some good old fashioned testing is highly desirable to minimize the risk of replacing parts that turn out not to be bad.

The other disadvantage - at least from one point of view - is that you do not learn much by just following a procedure developed by others. There is no explanation of how the original diagnosis was determined or what may have caused the failure in the first place. Nor is there likely to be any list of other components that may have been affected by overstress and may fail in the future. Replacing Q701 and C725 may get your equipment going again but this will not help you to repair a different model in the future.

Please see the document: On-Line Tech-Tips Databases for the most up to date compilation of these resources for TVs, VCRs, computer monitors, and other consumer electronic equipment.

A site to rival this one - but WITH a tech-tips database and nice graphics

Check out:

- http://www.fixer.com/ (Fixer.com - VCR Repair and Tech-Tips Database)

This site includes a relatively short but fairly complete VCR repair guide that covers most of the common classes of problems - with nice diagrams to help with the explanations.

The VCR-only tech-tips database is clearly indexed by manufacturer and model number. Every repair includes a level-of-difficulty rating - which is handy! Many include layout and parts placement diagrams as well.

The developers of this site also sell a variety of generic VCR repair parts, tools, and TV remote controls.

My only real complaint is with respect to the annoying flipping banner at the top of their main pages! :-(

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VCR Placement, Preventive Maintenance, and Rental Tapes

General VCR placement considerations

Proper care of a VCR does not require much. Following the recommendations below will assure long life and minimize repairs.

* Allow adequate ventilation - VCRs are not huge users of power but there is some heat buildup nonetheless. Leave at least 1-1.5 inches around all sides and top for air circulation. Try not to place the VCR near heat producing equipment.

* Do not put anything on top of the VCR that might block the ventilation grill. To be safe, don't put anything on top - period. Tapes are especially bad - for the tapes - as the heat and possible magnetic fields in the vicinity will tend to age them prematurely.

  In addition, modern VCRs are NOT built like the Brooklyn Bridge! The weight of a TV or stereo components could affect the VCR mechanically, messing up tape path alignment or worse.

* If possible, locate the VCR away from the TV. Some VCRs are particularly sensitive to interference from the TV's circuitry and while this won't usually damage anything, it may make for less than optimal performance.

* Don't locate VCRs in dusty areas if possible. Consider the use of a dust cover when not actually being used if you have no choice of location.

* Don't locate VCRs in areas of high (tobacco) smoke or cooking grease vapors. I cannot force you to quit smoking, but it is amazing how much disgusting difficult to remove brown grime is deposited on sensitive electronic equipment in short order from this habit.

* Make sure all input-output video and audio connections are tight and secure to minimize intermittent or noisy pictures and sound.

* Finally, store video cassettes well away from all electronic equipment including and especially loudspeakers. Heat and magnetic fields will rapidly turn your priceless video collection into so much trash. It is also recommended that you store the cassettes on edge so that the tape edges are not subject to pressing against the case and that you run them through a VCR or winder/rewinder from start to end and back on FF/REW at least once a year (another pair of recommendations that are rarely followed).

Video tape quality

> "What are the 'good' and 'bad' brands of videotapes (T-120)? Are the 'extra' or "high" grades really better?"

I would avoid brands you never heard of. K-mart brand, Recoton(sp), the street vendor from whom you buy Chinese food, whatever.

Higher grade tapes are not necessarily worth the expense but in my experience with some like Maxell and Scotch, going one level up from the cheapest is worthwhile and results in a noticeably better picture.

Only a few companies actually manufacture the raw tape stock. For what it's worth (FWIW), I have used Scotch in the past. It was inexpensive and the quality was good and consistent. I haven't purchased video tape in quite awhile now so I do not know if this is still true (Winter 2003).

The higher grade tapes may actually be harder on the video heads due to their formulation but this probably doesn't matter for the ordinary user.. You don't need HiFi grade tapes for HiFi - any tape will work. However, higher grade tapes may last longer with higher quality results in demanding situations like 24 hour a say security monitoring.

Consumer Reports does a review every so often, check back issues. I believe their conclusions were generally to buy name brands by price. Whether you believe in Consumer Reports or not, checking their ratings at least gives you an additional data point.

How long do video tapes last?

(From: Raymond Carlsen (rrcc@u.washington.edu).)

I have not seen any "official" guidelines on tape longevity for a long time, since the Beta days. Use of old tapes will not generally ruin video heads but may clog them. Proper manual cleaning restores normal operation.

Your mileage really depends on several factors, the most important being the conditions under which it's used. I've seen VCRs that can chew up a tape in one or two passes and make it unusable. High humidity and heat will cause tapes to stick to the head drum and wear prematurely. Shuttling tapes back and forth and leaving them sit in pause (on one spot) can accelerate wear.

Under ideal conditions: clean machine in good alignment running a tape from beginning to end without stopping is as good as you're going to get. Alignment tape manufacturers used to indicate expected life as the "number of passes". No significant degradation in 50 passes, but after that, dropouts become obvious. Maximum life is 200 passes. At that point, the tape is starting to break down with oxide particles being shed onto the heads (actually happens with all tapes to some degree) causing head clogging. With tapes of any age, a liquid spill such as soda pop ends the game right there. It can be cleaned, but unless it's your precious home movies, forget it.

I would use a tape until the dropouts become annoying. Dropouts are places on the tape where the oxide is missing. You'll see them more at the beginning of a tape where it's mechanically stressed by loading and unloading. A lateral scratch on a tape (caused by buildup of gunk in a VCR) will show up as a 3 or 4 line continuous dropout somewhere on the screen. Look at some heavily used rental tapes and you'll get the idea. So, bottom line: use it until it shows it's age. :)

Preventive maintenance

You no doubt have heard that a VCR should be cleaned and checked periodically. This is basically good advice but few people actually do follow it. I cannot give a specific schedule to follow as many factors influence the amount of wear and tear on your VCR:

- If you mostly use new brand-name tapes to make your own recordings, rarely play rental tapes, and have the VCR located in a clean cool relatively dust free and smoke free location, you may be able to go 5 years with no problems. However, a more prudent interval would be 1-2 years between preventive maintenance and rubber replacement after 4-5 years. Obviously, if you time shift every evening or have frequent marathon viewing parties you should probably reduce the PM interval.

- If you play rental movies every weekend or older tapes and have chain smokers in the house, every 3 months may not be frequent enough. I would suggest 6 months to 1 year between preventive maintenance and rubber replacement after 3-4 years.

If you want some guidelines, see the next section: Sample VCR preventive maintenance schedule.

Realistically, you are not going to do any PM anyway. So, just be aware of the types of symptoms that would be indications of the need for cleaning or other preventive or corrective maintenance - erratic loading, need to convince the VCR to perform certain operations, whirring motors without completing cycle, VCR taking longer to go into or out of a particular mode than you recall, jittery or noisy picture, or wavering or muddy sound. If your inspection reveals deteriorated rubber parts, obviously these should be replaced regardless of their age.

Of course, acute symptoms like a tape jam or tape munching episode is a sign of the need for emergency treatment. This still may mean that a thorough cleaning is all that is needed.

I generally don't consider cleaning tapes to be of much value for preventive maintenance since they do not run long enough or with enough force to clean the rollers, stationary heads, and guide posts. Also, the dry type, in particular, are abrasive and frequent use may cause premature wear to the expensive video heads.

The following are some reasons to inspect and clean a VCR periodically:

- This will maintain performance at factory new levels. Dirt, dust, and shed tape oxide all contribute to a reduction in stable tape movement and possible problems with noisy or jumping pictures and muddy or wavering sound.

- Dirt, dust, and other crud can be deposited on the tapes you run through the VCR contaminating them and passing problems on to this or other VCRs in the future.

- Your inspection will reveal if service parts like belts, tires, the pinch roller, etc. are in good conditions so that future surprises will be minimized.

If you follow the instructions in the section: General guide to VCR cleaning and rubber parts replacement, there is minimal risk to the VCR. However, don't go overboard. If the belts are in good condition (by appearance and stretch test), just clean them or leave them alone. This is especially true in the (generally infrequent) designs of some models of VCR tape transports where significant disassembly is required to replace a belt. In this situation, you risk not being able to put everything back the way it was. Most belts can be replaced with little or no disassembly beyond removing the top and bottom covers and possibly any circuit boards that may be in the way, Sometimes one or two additional screws will need to be loosened or removed to move a bracket or shield.

Sample VCR preventive maintenance schedule

Here is an example of the recommended inspection, lubrication, and replacement schedule for a typical VCR as provided by the manufacturer. This is from the Sams VCRfact for a particular non-HiFi RCA VCR. I am providing this for information only and am not necessarily recommending these or other similar hard and fast rules for VCR preventive maintenance.

It is not clear here what a 'tape' is though the comments that go along with this table seem to indicate that it means a T120. However, parts that deal with tape loading are affected not by how long a tape is played but by the number of loading cycles. Wear on the video heads, on the other hand is strictly a function of play/record time. Wear of the A/C and erase heads depends on both time and tape speed. Thus, these are additional reasons not to take the numbers below too literally.

```
  After         What to do                       Which parts
------------------------------------------------------------------------------
250 tapes         Clean         A/C head, capstan, erase head, pinch roller,
                                 impedance roller, supply reel table, takeup
                                 reel table, video heads.

500 tapes        Replace        Video heads (upper cylinder).

750 tapes        Replace        Pinch roller

1000 tapes       Grease         Loading cam gears, impedance roller shaft,
                                 roller guide tracks.

                   Oil          Supply reel shaft, takeup reel shaft.

                 Replace        Reel belt, loading motor belt, main brake
                                 spring, main brake arms (left and right).

2000 tapes       Replace        A/C head, erase head, supply reel table,
                                 takeup reel table.

2500 tapes       Replace        Cylinder unit.
```

Rental tape considerations

It would be nice for your VCR if rental movies had never been invented. You have no idea of the history of any tape you bring home. The following may also apply to tapes in your video library or tapes given to you by friends or relatives:

- The tape may be old and old tapes shed a lot more oxide and crud than newer tapes. A single playing may clog your video heads.

- The tape may have been damaged by a prior viewing and one pass through may ruin your expensive video heads. A tape that has been seriously crinkled due to a VCR tape eating incident and then wound back into the cassette may be a ticking time bomb for your VCR. A tape with a partial break or one that has been improperly spliced is even more likely to cause serious damage. Do not splice tapes - see the section: Recovering damaged or broken tapes.

- The cassette mechanism itself may have been damaged (from being dropped or stored in a hot automobile) with unknown consequences for your VCR.

Note: if you should ever damage a rental tape as a result of a cranky VCR or for any other reason, don't just give it back to the video store. Please let them know. Also, if your VCR should jam with a tape inside, do not forcibly extract it - read the appropriate sections later in this document. If in doubt, let the video store know what happened and follow their recommendations.

Given that you are not likely to give up the movie couch potato addiction, some problems can be avoided by fast forwarding a couple of minutes into the tape before hitting PLAY. Damage to rental tapes often occurs near the start - and this will avoid some of the useless coming attractions as well!

If you notice the video breaking up or deteriorating while you are watching, immediately ejecting the tape may be the most prudent option since the worst may be yet to come!

While I cannot control your viewing habits, playing a lot of old, dirty, deteriorated tapes (rental or from your own tape library) will eventually take a toll on your VCR. At the very least, you should perform a general cleaning and inspection at more frequent intervals.

(From: Jim Lagerkvist (jlager@tir.com).)

Renting a video tape has all the same potential consequences as renting a hooker. That tape may pass to your machine anything from pizza grease to splices made from duct tape or staples. I keep two VCRs in my house. One for rental tapes and another for known trusted tapes.

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VCR Maintenance and Troubleshooting Guide

Safety

Once you remove the cover(s) of a VCR (ignoring the warnings about no user serviceable parts, etc.), there are some risks to you and your VCR. You also, of course, void the warranty (at least in principle). Therefore, if the unit is still under warranty, having it serviced professionally may be your wisest option.

Stay away from the line side of the power supply - put electrical tape over the exposed connections. To be doubly sure, tape a piece of cardboard or thick plastic over the power supply section. Other than that, there is more danger of damaging the VCR by accidentally shorting something out or breaking a little plastic doodad than of you getting hurt.

- Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current, or get caught in moving parts (protect long hair as well).
- If circuit boards need to be removed from their mountings, put insulating material between the boards and anything they may short to. Hold them in place with string or electrical tape. Prop them up with insulation sticks - plastic or wood.
- Connect/disconnect any test leads with the equipment unpowered and unplugged. Use clip leads or solder temporary wires to reach cramped locations or difficult to access locations.
- If you must probe live, put electrical tape over all but the last 1/16" of the test probes to avoid the possibility of an accidental short which could cause damage to various components. Clip the reference end of the meter or scope to the appropriate ground return.

- Perform as many tests as possible with power off and the equipment unplugged. For example, the semiconductors in the switching power supply of a VCR can be tested for shorts and the fusable resistors can be tested for opens.

- If you need to probe, solder, or otherwise touch circuits in a switching power supply with the power off, discharge (across) large power supply filter capacitors with a 2 W or greater 20-100K resistor and then verify with your voltmeter.

- The use of GFCI (Ground Fault Circuit Interrupter) protected outlet is a good idea but will not protect you from shock from many points in a line connected power supply. A circuit breaker is too slow and insensitive to provide any protection for you or in many cases, your equipment. A GFCI may prevent your scope probe ground from melting should you accidentally connect it to a live circuit, however.

- Don't attempt repair work when you are tired. Not only will you be more careless, but your primary diagnostic tool - deductive reasoning - will not be operating at full capacity.

- Finally, never assume anything without checking it out for yourself! Don't take shortcuts!

Troubleshooting tips

Many problems have simple solutions. Don't immediately assume that your problem is some combination of esoteric complex convoluted failures. For a VCR, it may just be a bad belt or an experiment in rock placement by your 3-year old. Try to remember that the problems with the most catastrophic impact on operation (a VCR that eats tapes) usually have the simplest solutions (replace the idler tire). The kind of problems we would like to avoid at all costs are the ones that are intermittent or difficult to reproduce: the occasional interference or a VCR that sometimes will not record your favorite soaps on alternate Thursdays before a full moon.

If you get stuck, sleep on it. Sometimes, just letting the problem bounce around in your head will lead to a different more successful approach or solution. Don't work when you are really tired - it is both dangerous and mostly non-productive (or possibly destructive).

Whenever working on precision equipment, make copious notes and diagrams. You will be eternally grateful when the time comes to reassemble the unit. Most connectors are keyed against incorrect insertion or interchange of cables, but not always. Apparently identical screws may be of differing lengths or have slightly different thread types. Little parts may fit in more than one place or orientation. Etc. Etc.

Pill bottles, film canisters, and plastic ice cube trays come in handy for sorting and storing screws and other small parts after disassembly.

Select a work area which is well lighted and where dropped parts can be located - not on a deep pile shag rug. Something like a large plastic tray with a slight lip may come in handy as it prevents small parts from rolling off of the work table. The best location will also be relatively dust free and allow you to suspend your troubleshooting to eat or sleep or think without having to pile everything into a cardboard box for storage.

Another consideration is ESD - Electro-Static Discharge. The electronic components in a VCR are vulnerable to ESD. There is no need to go overboard but taking reasonable precautions such as getting into the habit of touching the chassis first before any of the electronic components is a good practice. The use of an antistatic wrist strap would be further insurance.

A basic set of precision hand tools will be all you need to disassemble a VCR and perform most adjustments. These do not need to be really expensive but poor quality tools are worse than useless and can cause damage. Needed tools include a selection of Philips and straight blade screwdrivers, needlenose pliers, wire cutters, tweezers, and dental picks. A jeweler's screwdriver set is a must particularly if you are working on a portable VCR or camcorder. For adjustments, a miniature (1/16" blade) screwdriver with a non-metallic tip is desirable both to prevent the presence of metal from altering the electrical properties of the circuit and to minimize the possibility of shorting something from accidental contact with the circuitry.

You should not need any VCR specific tools with the possible exception of a miniature metric hex key wrench set for loosening the set screws on the roller guides should you need to perform a tape path alignment. I have never needed a VCR head puller. You can make a tool for the special nut found on many A/C head assemblies for tracking adjustment by filing a slot in the blade of a straight blade screwdriver.

A low power fine tip soldering iron and fine rosin core solder will be needed if you should need to disconnect any soldered wires (on purpose or by accident) or replace soldered components.

CAUTION: You can easily turn a simple repair (e.g., bad solder connections) into an expensive mess if you don't have both a decent soldering iron and the soldering skills to go along with it. If in doubt, find someone else to do the soldering or at least practice soldering on a junk circuit board first! See the document: Troubleshooting and Repair of Consumer Electronics Equipment for additional info on soldering and rework techniques.

For thermal or warmup problems, a can of 'cold spray' or 'circuit chiller' (they are the same) and a heat gun or blow dryer come in handy to identify components whose characteristics may be drifting with temperature. Using the extension tube of the spray can or making a cardboard nozzle for the heat gun can provide very precise control of which components you are affecting.

Basic cleaning supplies include Q-tips (you may know them as cotton buds) for everything BUT video heads, chamois covered cleaning sticks (for video heads), lint free cloths or paper towels, water, and isopropyl alcohol (preferably 91 percent medicinal grade or better).

For info on useful chemicals, adhesives, and lubricants, see the document "Troubleshooting of Consumer Electronic Equipment".

If you have several VCRs or do repairs for friends (former friends?), there are inexpensive kits of VCR mechanical parts like washers and springs that come in handy. General belt or similar kits are not worthwhile unless you are in the service business - there is too much variety in the sizes and other characteristics of these types of parts to make an assortment a good investment.

Note: while working with the top off, you may need to put pieces of strategically located cardboard over the area of the cassette to block extraneous light from causing erratic behavior (modes aborting, not starting at all, etc.) with the start/end-of-tape sensors. Not all VCRs are sensitive to extraneous illumination but I have been bitten more than once by not doing this. Using overhead instead of direct illumination will probably help as well. In extreme cases, placing electrical tape over the end sensors may be needed but this will likely confuse the microcontroller under certain conditions into thinking that a non- existent tape is present - or if your troubleshooting will permit, leave a cassette in the transport. (I have heard of at least one case where this was a problem even for normal operation - apparently, light was falling on the VCR in just the wrong way where it happened to be located. The VCR would enter rewind mode regardless of what the helpless human wanted unless tipped on end!)

Test equipment

Don't start with the electronic test equipment, start with some analytical thinking. Many problems associated with consumer electronic equipment do not require a schematic (though one may be useful). The majority of problems with VCRs are mechanical and can be dealt with using nothing more than a good set of precision hand tools; some alcohol, degreaser, contact cleaner, light oil and grease; and your powers of observation (and a little experience). Your built in senses and that stuff between your ears represents the most important test equipment you have.

A DMM or VOM is necessary for checking of power supply voltages and testing of sensors, LEDs, switches, and other small components. Unless you get deep into the electronic repair of VCRs, an oscilloscope is not required.

There are two items of important test equipment that you probably already have:

- A video signal source - both RF and baseband (RCA jacks). Unless you are troubleshooting tuner or video/audio input problems, either one will suffice. RF sources include a pair of rabbit ears or an outdoor antenna, a cable connection, or a VCR with a working RF modulator. Similarly, a working VCR makes a handy baseband or RF signal source.

- A display device. A video monitor or TV makes an excellent video signal display. Many video problems can be diagnosed by just examining the picture. If you have an old TV with a vertical hold control, this is useful when adjusting backtension, should the need arise. A B/W TV is adequate for many of the tests you will be performing.

Why you should read the entire FAQ first

If you have no prior experience with precision electromechanical repair, don't just jump in as the following actual experience demonstrates:

(From: someone who would prefer not to be identified).

> "Ok, I did something dumb. I was given an old VCR (early 80s) a couple weeks ago (JVC-7100U). It stopped playing and recording, but FF and rewind worked fine. Reading the FAQ, I decided to check it out. I took the top off, and was trying to make the motor run so I could see the problem. There was an incandescent light, and I figured there was a light sensor, so I moved the lamp out of the way. The FAQ suggests electrical tape over the lamp, but I hadn't read it yet. My manipulation caused the lamp to fail. Until I could replace it, I just jumped the connection, which worked fine for awhile. I had just figured out the problem with play/record was a drive wheel not making contact with the take-up reel. It seemed to be a result of a weak spring, and I was trying to figure out which one, when the screwdriver I was manipulating the arm with slipped, and contacted the back side of a circuit board. Lesson number two: Use a chopstick for that purpose. I believe it was at this point I realized I got no reaction from any of the VCR control buttons, so maybe I shorted something out. All the buttons worked before. Even worse, as I was reinstalling the tape loading mechanism, the screwdriver slipped again, in a different place, and I did see a flash when it contacted the back of the circuit board. Whoops."

Don't let this happen to you. Or, at least start out with an old expendable VCR and accept the hits to your pride!

Cassette cheaters

When troubleshooting mechanical problems in a VCR, one of the handiest accessories is a cassette cheater - a frame to fool the VCR into thinking there is a cassette in place so that you have access to the reel spindles and idler.

You can buy these for $6-12 but you can make one that is almost as nice:

1. Take a discarded cassette, open it up and throw away everything but the top and bottom halves and the screws.

2. Punch out the plastic windows - and somewhat more of the top and bottom if you are so inclined - relatively little of the original structure is actually needed to fool the microbrain of the VCR! The more open the cheater is, the easier it will be to see and access guts of the VCR while running.

3. Reassemble the two halves of the cassette with the screws (you did save the screws, right?).

4. Put a bit of black tape over the sensor holes on the sides of the cassette (near where the hinge pins of the flap went).

These cheaters will load and 'play' just fine except that some machines actually sense that the supply reel is being turned by the tape movement during loading or always and will shut down if it isn't (among other peculiarities) so you may have to do this by hand.

There are several benefits to using one of these, one of which is that there is no chance of ruining a prized tape due to a hungry VCR. You will also be able to feel the spindles to get an idea whether they are turning properly and with enough torque in all modes. If you break out enough of the top and bottom, you will have access to the idler and other under-cassette parts at the same time. If you examine one of the commercial cassette cheaters, you will see that very little is needed beyond the outer frame as long as it sits properly on the indexing posts and doesn't jam the mechanism when loading/ejecting.

Test tapes

When aligning the tape path, a test tape will be needed as a reference. Actually, you want two - one recorded at the SP (2 hour) speed and another recorded at the EP (6 hour) speed. These do not need to be exorbitantly priced professional alignment tapes. A couple of recordings made on a known working VCR will get you close enough for most purposes. Do not use these same tapes for diagnosing or testing of mechanical problems, your VCR may be hungry and they may get eaten.

For general video diagnosis including mechanical and tape eating problems, a bunch of sacrificial tapes is handy - advertising, promos, feature shorts - anything you do not care about but have been recorded on working VCRs. Very often they get mangled and you do not want to continue to use mangled tapes which may damage the VCR - in particular the video heads. However, once you have the VCR basically working, you will want to test it start to finish on a T120 cassette. This is because the reel hub size on those short video cassettes is not the same as a standard (most commonly used) T120 cassette and may mask problems if the VCR is mechanically marginal in some respects.

Getting inside a VCR

You will void the warranty - at least in principle. There are usually no warranty seals on a VCR so unless you cause visible damage or mangle the screws, it is unlikely that this would be detected. You need to decide. A VCR still under warranty should probably be returned for warranty service for any covered problems except those with the most obvious and easy solutions.

It is usually very easy to remove the top and bottom covers on VCRs. For the top cover, there are usually some very obvious screws on the back or sides, and in rare cases on the top. There may be a couple of screws on the bottom as well that secure the top cover. For top loaders, you will probably need to remove the cassette holder lid - there will be two screws, perhaps hidden by rubber plugs.

Once all the screws are out, the top cover will lift up or slide back and then come off easily. If it still does not want to budge, recheck for screws you may have missed.

For the bottom cover, there are usually a half dozen or so screws around its perimeter and sometimes in the middle as well. There may be one or two grounding screws as well which are of different length and threads - these should go back in the same location from where they came. Bottom covers are usually simple sheet metal. In rare cases, you will need to remove the front panel to free the bottom cover (or vice-versa).

Circuit boards may prevent access to the top or bottom of the tape transport. Usually, removal of a few screws (often marked with red paint or arrows on the circuit board) and perhaps pressing of a couple of snaps will permit the board to be swung up on a hinge out of the way.

Front panels usually snap off, possibly requiring the removal of a few screws on top or bottom.

Make notes of screw location and type and store the screws away in a pill bottle, film canister, or ice cube tray.

When reassembling the equipment make sure to route cables and other wiring such that they will not get pinched or snagged and possibly broken or have their insulation nicked or pierced and that they will not get caught in moving parts. Replace any cable ties that were cut or removed during disassembly and add additional ones of your own if needed. Some electrical tape may sometimes come in handy to provide insulation insurance as well.

Why does my VCR shut down or behave strangely when I remove the cover?

There are various sensors in a VCR that are light sensitive - it is not a safety interlock (though it acts this way in some VCRs) but a result of the way the tape start and end sensors operate. VHS tapes have a clear leader and trailer. An LED or light bulb poking up near the center of the cassette shine towards sensors at either side of the cassette. When light is detected the VCR assumes that it is at the appropriate end of the tape and shuts off (or rewinds if in PLAY mode when it senses the end depending on model).

During servicing, a piece of opaque cardboard or other insulating material should be placed above the cassette basket if any strange behavior is detected that was not present with the cover in place. Not all VCRs are particularly sensitive external illumination.

Getting built up dust and dirt out of a VCR

This should be the first step in any inspection and cleaning procedure.

Do not be tempted to use compressed air!

I would quicker use a soft brush to carefully dust off the circuit boards and power supply. Work in such a way that the resulting dust does not fall on the mechanical parts.

For the deck itself, using compressed air could dislodge dirt and dust which may then settle on lubricated parts contaminating them. High pressure air could move oil or grease from where it is to where it should not be. If you are talking about a shop air line, the pressure may be much much too high and there may be contaminants as well.

A Q-tip (cotton swab) moistened with politically correct alcohol can be used to remove dust and dirt from various surfaces of the deck (in addition to the normal proper cleaning procedures for the guides, rollers, heads, wheels, belts, etc.)

What to do if a tiny tiny part falls into the VCR

We have all done this: a tiny washer or spring pops off and disappears from sight inside the guts of the unit. Don't panic. First - unplug the VCR if it is plugged into the AC. Remove the battery pack from a camcorder.

Try to locate the part with a bright light without moving the VCR. You may have gotten lucky (yeah, right). Next, over an area where a dropped part will be visible (not a shag carpet!), try any reasonable means to shake it loose - upside down, a little gently tapping and shaking, etc. A hard surface is better in some ways as you might hear the part drop. On the other hand it may bounce into the great beyond.

If this does not work, you have two options:

1. Assume that the part has landed in a place that will not cause future problems. There could be electrical problems if it is metallic and shorts out some circuitry or there could be mechanical problems if it jams some part of the mechanism. There is an excellent chance that the part will never cause any harm. What chance? I don't know, maybe 99%. It is not worth taking the unit to pieces to locate the part. You are more likely to damage something else in the process. Obtain a replacement and get on with your life. The exception is, of course, if you now begin experiencing problems you **know** were not there before.

2. Take the unit to pieces in an attempt to locate the part. For all you know, it may be clear across the room and you will never find it inside. If all the gymnastics have not knocked it loose, then it may be really wedged somewhere and will stay there - forever. If the VCR behaves normally, then in all likelihood it will continue to do so.

To prevent this sort of thing from happening in the future you will no doubt be much more careful. Sure you will! Some suggestions to prevent ejection of an E-clip, split washer, or spring into the great beyond:

- Construct a paper dam around the area.

- Tie a thread or fine wire around the part before attempting to remove it. Keep this 'safety line' on until after it has been reinstalled, then just pull it free.

- Keep one finger on the part as you attempt to pop it free.

- Hold onto the part with a pair of needlenose pliers or tweezers while prying with a small screwdriver.

(From: Paul Sagi (kamrok@tm.net.my).)

For finding a small part dropped on the floor, I darken the room, then shine a flashlight parallel to the floor, with the beam just touching the floor. the oblique (if that is the correct word?) beam shows up the part (and any dirt if the floor was not recently swept!) clearly. this works best on smooth floors or short-pile carpets. on shag carpets, if the part is on top of the pile, instead of having fallen into it (fat hope), the method works also. for shag carpets where the part has tried to hide, shine the light downwards at right angles and imagine how the part would look if seen against the background of the carpet, to prime the mind to recognize it when seen. a strong magnet (for steel parts like e-rings) can help when the above methods fail. sweeping or vacuuming the carpet or floor, then sorting through the debris can also help, especially for non-magnetic parts (sometimes cannot know if the part is magnetic or not until after it is found!)

I do not agree with the advice that a small part that cannot be located often can be left safely inside an electronic device. remember Murphy? he is ever-vigilant and delights in ensuring the part will have fallen where it can do harm when the power is switched on.

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VCR Tape Transport Fundamentals

Parts of the tape transport in a VCR

Thanks to Brian Siler (bsiler@bigfoot.com) for using his Snappy(tm) rig to capture some of these original photos.

Please refer to the photo: Typical VHS VCR Tape Transport Components or Sharp VCR Transport with Major Parts Labeled for parts identification.

The following description applies to 99.9% of the VCRs in existence today. I have seen one that had a sideways loading mechanism - very weird.

Looking at the unit from above with the front toward you:

- Supply spindle - left hand side platform on which the supply tape reel (inside the cassette) sits. The edge which contacts the idler tire, and associated brake pad, should be cleaned.

- Takeup spindle - right hand side platform on which the takeup tape reel (inside the cassette) sits. The edge which contacts the idler tire, and associated brake pad, should be cleaned.

- Idler - assembly which swings between supply and takeup reels and transfers power to the appropriate reel to wind the tape up during play and record and often to drive FF and REW. This may use a rubber tire or a gear.

- Idler tire - the black rubber ring on the outside of one part of the idler which actually contacts the reel edges. This is single most likely part to need replacement after a few years of use. Some VCRs use a gear instead of a tire, but the tire is most common, especially in older units. Clean and inspect - replace if in doubt. See VCR with Idler Tire for a typical tire-type idler assembly.

  Some VCRs use gears in place of rubber (as is the case with the VCR shown in the photo: Typical VHS VCR Tape Transport Components. Teeth can break off but these are generally quite reliable. Some high-end decks may have separate motors for reel rotation.

- Roller guides - there are two, one on each side. These assemblies move from their retracted position toward front of machine to their loaded position for play and record. The white rollers should spin freely and be clean. When retracted, the roller guide assemblies will be slightly loose. However, when the tape is wound around the video head drum, they must be snug against the V-Stoppers - the brackets at the end of the tracks.

  Also on the same assembly are tilted metal guide posts - again one for each side. These sometimes fall out with obvious consequences.

Proper functioning and adjustment of the roller guides is the most critical requirement for proper tracking. (However, do not touch their settings without being really sure that they are at fault and not until you have read the sections relating to tape path alignment.) Clean and inspect.

- Roller guide tracks - combination of plastic and metal slots in which the roller guide assemblies slide during tape loading and unloading. Check to make sure there is still some healthy grease on the surfaces. If gummed up or excessively dirty, clean and relube with a dab of plastic-safe grease on each sliding surface.

- Video head drum or upper cylinder - approximately 2.45 inches in diameter by .75 inches high. This rotating assembly contains the video heads (and HiFi audio and flying erase heads, if present). Stay away from this unit. as video heads are very delicate. If you must clean it, refer to the specific instructions on cleaning video heads elsewhere in this document. Video heads do not normally require cleaning despite what the cleaning tape people will have you believe. If you are not having video noise problems, they should be left alone.

- Capstan - right side after tape exits from roller guide. The capstan is a shaft about 3/16" diameter which during play and record (and search) modes control tape movement forward or reverse when the pinch roller is pressed against it. Should be cleaned thoroughly to assure proper tape movement during play, record, and search modes.

- Pinch roller - black rubber roller about 1/2" diameter, 3/4" high which spins freely and is pressed against the capstan during play, record, and search modes. It is constructed as a molded rubber sleeve fused to a metal roller on a small ball bearing.

  A hard, shiny, dried out pinch roller can lead to tape edge munching and erratic sound, speed, and tracking. Clean thoroughly. Inspect for cracked, hard, shiny, or otherwise deteriorated rubber, and lack of free and smooth rotation. Replace if any of these are present.

  Even if you have no obvious record or playback symptoms, if the pinch roller appears concave or with a distinct worn ridge, replacement is recommended - erratic behavior will soon be the result. A tape which runs off center due to a bad pinch roller may result in tape edge damage and over time can also alter the wear pattern of the audio/control head and various guide posts.

  A quick test of the pinch roller is to put the VCR into PLAY and *carefully* try to stop it from turning between your thumb and forefinger - a good pinch roller will not be easy to stop.

  However, don't replace a pinch roller that is in good condition. The replacement may be inferior. (Apparently for at least some JVC VCRs, the original pinch roller is of very high quality and will last the life of the VCR if cleaned properly.)

- Audio/control Head Stack - between right roller guide (when tape is loaded around drum) and capstan. Includes magnetic heads for non-HiFi (linear) audio and synchronization control track. Should be cleaned since tracking and non-HiFi audio performance is critically dependent on its performance.

- Back tension arm - left side just as tape exits cassette - this is coupled to a felt Back Tension Band and serves to maintain a constant tension on the tape during play, record, and forward search. Retracts toward cassette when tape is unloaded. Back tension is somewhat critical and may need adjustment after long use.

- Various other fixed guide posts - vertical stationary metal posts which tape contacts. Should be cleaned but rarely need adjustment. The positions of these vary somewhat by manufacturer.

- Full erase head - left side towards rear which tape passes over just before going around roller guide, guide post, and drum. Rarely causes problems. Clean.

- Impedance roller - left side near full erase head. Freely rotating roller stabilizes tape movement. Some VCRs lack this component. Clean.

- Half loading arm - right side near capstan/pinch roller. On VCRs with 'rapid or instant access transports' this helps to position the tape in the intermediate (half loaded) position. A similar arm is usually present in other VCRs and helps to position the tape around the pinch roller. Check for free movement. Clean. Lubricate bearing if sluggish.

- Belts - various size black rubber bands - a typical VCR will have between 0 and 12 of these on top and bottom. Typical is 3 or 4. Most are of square cross section though an occasional belt may be flat or round. The belts will need replacement after a few years. Clean and inspect. Replace any belts that are hard, cracked, stretched, or flabby. A good belt will feel soft and rubbery without cracks or other signs of deterioration. It will return to its relaxed length instantly if stretched by hand about 25%. Belt kits are generally available by VCR model but individual belts can be ordered as well. In either case, this is very low cost maintenance which can make an absolutely huge difference in the happiness of your VCR. New belts can often restore a comatose VCR to perfect health.

For additional information on replacement rubber parts, see the section: Determining belt, tire, and pinch roller specifications.

Alex's quick tips

(From Alex (ramjam@globalserve.net).)

1. To confirm that a worn idler tire is causing a malfunction, without disassembly, I use a product called "Rubber Renue" (M.G.Chemicals Ltd. 13-80 Hale Road, Brampton, ON L6W 3M1 Canada 416 454-4178). First I clean the tire with isopropyl alcohol (99%) then using the other end of the Q-tip I apply Rubber Renue. You don't need much, I have had the same 100 ml (3.4 oz.) bottle for over 6 years. What the product does is rejuvenates and conditions the rubber (read: makes *sticky*) as to allow normal or near normal operation. I don't recommend this as a permanent fix, though it can be, it is a great diagnostic tool and the whole procedure takes about five minutes.

2. To fix squeaky pulley shafts and collars I use a pipe cleaner (most smoke shops sell them) to clean the collars, I then use transmission fluid (the same stuff you put in your car) as a lubricant on the shaft. It's lightweight, it doesn't gum up, it's cheap and can be bought just about anywhere. Just remember not to use too much as it spreads easily, which can be disastrous in a VCR.

Most common problems

- VCR refuses to FF or REW and shuts off.
- VCR shuts off entering PLAY or REC or at random during PLAY or REC.
- VCR eats tapes.
- VCR doesn't accept tapes or ejects them without cause.
- Sound is wavery, fluctuating, or muddy.

The cause for all of these is very often a bad idler tire or other dirty, worn, or tired rubber parts. See the section below: "General guide to VCR cleaning and rubber parts replacement". A VCR that just munched down your favorite tape is very likely only in need of a little tender loving care.

WARNING: Don't turn a simple repair into a full length double feature. Most tires and belts come off without extensive disassembly. However, if your VCR is the exception, DO NOT remove anything to get at the rubber part that may be part of a critical timing relationship - racks or gears, for example - before fully understanding the implications of this action. In some cases, if a gear is rotated even one tooth from where it should be, there can be unforeseen and catastrophic consequences. See the section: Mechanical relationships in VCRs for more information before proceeding any further!

General guide to VCR cleaning and rubber parts replacement

All the guideposts, wheels, and rubber parts of a VCR should be cleaned periodically - how often depends on usage. Of course, no one really does it unless something goes wrong.

Do not attempt to clean the video heads until you follow the proper procedure given elsewhere in this document, you can break them - very expensive lesson. In most cases, they do not need attention anyhow.

Q-tips and alcohol (91% medicinal is OK, pure isopropyl is better. Avoid rubbing alcohol especially if it contains any additives) can be used everywhere except the video heads. Just dry quickly to avoid leaving residue behind or damaging the rubber parts further.

Cleaning may get your machine going well enough to get by until any replacement rubber parts arrive and to confirm your diagnosis.

Things to clean:

1. Capstan and pinch roller. These collect a lot of crud mostly oxide which flakes off of (old rental) tapes. Use as many Q-tips (wet but not dripping with alcohol) as necessary to remove all foreign matter from the capstan (the shiny shaft that pulls the tape through the VCR for play and record). Just don't get impatient and use something sharp - the crud will come off with the Q-tips and maybe some help from a fingernail. For really hard encrusted crud, a scrap of soft metal like aluminum, brass, or copper may be of help if you're the impatient type. DON'T use iron or steel - you will be buying a new (expensive capstan assembly!

   Clean the pinch roller (presses against the capstan in Play, Record, and Search mode CUE and REVIEW) and until no more black stuff comes off. Use as many Q-tips as necessary until no more black gunk collects on Q-tip.

   If the pinch roller is still hard, shiny or cracked, it will probably need replacement. Many are available for about $6 from the sources listed at the end of this document. It is sometimes possible to put the pinch roller in an electric drill, drill press, or lathe, and carefully file off the hard shiny dried out rubber surface layer, but only use a last resort - and this fix is probably temporary at best. For a very detailed and complete step-by-step procedure, see: VCR crinkling tape, sound fading, speed flipping. (This is an archived sci.electronics.repair newsgroup posting.)

2. Various guideposts including the roller guides (the white rollers on metal posts which are near the video head drum when in play or record mode). When in FF or REW, or with no tape present, these move on tracks to a position toward the front of the VCR. Note that the roller guides with the white rollers and tilted metal posts will be fairly loose when in the unloaded position (but you should not be able to lift them off the tracks). When actually playing or recording a tape, they will be snug against the stoppers at the end of the tracks.

3. Idler tire (idler swings between reels and transfers motor power to reels - clean until no more black stuff comes off. A dirty or worn idler tire is probably the single most common VCR problem.

   If the idler tire appears cracked, glazed, or dried out, it will need to be replaced. About $.50 to $1.00. As a temporary measure, you can usually turn the tire inside-out and replace it. The protected inner (now outer) surface will grip well enough to restore functionality until a replacement tire arrives - and verify the diagnosis as to the cause of your problem.

   Also, the idler assembly includes a slip clutch. If this weakens, the idler may not have enough force to press on the reel table edges. If it becomes too tight, there may be audio, video, or crickled tape problems and/or excess wear of the idler tire. When in doubt, the entire idler assembly is often available as a replacement part. They can often be disassembled and adjusted if necessary.

4. Reel table edges - surface on the reel tables where the idler contacts.

5. Audio/control head (right side) and full erase head, (left side). Q-tips and alcohol are OK for these.

6. Anything else that the tape contacts on its exciting journey through your machine.

7. Rubber belts. Access to some of these will probably require the removal of the bottom cover. After noting where each belt goes, remove them individually (if possible) and clean with alcohol and Q-tips or lint free cloth. Dry quickly to avoid degrading the rubber from contact with the alcohol. If a belt is trapped by some assembly and not easy to remove, use the Q-tip on the belt and/or pulley in place. However, if it is stretched, flabby, or damaged, you will need to figure out how to free it.

   Make sure that there are no twists when a square cut belt or replacement is installed on its pulleys.

   On some models, you may need to unscrew circuit board(s) blocking access to either the top or bottom of the tape transport. Make notes of what went where - particularly different types of screws and routing of wires.

   Any belts that appear loose, flabby or do not return instantly to their relaxed size when stretched by 25% or so will need to be replaced and may be the cause of your problems. Belts cost about $.30 to $2.00 and complete replacement belt kits are often available by model for $3. to $12. Meanwhile, the belts will function better once they are cleaned, maybe just enough to get by until your replacements arrive.

8. Video heads: READ CAREFULLY. Improper cleaning can ruin the expensive video heads. DO NOT attempt to clean the video heads without reading and following the procedure described in the section: Video head cleaning technique.

   While VCRs should be cleaned periodically, the video heads themselves usually do not need cleaning unless you have been playing old or defective rental tapes which may leave oxide deposits on the tips of the delicate ferrite head chips. Unless you are experiencing video snow, intermittent color, or loss of or intermittent HiFi sound (HiFi VCRs only, the HiFi heads are located on the video head drum and for the purposes of cleaning, treated the same way) leave the video heads alone.

   If you really feel that video head cleaning is needed, refer to the sections on video head problem diagnosis and cleaning elsewhere in this document.

Polishing your tape path

(From: Gillraker (eternity@mcp.cybertron.com).)

I pride myself on the cleanings I do with all repairs, I like to keep my shop up to command performance and a cut above the rest I usually even clean up the chassis and deck of most equipment and relubricate and all the trim.

I have seen my share of broken heads come in from people after they use a Q-tip...or a store bought cleaning tape...

I use a few different size hemostats with a folded up lint free cloth. When folded, it really buffs the cylinder units and leaves a nice shine on the tape guide rollers, and audio and erase heads too. I have cleaned a head with chamois swabs and then gone over them with my own cloth and was horrified to see the residue that was left from ordinary swabs, when it was all collected on the cloth. It doesn't snag the video or stereo hi-fi heads either - I have cleaned a few thousand this way and never snagged any .

I use generation 2000 disk cleaner for heads and acetone to degrease the posts and capstan - just a dip - not too much.

(Editor's note: take care with strong solvents like acetone - both to protect your health and avoid damage to plastic parts. --- sam)

Tom's comments on approaches to cleaning

(From: Thomas L DeTogne (tdetogne@home.com).)

Pardon me while I trip over my long gray beard :-).

In the old days, we used to clean the platters in a disk drive using what were essentially tongue depressors wrapped with a Texwipe (Lint-free paper). We would first use 99% pure isopropyl alcohol and follow it with freon. (AAAAAh! the Ozone layer!) We would then manually run the heads out over the platters (while they were spinning) and listen for 'ticks'. If we heard any, we'd repeat the process. For those who smoked in the computer room, the residue could build up rather thick and evenly. Getting the whole mess off was a chore. If such was the case, I actually would use Soap and water, followed by water, then the alcohol and finally the freon. (This was more like R-22 and not the R-12 variety. That, we used do dump into the atmosphere freely trying to cool down components.)

I have resurrected many road-kill VCRs by using those cleaning techniques on them. I haven't as yet had to use soap, but using other than alcohol proves beneficial. Just don't get too liberal with any of the cleaning fluids. By the way, the freon was used to remove any residue left behind by the alcohol.

Lubrication of a VCR

The short recommendation is: Don't add any oil or grease unless you are positively sure it is needed. Most parts in a VCR are lubricated at the factory and do not need any further lubrication over their lifetime. Too much lubrication is worse then too little. It is easy to add a drop of oil but difficult and time consuming to restore a VCR that has taken a swim.

NEVER, ever, use WD40 in a VCR! WD40 is not a good lubricant despite the claims on the label. Legend has it that the WD stands for Water Displacer - which is one of the functions of WD40 when used to coat tools. WD40 is much too thin to do any good as a general lubricant and will quickly collect dirt and dry up. It is also quite flammable and a pretty good solvent - and there is no telling what will be affected by this:

(From: Matthew Fries (freeze@visi.com).)

> "I heard a horror story when I was in tech school about someone who heard a little squeaking inside the VCR when it was in PLAY mode, so he sprayed WD40 in through the tape door (front loading) and 'lubricated' the entire inside of the VCR. The students who were working on this took apart the entire mechanism, sprayed it clean with TF solvent (4 cans - there goes the ozone) and it still didn't work. No surprise."

A light machine oil like electric motor or sewing machine oil should be used for gear or wheel shafts. A plastic safe grease like silicone grease or Molylube is suitable for gear teeth, cams, and the roller guide tracks.

Unless the VCR was not properly lubricated at the factory (which is quite possible), the only likely areas needing lubrication are the roller guide tracks - clean and grease. Sometimes you will find a dry capstan, motor, lever, or gear shaft but this is less likely.

In general, do not lubricate anything unless you know there is a need. Never 'shotgun' a problem by lubricating everything in sight! You might as well literally use a shotgun on the VCR!

Head demagnetizing

With audio tape decks, demagnetizing is often recommended to improve sound quality and frequency response. There is some debate as to how much benefit there is to this practice but if done properly, there is little risk. Demagnetizing removes the residual magnetic fields that can build up on ferrous parts of the tape heads and various guideposts and other parts in the tape path which may affect frequency response.

For the following, do not go near the video head drum, only perform demagnetization of the stationary A/C head, erase head, and guide posts and rollers. In my opinion, the video heads should almost never need to be demagnetized. The ferrite material from which they are constructed is not prone to easily being magnetized like steel.

Use a small demagnetizer designed for a tape deck or cassette deck. Do not use anything homemade that might be too powerful or a bulk tape eraser which would certainly be too powerful.

Make sure the tip is covered with a soft material to prevent damage to the finely polished surfaces in your VCR.

Turn power on to the demagnetizer when a couple of feet away from the VCR. Then, slowly bring it in close and slowly go over all surfaces of anything that the tape contacts or comes close to in the tape transport. The key word here is **slowly**. Move fast, and you will make the magnetic fields stronger. When finished, slowly draw the demagnetizer away to a distance of a couple of feet before turning it off.

Homemade VCR head demagnetizer

Rather than trying to build something that plugs directly into the AC line, use an *AC* wall adapter. Typically something from an old modem with a rating of around 1 A at 12 VAC should be fine. There is no significant safety hazard to touch connections with power on and they are short circuit protected so no matter what you do, there will be no immediate damage to the adapter.

Use a large nail with its point filed down to a blunt tip covered with tape or a plastic or rubber boot to protect the polished surfaces of the heads. I have no idea of the exact number of turns but I'd say start with 100 turns of #20 to #26 AWG insulated wire. There should be a noticeable vibration when bringing the tip with 1/4 inch or so of a ferrous surface but not much beyond this.

CAUTION: This may be too strong for the video heads - stay away from them! In fact, it may be too strong at the full 12 VAC. A lower voltage adapter may be better or use on a Variac. If it pulls nails out of your drywall, it's too strong. :) Use at your own risk!

Building a bulk tape eraser

A variety of approaches work for this - all based on strong magnetic fields. These will erase floppy diskettes, audio and video tapes, and all your credit cards and Turnpike passes!

- Magnets removed from large loudspeakers (including the pole pieces where the voice coil went) and microwave oven magnetrons.

- Some motors, transformers, the butt-end of some soldering guns, etc.

(From: Steven L. Bender (buqu35d@prodigy.com).)

You need a Power Transformer about 3" in each direction, can be like a low voltage 12 volt / 3 Amp unit or rated higher. Remove end bells if any, remove all the metal laminations (break the first one, yank it, and the rest will come easier). Re-insert all the metal laminations facing in the same direction, with the "E" all pointed the same, re-glue, varnish, or whatever. Connect AC Plug to the Primary, then insulate the whole works with Plastic tape and outre layer of Duct tape. After insulating it with several layers of tape - Instant Bulk Eraser.

Warning - Do not apply power for more than 60 seconds at a time! (It will get hot and burn your hand after two minutes.)

I had one of those for some years, but accidentally left it plugged in, (pulled the wrong wire out of the 6 to 1 outlet box) and after a few minutes, it smelled and was too hot to touch, and made a nasty noise as the copper started to melt... (Sounds Effects of Liquid Krell Metal in the distance...., Forbidden Planet - Paramount, 1956).

Luckily I didn't walk out, another few minutes and it would have caught fire..

I am not liable for any personal, profession, or consequential damages from use of this information !!!

(From: Steve Walz (rstevew@armory.com).)

Use a transformer and remove the EI core pieces and replace all the E's only in the same direction. Current limit it with a wire-wound resistor so it doesn't overheat and put a momentary pushbutton on it and a power cord to wall AC and insulate it so you don't shock yourself. Then place it so the open face of the E core pieces faces the tape or disk or whatever to be erased and push the button. Run it all over both sides of the tape or disk and pull the tape or disk away before letting up on the button if you wish to erase it. If you wish to magnetize a tool or such, simply let up on the button while the object or tool is still in contact with it. That's how that works! (You may have to do it a couple times before you catch the AC cycle at the peak! --- Sam.)

(From: Pat Swayne (me@patswayne.com).)

Here's a safety tip for your homemade bulk tape eraser: Use a small length of very thin solder as a fusable link. Place this as close to, but insulated from, the primary windings as possible, and pass the current through it. If the thing gets too hot, it will melt the solder and break the connection.

(From: Sam.)

It would have to get mighty hot for that to be effective but it's cheap enough. Of course, a thermal fuse or thermostat would be a more well controlled alternative.

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Cassette and Tape Loading Problems

Cassette loading and eject problems

Cassette loading places the cassette into proper position on the tape transport. In a front loader, pushing the cassette gently into the slot should cause a motor to take over and suck it in and down to rest on indexing pins. The mechanism that actually holds the cassette is called the cassette basket. Several types of problems are possible: the VCR may ignore you when you push the cassette in or press EJECT, or it may spit it out immediately or cycle back and forth. On a top loader, you do most of the cassette loading manually, so the only likely problem will be if EJECT does not work.

If attempting to load a cassette produces no response (though the VCR has power), then there could be a problem with the microswitch that senses the presence of a cassette, the cassette loading motor (if separate from the main motor), a slipping or broken belt, or a faulty driver or other electronic problem. Sometimes this could mean that the microcontroller is confused due to a faulty mode switch or because the mechanism somehow got into a peculiar state. Manual cycling of the cassette loading mechanism might reset it. Gently push a cassette in and turn the appropriate shaft or pulley by hand. First, try this with the VCR unplugged. If nothing happens or you feel resistance, try the other direction. Assuming you find no problems - there is no significant resistance to your turning and the cassette basket cycles from fully ejected to fully seated on the transport baseplate, leave the cassette basket in a partially loaded position and plug the VCR into the AC power and turn it on (this may not be necessary depending on the design of your VCR). It should now reset itself and either load or eject the cassette. If there are still no signs of a response, a power supply, motor, or electronic problem is likely.

Note: If this only happens with T160 (8 hour) tapes, it may be a problem with the thinner tape confusing the sensors. Avoiding these tapes is really the best thing to do since they can cause all sorts of problems (especially if they are an off-brand and of inferior quality to begin with).

If you hear a motor whirring but nothing happens, this is almost certainly a slipping or broken belt or something blocking the proper movement a mechanical part.

If pushing a cassette into the VCR results in it being ejected as though it tasted really bad (there may or may not be hesitation), or if the cassette cycles back and forth without stopping, there could be several possible causes.

If it stops part way during loading, does it pause as though the motor is straining or just abort with no warning? If the former, then check carefully for foreign objects, or lack of lubrication. A typical cause is a belt slipping, usually not the idler in this case. Help it out gently and see if that will complete the cycle. Sometimes it is helpful to cycle the mechanism by hand - turning the appropriate shaft or pulley and feeling and watching for any place where it binds. If the basket moves in the wrong way or you feel any significant resistance, try the other direction. Sometimes, the sticky cassette labels partially or totally peal off and clog the works. You may find a toy or rock inside carefully inserted by your 3 year-old! A bit of the cassette shell might have broken off and jammed the mechanism just to confuse you!

If the microcontroller were detecting an abnormality, then it would abort instantly but would most likely try to unload the tape before giving up but not in all designs. It is possible that if the expected behavior is not produced by the end/beginning-of-tape sensors during cassette loading, an abort could be initiated. Therefore, these sensors could be suspect. In some cases, the mode switch may be dirty or faulty. A gear may have broken some teeth or slipped a couple of teeth and the timing relationships may be incorrect. There may be a microswitch that is controlled by the cassette basket position and this may be defective or dirty.

Similarly, if the cassette seems to be cycling in and out in an apparently infinite loop, there may be an obstruction or the microcontroller is confused by a bad sensor or the basket is out of synchronization with the rest of the mechanism. A squirt of contact cleaner into the microswitch sensor and/or reflowing its bad solder connections may solve this type of problem.

Similar comments apply to cases where pressing the EJECT button produces no response. In particular, if the cassette was loaded successfully and you just finished a thoroughly enjoyable movie, the microcontroller may think the mechanism is not safe and is not ejecting to protect your valuable tape from possible damage should it not be fully retracted into the cassette. As with loading, EJECT may result in partial movement and shutdown or reloading the cassette into the down position. All the same causes apply.

There are even some poorly designed VCRs where extraneous light through the vent holes or tape door affect sensors and cause erratic operation. If a bright light is shining on the VCR, block and see if anything changes!

Ejecting a cassette from an uncooperative VCR

It is a common experience - the rental movie is due back at the video store **now** but no matter how you press the EJECT button, yell, scream, hold your breath, or jump up and down, the cassette refuses to be appear.

To remedy the underlying problem, see the sections on: "Cassette loading and eject problems" and other for appropriate information. This section only deals with getting the cassette out without damaging either your valuable recording or VCR.

Under no circumstances should you force anything - both your tape and your VCR will be history.

First, see if the VCR just got into a confused state - pull the plug and patiently wait a minute or two. This may reset the microcontroller and all will be well. These things happen.

If this is not successful, you will need to open up the VCR (unplug it first!) and attempt to cycle the mechanisms by hand. Probably both top and bottom covers will need to be removed. The following procedures assume that there are no broken parts, foreign objects, or other damage which might prevent manual cycling of the tape loading and cassette loading mechanism. (Inspect for toys and rocks.) Also note that some VCR designs use solenoids to engage various operations. This will complicate your task (to put it mildly) as locating and activating the proper ones at the appropriate time is, well, a treat.

1. Tape unloading: The first step is to determine if the tape has been unloaded from the video head drum back into the cassette. If the tape is fully retracted into the cassette - there is no tape showing, then go on to step (2). If not, you will need to figure out which shaft or pulley to turn to unload the tape. Trace the linkage or gears that move the roller guides back to their motor - it may be the main capstan motor or a separate small motor used only for this purpose. Rotate this in the direction which moves the roller guides back towards the cassette. It will take many revolutions - be persistent. If you feel any significant resistance or the roller guides move out toward the drum, turn the other way. The tape is fully unloaded when the roller guides are all the way into the cassette and the tape is straight across the cassette's stationary guideposts.

If a single motor performs both the tape loading and cassette loading functions, stop turning as soon as you see the cassette start to rise and read the next section before proceeding.

If you are not fully successful or if there is still a tape loop outside the cassette even once you have been turning for what seems to be an eternity, you can still try to eject the cassette but will need to be extra careful not to crinkle the tape as the cassette door closes with the tape sticking out. Before proceeding on in this case, try to find a way to turn one of the reels to pull that tape back in as this will make your task a lot easier. There may be an idler that swings between the two reels and this may be accessible from the bottom (the cassette will block it on top).

2. Cassette unloading. Once the tape is fully retracted into the cassette, the cassette can be ejected safely. If a tape loop is still sticking out of the cassette - and you care about the recording - you will need to be especially careful not to crinkle the tape as the cassette door closes. It is usually not possible to get the cassette fully out without its door closing, so the best you can do is to make sure when this happens, the tape is flat across the gap. With care, it should survive.

   On a top loader, there is usually a solenoid specifically for EJECT or a simple mechanical pushbutton. Once the appropriate lever is pressed, the cassette should pop up - hold the basket with one hand as you do this to prevent any exposed tape loop from being crinkled.

   On a front loader, locate the cassette loading motor and begin turning it in the appropriate direction - this will be fairly obvious assuming there are no broken gear teeth or other broken parts and that something isn't totally jammed. If this is the main capstan motor, then just continue turning as in (1). Eventually the cassette should raise up and out.

   As above, applying external low voltage power (6 to 12 VDC) to the motor *after* disconnecting it is an alternative if you cannot gain access to its shaft to turn it by hand.

   If you have a tape loop, be extra careful not to catch it on any guideposts or obstructions as you remove the cassette. Then, wind it back into the cassette by turning one of the reels (you may have to depress the release button on the bottom of the cassette with a pencil - this is the small hole in the center near the label side.)

   And in some cases, just turning the VCR upside-down and gently easing the cassette out will work. But as noted, don't force anything.

   Assuming the tape is not torn and not badly crinkled, it should be fine. If it is severely damaged, refer to the section: Recovering damaged or broken tapes.

VCR is confused - will not eject non-existent tape

If for some reason, the microcontroller gets confused and refuses to raise the basket and there is no tape in the VCR, first, try pulling the plug for a minute or two. This may reset the error condition. However, since the mechanism is in an illegal state, the microcontroller may refuse to do anything for fear of making things worse.

Assuming that the problem is still present, here are two suggestions:

- Manually turn the appropriate motor shaft with power off to put the mechanism through the eject cycle. In many VCRs, this is as simple as turning the EJECT motor or possibly the main motor. Be patient and gentle - it will take a while.

If there is some underlying problem which caused the basket to be lowered without a cassette in place, than the VCR may return to the illegal state, do nothing, or do something else that is peculiar once power is restored or any button is pressed.

- Convince the microcontroller that a tape really is present when there is none. You need to (1) cover the start/end sensor LED poking up in the center of the deck, (2) depress any other microswitches that sense tape present, press EJECT, and (3) possibly turn the non-driven reel by hand a bit while it is attempting to wind the tape loop back into the cassette. Three or four hands are a definite asset. Make sure you get your fingers out before they are caught! Again, an underlying problem may produce unexpected results.

For additional info on initialization problems, see the section: VCR is failing the power-up sequence.

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Fast Forward and Rewind Problems

VCR will not fast forward and/or rewind

Usually, the owner will admit that the machine is pre-Jurassic and has never been cleaned or serviced.

Anyway, rule out the idler tire as well as the idler clutch - if it weakens, then the idler wheel does not press against the appropriate reel with enough force to grip.

Is it s top or front loader? If a top loader, you should be able to trick it into playing a nonexistent tape by covering up the end-of-tape light (the one sticking up in the middle) so that it will think there is a tape inserted. (In some models, there might also be a microswitch.) This may permit you to see what is going on.

If a front loader, then it is tougher. You need a cassette cheater (see the section: Cassette cheaters). Then, with the cheater in place happily fooling the VCR, feel the spindles while the machine is operating. In FF or REW, you may find that they are not being driven or or being driven very weakly. Try to determine if the idler is even being pushed into position or is hung up on something.

If there is any chance that it is the idler tire, try turning it inside-out. The relatively protected inner (now outer) surface may grip well enough to confirm the diagnosis.

Has it been serviced in the last 15 years? The last 100 years?

VCR aborts fast forward or rewind

In this case, the tape starts to move - possibly at a reasonable speed - but then may shut down - possibly erratic or tape dependent.

Make sure the tape is not the problem - try another one.

If it starts the operation (as evidenced by whirring sounds and the tape counter changing numbers) but at some point - perhaps near the end of the tape - aborts and shuts down, then a worn idler tire, worn or broken idler clutch, bad belt, or lubrication problem is likely. See the section: VCR will not fast forward and/or rewind as well as Lubrication of a VCR.

With instant start transports - where the tape is maintained around the video head drum for all but the fastest rewind, there could be other control problems as well.

If the tape starts fast forwarding or rewinding properly (from a visual inspection with the cover off) but the tape counter does not change value and then the unit shuts down, a reel rotation sensor problem is likely. See the section: Reel rotation sensors.

If the operation aborts at the same location on only certain tapes, there could be pinholes in the tape oxide coating allowing light to pass through and confuse the sensors. This happens mostly with T160 or old well worn tapes. If you can locate the problem area, you can try indelible ink on the NON-oxide side of the tape but DO NOT use adhesive tape or glue. Else, discard the tape or live with its behavior.

Noisy REW or FF

While these operations are never exactly quiet, when grinding or squeaking noises are evident, it is time to at least consider the possibilities.

First confirm that the same thing happens with more than one cassette - it could be defective.

(Portions from: Alan McKinnon (alan.mck@pixie.co.za) and Oldguyteck (edward.croteau@the-spa.com).)

You get several types of noisy rewind:

- A high pitched squeak - dirt and/or dried or lost lubrication on reel spindles, remove both reel tables, clean and lubricate the shafts. On older machines you often find this as well on idler pulleys.
- Periodic 'eek-eek-eek' type noise, check for an out of round rotating part rubbing on something. No pat answers here, you have to get your eyes out and look.
- A grating metal on metal noise that sounds like car brake pads that should have been changed 5000 miles ago is always the capstan rubbing on its bearing. The only cure s a new motor. Ignore those that tell you to strip and clean the bearing. I've tried this trick at least 10 times on different machines - it won't last. If a capstan motor is worn enough to howl, the shaft and bearing are way beyond repair.

Miscellaneous causes:

- Cassette not seating properly and/or tape path alignment problems. Press down on the cassette during REW or FF and see if it shuts up.
- Brake levers not disengaging completely, pads worn, or misadjusted.
- Missing fiber washers (who worked on the VCR last?); worn, broken, or distorted gears; other lubrication or dirt problems, etc.
- Bad bearings in main motor (usually older VCRs).

The list goes on and on. In the end, the only way to narrow down the problem will be with your eyes and ears!

Tape rewinders

Should you buy a tape rewinder to save wear and tear on your VCR? Take it or leave it. I think they are good if your VCR is old and for whatever reason has trouble with FF or REW. However, sluggish FF or REW may be a precursor to tape eating and should be addressed to avoid an impending failure which may ruin a tape. Rubber parts deteriorate by just existing. The surface layer oxidizes and use may actually be good (don't quote me!).

I would not bother with a rewinder just to prevent wear and tear on the motors or heads.

- In many VCRs - particularly older VCRs without real-time tape counters, the tape is totally retracted into the cassette during high speed FF or REW and does not contact the heads at all.

- In newer VCRs with real-time counters, the tape will contact the control head lightly but wear should not be worth worrying about.

- Wear on the video heads where the tape remains in contact with them during rewind as in some high performance VCRs is not significant. This is due to the fact that the heads spin rapidly and wear isn't much different between normal play/record modes and fast rewind - it is the total time that matters for head wear - and rewind time is minimal. In addition, some VCRs reduce the tape tension during fast rewind as a further precaution.

  In more detail, assuming a 3 minute rewind time for a T120 tape (total tape length 240 m), the linear tape speed for REW or FF is 80 m/minute or 1.333 m/s. Relative video head-tape speed in normal play is about 4.83 m/s. So, the 1.333 m/s (actually, due to the slant of the tracks, it is very slightly less) gets added (REW) or subtracted (FF) from 4.83 m/s. So, assuming the machine is properly adjusted) this is similar to an equivalent length of time in normal play and is really is negligible. I wouldn't lose sleep over video head wear in this case or get a rewinder just to save wear on the video heads.

- Wear and tear on the motors is not a serious problem - and actually may be much less than when playing a tape.

If the convenience of being able to rewind off-line is important to you, then there may be no harm in using one. However, some rewinders can be hard on video tapes as they usually do not sense the clear leader but stop rewinding when the tape tension increases at the end of the tape. This may eventually damage the tape and/or pull the tape from the takeup reel hub. I have heard of some crinkling the tape edge and actually mangling tapes.

(From: Jim Lagerkvist (jlager@tir.com).)

There are dozens of fast rewinder units claiming to save wear on your VCR. The earliest ones snapped-off the clear leader from the hubs. The later ones with IR sensors simply made the real problem obvious:

Precious recordings are being damaged by a cheap transport screaming the tape at high speed. The tape is either creased or an edge is rippled (usually the control track).

I have a long list of heartbroken people that have lost their archives with these things; me included. If a customer complains about a tape suddenly not viewing well, ask if they use one of these things.

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Play and Record Mechanical Problems

Quick list of common mechanical problems

The following aren't in any serious order but those toward the top of the list are the most likely to occur:

0. Need for cleaning.
1. Dirty or deteriorated rubber belts and/or idler tire.
2. Idler clutch too weak or too strong from wear.
3. Need for lubrication of selected parts.
4. Worn brake pad or engagement problems.
5. Broken or misadjusted back tension band.
6. Dry or worn capstan motor bearing.
7. Gear timing incorrect due to forcing of mechanism of gear damage.
8. Other broken parts.

See Some Locations for VCR Mechnical Problems parts identification in a typical transport.

VCR refuses to record

If efforts to record (directly or via the timer) are totally ignored or cause the cassette to be ejected, then the record protect tab on the cassette may be broken off or the record protect sense switch in the VCR may be dirty or defective. This switch sits just under the cassette slot (on front loaders). Locate it by referencing the tab position on the loaded cassette. It can easily be tested with an ohmmeter - if you can get to it. To confirm, short out or disconnect (which you will need to do depends on the design of your VCR) the appropriate wires (maybe there is a connector - this could have bad contacts as well) and see if the VCR is more cooperative.

VCR aborts play or record during startup or shortly thereafter

This is a problem with the process called 'tape loading' - pulling the tape loop out of the cassette and wrapping it around the spinning video drum, engaging the capstan and pinch roller and reel rotation.

Check all the belts above and below the deck. Belts can appear to be firm but if they do not return immediately to their relaxed length when you stretch them 25%, they will need to be replaced.

With the cover off, observe the behavior when you hit play. (You may need to put a piece of cardboard over the cassette to block external light from interfering with the start/end tape sensors). Assuming this is a basic VCR (no instant start features), you should see:

1. The video head drum begins to spin.

2. the roller guides move smoothly on the tracks, wind the tape around the drum, and stop snuggly pressed against the 'V-Stopper' at the end of the tracks.

3. The pinch roller moves into position and presses the tape against the capstan.

4. The tape begins to move and is wound up by the takeup reel.

5. The picture and sound appear on the TV.

With a 'rapid or quick start' (or it may be called something else) transport, the tape moves to a half-loaded position when the cassette is inserted. This is at an intermediate position partially pulled out of the cassette but not wrapped around the drum. On VCRs with a real-time counter and/or index search capabilities, the tape will be in contact with the control head.

With an 'instant start' transport, the tape will fully load around the spinning drum when the cassette is inserted but the capstan will not engage and no tension will be applied to the tape until you press PLAY or REC. (After about 5 minutes, the drum will stop and it may unload to the half loaded or unloaded position.)

Note that for VCRs with a real-time counter and/or index search capabilities, the tape must be in contact with the control head (but not the video heads) for all relevant modes. These VCRs (which include many modern units) must therefore pull the tape at least partly out of the cassette.

In all cases, the completion of the sequence results in approximately the same mechanical configuration during PLAY.

Several likely possibilities when it shuts down:

1. Everything occurs as above, picture and sound appear for a few seconds, but then the VCR unloads the tape, ejects the cassette, goes into REW mode, stops, or shuts off. Two common causes:

   - The takeup reel does not turn and tape spills into the machine. This is sensed by the microcontroller which aborts record or play and attempts to save your valuable cassette. Most likely cause: old/dirty idler tire. As a test, turn the idler tire inside-out. The fresh surface will now work well enough to confirm this diagnosis and will continue working long enough for your replacement idler tire to arrive. See the section: General guide to VCR cleaning and rubber parts replacement.

   - The takeup reel is turning properly but one of the reel rotation sensors or its electronics is defective. As a test, check to see if the tape counter is changing at any time during the loading and abort process. Non-real-time tape counters usually get their pulses from this same sensor. (Real-time counters operate off of the A/C head control pulses and therefore would not be affected by a defective reel sensor). Some older VCRs used a belt driven counter - the belt may have broken or fallen off. Most newer VCRs use an optical sensor which may simply be dirty. See the section: Reel rotation sensors.

2. The roller guides are getting hung up and not fully loading the tape either as a result of an obstruction or dried up grease, or a slipping tape loading belt (often accompanied by an spine tingling squeal). Parts may have broken or fallen off of the roller guide assemblies preventing them from fully engaging the 'V-Stoppers'. A similar fault may prevent the capstan from fully engaging against the tape and pinch roller. A toy, candy, or a plastic bit of a cassette shell may be jamming something.

3. The mode switch sensor is dirty or defective and confusing the poor microcomputer as to the position of the loading mechanism. In this case, the loading process may stop half way, pause, and then unload as in

(1) or (2), above. Or, it may do almost anything. See the section on: "Erratic behavior in various modes".

4. Some other condition such as the end-of-tape sensor thinking that you are at the end of the tape is aborting the tape loading process. This might be indicated by a sudden reversal and shutdown rather than a pause (usually accompanied by the sound of a motor whirring) at some point attempting to complete part of the cycle. For problems with record in particular, the record protect tab switch may be dirty or worn resulting in random aborts.

5. Electronic problems like bad grounds or other bad connections are also possible. Since with some models, (a number of JVC manufactured VCRs, for example) ground integrity is via screws through the mainboard, should these loosen, erratic behavior may result. Tighten the screws.

6. A defective microcontroller or other logic could also be at fault but this is less likely than any of the preceding.

VCR aborts play or record at random times or near end of tape

In this case, the VCR starts to play or record but, say, an hour later, shuts down for no good reason - at least not as a result of a command you thought you issued.

Make sure the tape is not the problem - try another one. There may be spots on the tape where the oxide has come off resulting in pinhole (or larger) areas which are activating the end-sensors.

Confirm that you are using the proper play or record modes - not OTR (One Time Record) or other timed play or record modes which will likely operate in increments of 15 minutes depending on how many times you press the button. In addition, on certain VCRs, if the program timer is enabled with a program setting that has its stop time occur while you are using the VCR - even if the record operation has been aborted by pressing the stop button - the VCR will shut down.

If play or record aborts at the same location on only certain tapes, there could be pinholes in the tape oxide coating allowing light to pass through and confuse the sensors. This happens mostly with T160 or old well worn tapes. If you can locate the problem area, you can try indelible ink on the NON-oxide side of the tape but DO NOT use adhesive tape or glue. Else, discard the tape or live with its behavior.

Finally, make sure you are not using any 'insert editing' modes which require a previously laid down control track and would abort once blank tape was reached. See the section: Recording stops at random times on previously used tapes.

Once all the obvious problems and cockpit errors have been eliminated, mechanical problem still likely even though the VCR does not abort immediately. A worn idler tire, worn or defective idler clutch, bad belt, or improperly adjusted backtension, are all possibilities.

This is particularly likely if the problem is more likely to occur or only happens near the end of tapes as the required takeup reel torque is greater and any of the above mechanical problems will be exacerbated.

With instant start transports - where the tape is maintained around the video head drum for all but the fastest rewind, there could be other control problems as well.

If the operation starts properly (as indicated by a changing picture on the TV in play or from a visual inspection with the cover off) but the tape counter does not change value and then the unit shuts down, a reel rotation sensor problem is likely. See the section: Reel rotation sensors.

This could still be due to problems similar to those which cause an immediate abort if some components or connections are marginal. Also see the section: VCR aborts play or record during startup or shortly thereafter.

VCR eats tapes

The most common cause of a VCR eating tapes is a dirty/worn idler tire preventing the takeup reel from turning. See section: General guide to VCR cleaning and rubber parts replacement. The idler tire transfers motor power to the appropriate reel hub. If dirty, worn, dried out, glazed, cracked, or otherwise deteriorated, it will slip and cause the takeup reel (in play mode) to stop turning at some point. Hopefully, the microcomputer senses this and tries to wind the tape back into the cassette. But, you guessed it, this requires the idler tire so you end up with a mess of tape inside the machine. When you go to eject, you may get the cassette with a tape loop hanging out. If you are careful, you may be able to extract the tape without crinkling it too badly but don't just pull - it will break or be hopeless damaged. You will need to remove the top cover and carefully lift the tape loop out of the machine and wind it back into the cassette. If there is any significant crinkling or a partial break in the tape, discard the cassette. If it is priceless and irreplaceable, see the section: Recovering damaged or broken tapes. DO NOT try to use it or just return it to the video store without informing them of what happened - it is unfair the next renter as a badly crinkled or partially broken tape can destroy expensive video heads.

Tape loop hanging from cassette when ejected after play or record

(This may also apply to other modes for a VCR with a 'quick start' or 'instant start' transport.)

If your VCR aborts playing unexpectedly and shuts down and then, pushing EJECT results in a tape loop hanging out of the cassette when it is removed, this is considered tape eating - refer to the section: VCR eats tapes. However, if all other functions work normally but ejecting results in a tape loop, this section is for you.

Using a garbage cassette, try to observe exactly what is happening during EJECT. Specifically, is the operation terminating early or is there some problem with the appropriate reel not turning or not turning reliably or quickly enough? Is the tape getting hung up on the roller guides or on some other guideposts?

As with tape eating, the most common cause is dirty, old, deteriorated rubber parts - particularly the idler tire - preventing the tape from being fully wound back into the cassette. Therefore, the first step is to follow the procedures in the section "General guide to VCR cleaning and rubber parts replacement".

If this only started happening after you had the VCR apart for any reason, recheck your work - you may have neglected a connector, have the mode switch slightly out of position, or have gears which are improperly timed.

Many VCRs determine that the tape is completely wound back into the cassette by sensing rotation of the non-driven reel indicating that the tape is pulling on it as a result of being tight and pulled by the driven reel. If this sensor is defective, disconnected, the signal is noisy, or the associated electronics are faulty, the operation may be terminating early. As an experiment to confirm this, use a cassette cheater and while the VCR thinks it is winding the tape back into the cassette, turn the non-driven spindle by hand - this should stop the operation instantly. If it stops too quickly - before you turn the spindle, there could be a problem with this sensor. It is also possible for a failure of one of the reel brakes to allow one of the reels to continue spinning even after motor power has been shut off. Alternatively, a sticky brake band may increase the driven reel torque and fool the microcontroller into thinking that the tape slack has been taken up.

If the roller guides get hung up on the tracks while being retracted, even for an instant, the tape may become tight around the roller guides, pull on the non-driven reel, and stop the operation before the tape is fully wound back into the cassette. Check for obstructions and for adequate lubrication of the roller guide tracks.

If it is a late model Sony, the 'half loading arm' could need lubrication. See the section: Late model Sony VCR munches tape on eject.

Tape slows or stops (as though in pause or slow mode) while playing

What this means is that the tape continues to show a picture but it appears as it's struggling to pull the tape through the machine - which is basically what's happening. Once the picture freezes, it will probably abort due to the lack of reel motion.

With some VCRs, this may also result in periodic slowing or pausing. See the section: Sony capstan motor (bearing) problems.

There can be a variety of causes for this behavior but the most likely is related to a dry or worn capstan bearing or a defective capstan drive/servo circuit. The capstan rotation almost entirely determines tape movement during play and special effects modes. Only if for some reason the supply reel cannot rotate at all, could the capstan attempt to pull the tape across the video head drum unsuccessfully.

If you can catch the VCR in the act, then there are several tests that can be performed easily to localize the cause:

- If the capstan or its circuits are at fault, the tape tension on the supply side of the capstan will be normal. This is relatively loose if gently pressed side-ways or released by moving the back tension arm to the right. The picture will remain synced on the TV (though there may be noise bars due to incorrect tracking).

- Where a dry or worn capstan bearing is to blame, there may be an associated mechanical growning or grinding sound as well. Stop the VCR and immediately check to see if the capstan turns freely and smoothly.

  Cleaning and lubrication will help. Whether this is a permanent cure will depend on the severity of the damage.

- A magnetic sensor that is mounted too close to the perimeter of the capstan motor rotor can also rub as the rotor expands. As above, there will likely be noise - maybe a tick-tick sound with one tick per rotation of the capstan before it stops completely.

  Adjust the position of the sensor. It's hard to say from here how far away it can be but as a start, you should be able to slip a piece of letter paper between the sensor and the rotor without it rubbing at any position of the rotor.

- Where the capstan is belt driven (most nowadays are direct drive DC motors), a worn or flabby belt could be the cause. In this case, see if the belt is not successfully turning the capstan and check to see if the capstan itself is hard to turn - which would point to a bearing problem.

Inspect the belts and replace if necessary. In the meantime, clean the belts and pulleys which should result in some improvement and confirmation of the cause of the problem.

- If on the other hand, it is a supply reel brake that hasn't released, excessive back-tension, or something binding, the tension will be very high, causing the head drum to slow down and stop in extreme cases. Sync will be lost as this happens.

  You will have to determine what is preventing the tape from being fed properly. There could be a broken part, a problem with the supply reel or some other bearing, or something else like a defective brake release solenoid or its driver.

(From: Frank Fendley (frank.fendley@datacom.iglou.com).)

To see if the bearing is the problem, I usually remove the bottom cover of the VCR, play a tape for a fairly long time (or until the symptoms pop up), and then flip the VCR over and check the temperature of the IC on the capstan motor circuit board with my patented index-finger thermal probe. If the IC feels "hot", as opposed to warm or even very warm, I'm pretty confident that the bearing is at fault. (I define "hot" as too hot to leave my finger in place for more than a couple of seconds).

If the IC doesn't feel excessively warm after the symptoms start, I would suspect a heat problem in the servo section. This could be a tough repair, unless a can of freeze spray proves helpful in pinpointing the component.

Video head drum stops or slows during play or record

Check whether the backtension on the tape is applying so much pressure to the drum that it is slowing it down. Backtension should be just enough to keep the tape in good contact with the drum. If it is too tight, then you backtension felt may be worn or adjusted too high. There is a lever just as the tape exits the cassette - push this to the right to reduce tension. Someone may have attempted to repair a broken backtension band and reduced its length - I got a VCR for repair once where this was done.

If it is not the backtension, check free rotation of the drum when it stops - I bet it turns as freely as always. Could be a part in the motor driver that is faulty and failing when hot. However, the bearing could be worn or dry which would require disassembly and lubrication or replacement of the lower cylinder (assuming this is where the drum bearings are located).

Tape sticks to head drum

(From: Gary Woods (gwoods@albany.net).)

Usually under humid conditions, but not condensation of tape path, tape has excessive amount of drag around the scanner. S-tension is OK, or even a little light, but there is so much drag around scanner that the capstan skids.

- Reducing S-tension helps.
- Cleaning scanner helps.
- Cleaning capstan and treating pinch roller with PRB "conditioner" (smells like ether) helps.

None of these is a *real fix* and the problem recurs eventually. Somewhat dependent on the tape, but real problem appears to be drag around lower drum. Anyone know of a fix other than a new scanner?

(From: Daniel Schoo)

This seems to happen mostly on machines with a lot of play time. There is supposed to be an air film between the tape and drum to facilitate the reduction of friction. When the drum gets worn and polished the air is squeezed out and the tape sticks. Little can be done for this. You could replace the drum but this is expensive and not worth the effort for most machines. The other option is to try and rough up the drum surface by light sanding with 3M Scotchbrite(tm). I don't need to go into detail about how difficult this is to do correctly but what the heck you don't have anything to loose. Just be careful and stay clear of the heads. BTW I have seen "cleaning" tapes that rough up the drums very well!

Picture jittering vertically may be similar problem. Tape is not moving smoothly over the head drum.

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General Control Problems

VCR is alive but will not do anything

Typical symptoms: front panel display is active, it may be possible to set the clock or timer and change channels, but all transport related buttons are totally inert. Perhaps there is no response to any button. The VCR may or may not refuse to accept or eject a cassette.

This could mean many things including motor problems as well as a general power supply or control system failure. However, here are a several things to try first:

0. Check for cockpit errors - Someone may have accidentally set it for 'timer record' or in 'parental lock mode'. Is there a little clock or key symbol, 'L', (or something else you don't understand) displayed? Inspect the position of any slide or push-push switches.

   - Timer mode may be set by a pushbutton, push-push, or slide switch, or from the remote control.
   - Parental lock is usually accessible only from the remote control. See the section: VCR shows LOCKED in the display.

     Consult your user manual if in doubt about how the thing is supposed to work!

1. Cycle power - unplug the VCR from the wall (don't just use its power switch) for a minute or two to see if the microcontroller simply got into a confused state. This is more common than you would think. A random power surge can do it. The VCR may have gotten into a bad (mechanical or electrical) state.

2. Unplug the VCR and remove the covers. Rotate the shafts of each of the motors (cassette loading and tape loading or main motors depending on your VCR) clockwise a couple of turns (assuming there is no resistance to turning). Plug it in and listen for initialization sounds - it should detect that the mechanism has been moved and then reset to a safe position. See if it is now behaving.

3. If (2) doesn't do anything, try several turns counterclockwise instead.

4. If still no improvement, there may be more serious power supply, motor, or control system problems.

If any of these appears to solve the problem, it is quite possible that you will never experience it again. However, a dirty mode switch (see the section: VCR mode (sensor) switches may have resulted in an overshootto a bad mechanical state and without cleaning or replacement, the same thing may happen again.

VCR clock does not run

The clock runs either off the power line (zero crossings of the 50 or 60 Hz waveform) or from a crystal (possibly a reference derived from one of the other frequencies used elsewhere in the VCR). Conceivably, a bad backup battery or supercap might result in the clock remaining in setup or power fail mode.

Unfortunately, this probably isn't much help since identifying and locating the relevant components will be next to impossible without a schematic :-(.

VCR attempts to play non-existent cassette

You turn power on or just plug in the VCR to the AC outlet and it goes through the whirring sounds of playing a cassette - but there is not cassette present.

However, first try unplugging it for 30 seconds or so and plugging it in again. The microcontroller may just have had a bad day and gotten confused - either a bad reset or a power glitch.

Assuming this doesn't help:

This could be due to a faulty end sensor or a bad LED or light bulb that provide illumination for the end sensors.

If either sensor's output is the same as when a cassette is present (blocked), it very likely that the microcontroller will be confused. In some designs, this is indistinguishable from a cassette actually being loaded.

If the 'cassette in' indicator is on, then this is likely.

BTW, if a VCR uses an actual light bulb for that central light source and it is not lit when you attempt to load a cassette, it is burnt out. The LEDs used in most modern VCRs are IR and invisible, however.

With somewhat similar symptoms, it is also possible that the VCR is not able to complete the startup initialization due to a slipping belt, gummed up lubrication, or other mechanical or motor problem.

The clincher would be if you manually load a cassette (by turning the appropriate pulleys, etc. with it unplugged) and it then plays the cassette properly and acts normally until you try to eject. However, don't try this unless you are sure of how the mechanism works as it is easy to cause damage.

Erratic behavior in various modes

You press PLAY and the VCR gets halfway through loading the tape and suddenly aborts and shuts down. Or, you put a cassette in and it is immediately spit out as though it tasted bad to the VCR. Or, you press PLAY and the VCR goes into REWIND mode. Or, you pressed REVIEW and it ejected or attempted to eject the cassette.

Before you break out the screwdriver or shotgun, cover up the IR remote sensor and cassette slot. Some types of electronic ballasted fluorescent lights may confuse the remote control receiver. Or, someone or something may be sitting on the remote hand unit or it may be defective and continuously issuing a REW command! Excessive general illumination may even make its way into the tape start and/or end sensors and trick the VCR into thinking the tape is at one end. (If you are working on the VCR with its cover removed, block any stray light from hitting the area of the tape transport to see if behavior returns to normal.)

Assuming neither of these is the source of the problem:

First, eliminate the possible mechanical causes such as slipping belts or a bad idler tire which could prevent the VCR from completing your requested action - it then shuts down or attempts to return to a 'safe' position.

Bad connections are a possibility but not as likely as in a TV or monitor, for example. However, some VCRs (certain JVCs and clones, for example) ground parts of the circuitry via the circuit board mounting screws and simply tightening these are all that is needed to affect a cure.

The microcomputer or its associated circuitry could be defective as well - but this is not as common most people fear.

Occasionally, a faulty power supply may result in similar behavior. Its output voltages may be marginal, drop under load, or have excessive ripple due to dried up filter capacitors.

However, a more likely possibility than any of the above is that a sensor assembly present on most VCRs called the 'Mode Switch' or 'Mode Sensor' is dirty or bad. See the section: VCR mode (sensor) switches. Failure of the Mode Switch is a very common problem with numerous VCRs of many makes and models.

VCR mode (sensor) switches

In order for the microcontroller in a VCR to confirm correct functioning and completion of various operations like cassette and tape loading and roller guide position, some mechanical sensor feedback is normally used. The most important sensor assembly in most VCRs is called the 'Mode Switch' or 'Mode Sensor'. The purpose of the Mode Switch is to inform the microcontroller of the gross position of the mechanism at all times. For example, the mode switch may have 5 positions:

1. Tape unloaded and cassette out.
2. Tape unloaded and cassette in.
3. Tape half loaded against A/C head but not around drum.
4. Tape fully loaded around drum and roller guides at V-Stoppers.
5. Pinch roller pressed against capstan - play/record position.

The microcomputer monitors the outputs of the Mode Switch continuously when it is executing a mechanical operation (some monitor it at all times even with power 'off'). If an operation takes too long to move from state to state or an incorrect state transition occurs, the operation will be aborted and an attempt - possibly several - will be made to return the transport to a 'safe' position - unloading the tape and possibly ejecting the cassette.

Most Mode Switches are actually mechanical rotary or linear switches with sliding contacts. However, some VCRs use optical Mode Switches - IR LEDs, a slotted wheel or sliding mask, and photosensors. These are much less common and failures are even less likely. Most of the specific comments on below on cleaning and so forth apply to the mechanical variety. See: Studio Sound's Mode Switches Page for some photos of typical units.

If the Mode Switch contacts are dirty or worn, or if it has somehow loosened on its mountings and shifted slightly, one or more of these positions will report back incorrectly or erratically signaling an error condition. For example, a transition from state 1 to state 4 directly would totally confuse the poor controller. A Mode Switch that shifted out of place (or where other timing relationships in the VCR are messed up) might result in certain operations stopping at the wrong position as well. For example, if the Mode Switch shifts one way, the pinch roller may never quite press against the capstan or the roller guides may not snuggle up to the V-Stoppers as they should in play mode. If it shifts the other way, operations may fail to complete and run against the mechanical stops - stripped or broken gears may even the result.

A dirty or worn mode switch can result in cassette or tape loading, or unloading or eject operations aborting and resetting or the VCR shutting down. For example, some Emerson VCRs will move part way when loading and then shut down. Repeated attempts may get them fully loaded and then PLAY or other tape movement operations will work properly. However, unloading will result in similar cranky behavior.

Note that erratic behavior that happens after the tape has been playing or recording for awhile is probably not mode switch related since nothing is changing in terms of mechanical relationships and the mode switch is probably happy. However, there can always be exceptions.

Mode Switches are usually linear or rotary slide switches with 4 or more output terminals. They may or may not be easily accessible. On some, they are visible once the bottom cover is removed. On others, they are buried beneath a bunch of mechanical doohickies (technical term). Some are removable with a screw or two and a connector. Others require desoldering and the removal of a whole lot of stuff - all of which must be carefully replaced with exactly the same timing relationships - just to gain access.

Once, you get at them, you can often snap apart the housing and use contact cleaner on the sliding contacts and surfaces. I usually do not use any kind of lubricant as it can gum up on the contact surfaces resulting in erratic outputs - possibly the cause of the original problems in the first place. Some may not come apart and replacement is the only option if squirting contact cleaner through any visible openings does not help. Note that without disassembly, there is no way of knowing if there is still dirt or gummed up grease inside or if the contacts are actually pitted. Conversely, if squirting in some contact cleaner does not help, the mode switch may still be the problem since you have no way of knowing how far the contact cleaner penetrated or whether it had any effect.

Sometimes, bad solder connections to the mode switch are the only problem.

However, be very careful about not moving anything and take careful notes on the position of any parts that you disconnect as critical timing relationships are controlled by the gear positions. Stripped gears or other broken parts may result when the mechanism cycles. Also, in certain positions, levers or sliders operated by the mechanism you remove may spring out of position and you will need to make sure they get put back into the correct slots in any cams when you are done. Mark all gear positions even if they do not seem to be critical. See the section below on how not to mess up your day by ignoring timing marks or more simply: "Mechanical relationships in VCRs".

Note that if you experience erratic behavior with a VCR manufactured by Sharp, the probability of a dirty mode switch is very close to 1. See the section: Erratic behavior of Sharp VCRs.

There are even some poorly designed VCRs where extraneous light through the vent holes or tape door affect sensors and cause erratic operation. If a bright light is shining on the VCR, block and see if anything changes!

Mechanical relationships in VCRs

The complexity of the mechanism in a VCR can be quite intimidating. To avoid total frustration and really messing up your day, before you remove anything mechanical, take careful notes of precise relationships of any gear, lever, switch, anything that might possibly get back together in an ambiguous way. Often there are 'timing' marks on the gears just as you would find in a lawnmower or automobile engine. These will be little arrows or holes which will line up with stationary marks or with each other on adjacent gears when the mechanism is in a particular position. Often, it is best to put the mechanism in the position where the timing marks line up because there may be fewer levers, cams, etc. which are under pressure or tension in this position and thus fewer things to pop out at you. If there are no apparent timing marks, make your own with a scribe or pen. Sometimes mechanisms that at first appear not to be critical are obscured in such a way that they really control critical timing. So, when in doubt, make more notes than necessary - with diagrams. In rare instances, there may even be a diagram showing the timing relationships pasted to the bottom cover or stamped on the chassis. What a concept!

Intermittent behavior

This may mean that pressing on a circuit board, flexing a cable, or operating the VCR in different orientation affects behavior. Sometimes this is affected by temperature as well.

Note: if this only happens while servicing, confirm that excessive light is not affecting the start/end sensors.

Do not confuse these sorts of symptoms with those indicating a faulty or dirty mode (sensor) switch. See the section: Erratic behavior in various modes.

6. Unlike TVs and monitors which have high power circuitry and are prone to cold solder joints from poor manufacturing or thermal cycling, most of the circuitry in a VCR is low voltage and low power. Although problems with bad connections to these components is relatively rare, visual inspection should still be performed where erratic behavior is noted.

   Exceptions include:

   - Power supply regulator(s) or switchmode power transistor (depending on type).
   - Motor driver (power) transistors or ICs - particularly those for the main (capstan/reel) drive and video head drum.
   - RF, video, and audio jacks since they may be stressed mechanically.

7. Internal multiconductor (crimp terminated) cable connectors. These may just deteriorate with age and use. Clean and reseat the connector(s).

8. Circuit board ground screws. One or more of the screws holding a circuit board may also be providing a ground connections. These can work loose or corrode. Remove screw, scrape corrosion, and/or tighten.

9. Hairline cracks in circuit boards. If the VCR has been dropped, this is very common. Sometimes, these are very difficult to locate visually but locate them you must! See the section: VCR was dropped.

10. Broken or shorted wires. Some of the individual wires in various signal cables are quite thin and fragile. Overzealous movement of circuit boards while replacing belts or other maintenance operations can easily pinch these resulting in immediate or delayed failure. This may also take place when replacing boards. It seems that the manufacturers seem to make it impossible to squeeze all the wires back in where they came from!

    CAUTION: Always try to avoid pulling on the wires when removing a connector. This will minimize stresses which could result in the wire conductor breaking off inside the insulation - this would be very difficult to locate.

VCR does not work after cassette was forcibly removed

You were watching your favorite tape and suddenly the VCR emits a mechanical eek and is now dead - or you press eject and the VCR shuts down without regurgitating your tape. Worse yet, someone (we will not point fingers) forcibly removed the tape to return it to the video store.

Assuming that 'forcibly' does not mean that permanent damage was done, then the first place, as always, to check is the idler tire and then all other rubber belts. At this point it is hard to say whether your problem was compounded by the removal of the tape. If any gears were shifted with respect to one another, parts bent, or springs sprung, then without a service manual, it would be difficult for a technician let alone someone not familiar with your VCR to repair it.

An error at power on usually means that the microcomputer thinks that it is unable to put the mechanism into a 'safe' position. This could be due to slipping belts, broken gears, a bad motor, shifted sensors, or faulty electronics. The original symptoms may have been a slipping idler preventing the takeup reel from rotating allowing tape to spill into the machine. Power on problems may be more serious. See the section: VCR is failing the power-up sequence.

If this is not enough for you to get the hint

Here is a true story of forced eviction of a tape and the consequences. :-(This teaches you two lessons: Don't use violence to remove a stuck cassette and mark all gear, lever, sliders, etc. timing relationships before you disturb anything!

(From: AL (kb8wcq@tir.com).)

"I have a Panasonic VCR (model PV-4820) that will not acknowledge tapes. The original problem I found was in the power supply. I replaced all the electrolytic caps, and the PS now works- all the outputs measure OK and the display and tuner controls seem to work OK.

But once the PS went bad, it would not take in tapes, so the owner decided to force one in. He sheared half the teeth off of the 'link gear', which I replaced, but it still will not accept a tape. I can manually push a tape all the way in, with some resistance, until it sits down on the reels, but it is not acknowledged in any way. If I don't hold it down, it springs back out."

It sounds like you possibly failed to retime the link gear in relation to the rack gear on the loader assembly.

If that's the one I think it is and you have not timed one (of course this is something the average person does, say once a week? :-) --- sam) before, you probably should get the manual. Or try this: Remove the carriage assembly, turn the VCR on its side, press and hold the little height change lever (bottom side, near the solenoid), manually turn (CCW) the large belt-driven pulley until the mechanism is in the full eject position, note the position of the link gear, turn the large belt-driven pulley in the opposite direction until the link gear makes exactly one revolution, re-install the carriage (in the eject position) making sure the carriage gear and the link gear mesh properly.

Other than that it's pretty simple... Assuming of course nothing was disturbed with the gears below the deck, and that the link gear, mode switch, pressure roller lift cam, etc', are in their proper position.

Sounds simple enough! --- sam :-)

VCR is failing the power-up sequence

This often means that the internal microcomputer found the mechanism in an unusual state and was unable to reset it. Some VCRs will actually move portions of the mechanism to make sure that everything is OK to accept a tape. Failure here may be the result of a slipping or broken belt or a belt that has popped off of its pulleys, gummed up lubrication, or some other mechanical fault. How old is it? Rubber parts tend to become smooth and lose their elastic properties ('rubberiness') after a few years. Does the VCR make any kind of whirring sounds before shutting down? This would mean that it is attempting to move something back into position. Is there a tape in the machine? How about a toy, peanut butter and jelly sandwich, or a little applesauce? It could be a sensor or other electronic problem, but check out the mechanical possibilities first.

On a VCR which has been cleaned and with good rubber parts:

VCRs have a light or LED (IR, infrared) in the middle of the mechanical assembly that detects the end of tape. When a tape is loaded the tape will cover the sensor. The controller can tell if the tape is at the beginning, middle, or end by the sensor. The is achieved by a clear leader at the beginning and end of the tape. The microcontroller will detect a problem if the sensors do not detect the light or LED (middle of tape) and the carriage assembly is up (no tape loaded). The VCR will shut down.

1. If you have an incandescent light and it is not lit, it is burned out. If you have the LED type you can buy an IR tester from an electronic parts supplier or construct one as described at the end of this document. Replacement LEDs are readily available.

2. The VCR might be in a confused state. Many VCRs have a belt that drives a loading motor. This is the motor that drives the tape around the heads. If those guides are not fully retracted, the VCR shuts down. Check the belt and replace if necessary.

3. Ensure the tape guide assembly is fully retracted by physically turning the appropriate gears.

4. Some obstruction is preventing part of the mechanism from resetting. Visually inspect for foreign objects or rough edges on something preventing full movement. Dried up grease can also cause this.

5. A gear has slipped a tooth and one part of the mechanism does not track another. This may happen if a tape was forcefully ejected after being eaten. You may find that a tooth has actually broken off.

6. If this occurred after having disassembled part of the mechanism, confirm the timing relationships. Make

sure belts are installed in the correct locations - and on the correct sides of any intermediate pulleys where belts link more than two pulleys.

Without a service manual, determining the correct relationships for all gears may be impossible, but if only one has slipped you may be able to locate timing marks near the edges of the gears which should line up - usually when the tape is unloaded. (portions from michael@marconi.nsc.com)

VCR displays DEW warning

Your VCR has worked fine for several years but now you get the 'DEW' warning in the display and no tape functions work.

The dew sensor is intended to prevent operation of the tape transport if the humidity is so high that moisture would build up and cause the video tape to stick to the rotating drum and damage the heads or get hopeless tangled as a result.

First, perhaps the dew warning is telling the truth. If you have just moved the VCR from a cold area to a warm one, let it sit for an hour or so and see if the dew warning goes away. If you just fished it out of the toilet or scraped stewed peaches from the interior, well, dew may be the least of your problems. Or, if you have just cleaned the inside of the VCR (or maybe even the outside if you were really overzealous!), some of the liquid may have gotten on the dew sensor (it is likely to be near the video head drum) so waiting a few minutes may be all that is needed to rectify the situation.

Assuming that there is no reason for a dew warning, the dew sensor may be bad or have changed value. There may or may not be an adjustment for this.

Before you go inside, try unplugging the VCR to clear any spontaneous fault condition - see the section: VCR has gone whacko.

The dew sensor is a resistor that changes value when there is condensation. If the sensor is bad, you should be able to replace it with a resistor and keep the VCR happy. You should be able to determine the appropriate resistance by trial and error. If it is the type where the resistance decreases with moisture and the controller does not care if the resistance is too high, then you can just remove it. Either way, you have now lost the protection that the dew sensor provides. Replacement is obviously best.

Don't overlook the possibility of a bad connection - it may be plugged in and just need to be reseated.

One type looks like a ceramic board, maybe 1/4" - 1/2" on a side with a silver/gray printed circuit pattern.

If the A/D or whatever is used to determine when there is dew is faulty, then you will most likely need a service manual to troubleshoot it.

Apparently, given the marginal value of the dew protection and the problems caused by it, newer VCRs may not even have a dew sensor.

The following pair of recommendations would seem to contradict one-another slightly but could still be a start:

(From: John R. Hepburn (jhepburn@recorder.ca).)

I use a 3.3K... No great technical justification other than 1 to 10K works on most machines and I ended up with a lot of 3.3K from an auction. Now if I could just get about 10,000 more old VCRs with a flashing dew light I could get rid of this darn box!!!

(From: Dan Sofie (sofie@olypen.com).)

The problem may not be the dew sensor but the support circuitry instead. In most circuit designs with dew sensors, it is ON (moisture detected) at about 450 ohms or higher and it is OFF (dry) at about 450 ohms or less. Try bridging a 100 ohm resistor across the terminals to see if the light goes out. If not, the problem is not the dew sensor, but the circuitry it interfaces with.

VCR shows LOCKED in the display

You go and try to play a tape and the VCR displays the word 'LOCKED' or perhaps just a flashing 'L' or 'PL' in the display.

This may mean that the VCR has somehow been programmed to prevent use by unauthorized kids (you are not reading this if you are a kid, right?) Even if your model does not have this feature, the same basic chassis is probably used for a range of models so it could have gotten into a confused state.

- Sometimes, just pressing the TV/VCR, PLAY, POWER, VCR1, VCR2, (or other much more obscure) button on the remote control (it may be designed not to work from the front panel) for 10 to 30 seconds will clear this mode. Some remotes have a little 'key' symbol. How logical! Press it.

- Unplugging the VCR for a minute or two may work. Unplugging for long enough to drain the backup battery will probably work but you may then need to reinitialize the clock, channel selection, and programming.

- Best bet is to check your instruction manual (you can locate your user manual, right???).

VCRs with Alzheimer's Disease

Suppose your just-out-warranty VCR is now acting up for no apparent reason - making strange sounds, forgetting its programming, refusing to cooperate, etc.

I don't know what kind of recourse you may have as an unsatisfied consumer, but I would try to get some resolution through your place of purchase. Such a VCR has all the symptoms of Alzheimer's disease - it should not be failing in these ways so early in life unless it is under penalty of hard labor in the damp snake infested dungeon of an English castle! Or it has been the depository for peanut-butter-and-jelly sandwiches, applesauce, or marbles!

All the usual recommendations of cleaning and checking rubber parts and so forth apply to units that have seen significant use or are a few years old or both. Something this new under normal use should not be causing this amount of grief. However, sometime I wonder whether using a machine very little contributes to problems.

First try your place of purchase - there may still be some degree of interest in maintaining customer satisfaction.

If you have given up on the store, start by checking the rubber parts for dust and deterioration (with that kind of use, dirt should not be a problem, but dust or smoke can accumulate), check for adequate lubrication (but don't add any unless it is definitely needed and then only the smallest amount - VCRs do not need much oil or grease and too much will just compound your problems - and check for foreign objects especially if there are small kids about.

VCR has gone whacko

You may think you are on the set of the latest sci-fi movie. The VCR displays are counting at random, pushing buttons produce unexpected results, motors may be spinning, or the VCR may be repeatedly loading and unloading a non-existent tape. I may be attempting to play a tape even without you pressing any buttons.

While these could be symptoms of a actual problem, first try unplugging the VCR from the wall outlet (don't just turn it off) for a minute or so.

If this does not help, try unplugging for a couple of hours - this will usually drain the backup battery and reset many other functions of the VCR.

If one of these techniques results in the universe returning to normal, there may have been a power surge or lightning strike nearby which threw the microcontroller into a confused state. It may never happen again. However, power surges can be the result of heavy appliances like air conditioners on the same circuit. If this is the case, you should consider using a different circuit for your electronic equipment.

If this behavior started when the VCR was just plugged in or following some other action requiring the mechanism to move or initialize, check for mechanical problems like a broken belt or one that has popped off its pulleys or an obstruction like a rock or toy that is preventing the VCR from completing the required motions. Also see the section: VCR is failing the power-up sequence.

Once you have ruled out mechanical problems, it is likely that the VCR has a microcontroller, power supply, or other electronic problem which may require professional service.

VCR forgets settings following power failure

Normally, the AC line provides power to retain the clock, active channels, and programming settings. During a power failure, the clock and programming is usually powered using a supercap or battery (usually rechargeable). Channel settings for older style varactor type tuners were often stored in some kind of non-volatile memory while active channels for quartz tuners generally use battery backup.

The clock and programming backup may be a supercap - a very high value special electrolytic capacitor - as much a 1 F (1,000,000 uF) at 5-12 V. Alternatively, it may use a rechargeable NiCd battery. In either case, these are easily replaceable with standard parts. A NiCd battery pack of similar ratings should be readily available. Supercaps are available from large electronics distributors.

NiCd batteries fail in two ways - loss of capacity or shorted cells. If memory is retained for a much shorter time than it used to, then the battery has probably lost most of its capacity. If you measure less than n x 1.2 V for an n cell NiCd battery pack after it has been charging for awhile, there is likely a shorted cell. In either case, the best solution is a replacement though the various common techniques for rejuvenating NiCd battery packs can be attempted (remove from VCR first!).

The non-volatile memory could use a special chip like EEPROM which does not require power or a battery backed SRAM or be internal to one of the VCR's microcontrollers. Channel memory may use a separate power source from the clock and programming, possibly a Lithium battery since it is undesirable for the channel settings to be forgotten even if the VCR is unplugged for a month or more as it is such a pain to reinitialize them. Rechargeable batteries have too high a self discharge rate.

Display is dim

Where the display works but is dim, there can be several causes:

- Some VCRs have a 'night mode' which dims the display after, say, 10:00 PM. Check that you don't have the clock AM and PM set incorrectly. There is usually a way to disable this 'feature'.

- If the VCR has been used in a location where there are heavy smokers, whatever tar and nicotine somehow avoided getting trapped in their lungs may have been deposited on the front and rear surfaces of the plastic display window and on the front of the display tube. Remove the front panel and use alcohol and a soft cloth to thoroughly clean all these surfaces.

- The VCR may have seen a long active life. Like CRTs and other vacuum tubes, cathode emission and/or phosphor brightness can degrade over time. There may be nothing much that can be easily done to remedy this but see the comments below.

- The filament or anode voltage may be low or faulty due to a bad connection, dried up electrolytic capacitor, or other power supply problem.

See the section: Display is dead but everything else works for more information.

Note that as a preventive measure, if your VCR has a dimming feature, use it. Operating the displays at lower brightness will prolong its life.

CAUTION: Try the following at your own risk - too much voltage on the filament will melt it.

(From: John Robertson (jrr@flippers.com).)

If these are the blue fluorescent displays then they might be able to be recharged. A bit of background first - a number of years ago people were finding that the blue fluorescent displays in Gottlieb pinball games would dim over the years until they were unusable. One clever fellow discovered that if you heated the filaments in these tubes until they glowed a dull red, by increasing the filament voltage, then the tube would work again at almost it's original brightness, plus this "recharge" would last for years in many cases. The normal filament voltage for some of these displays was in the order of 4 VAC and if the filament was then run at about 8 to 12 V (dull red to medium orange glow) for about ten seconds that the job was done.

So, if these tubes have a filament (several very fine horizontal wires inside between the front glass of the tube and the digit plane) - the connections would be the very first and the final pin of the tube, check the voltage there (AC or DC?) and then with the device turned of and a variable voltage source try increasing the filament voltage until you see the glow, then try the display out in normal operation.

(From: Andy Cuffe (baltimora@psu.edu).)

I've also had some success with increasing the negative bias to the filament by a few volts. I have an NEC VCR that had a very dim display even after replacing the bad caps in the power supply. Changing a zener diode to increase the negative bias by about 5 V did wonders.

Display is dead but everything else works

This usually means that one or more of the voltages to the vacuum fluorescent display (VFD) are missing or that the display controller is bad. If the front panel suffered physical damage, the display tube, circuit board, or other components could be damaged.

The VFD is usually designed to operate in a multiplexed mode to minimize pins and drivers at the expense of more complex logic - but that is all inside the system controller chip anyhow. Thus, there are 'segments' which correspond to the portions of each character and individual symbols, and 'grids' which are in effect, enables for each character or group of symbols. Compared to a multiplexed LED display, the segments correspond to rows and the 'grids' to columns. The filament, grid, and anodes operate in the same manner as in a vacuum tube (valve for those on the other side of the lake) or a CRT, for that matter. A typical VFD might have 9 segments and 7 grids for a total of 63 possible individually controlled displayed items.

The filament requires 2 to 6 VAC. Each of the segment lines are sequentially pulsed to about 30 V or more while the appropriate set of grids are pulsed positive to enable the desired combination of displayed items.

Here is the pinout for a typical VFD (from a Sharp VCR):

```
Pin 1: Filament 1A   Pin 2: Filament 1B (Tied together)

Pin 5: Grid 6        Pin 6:  Grid 5       Pin 7:  Grid 4     Pin 8: Grid 3,
Pin 9: Grid 2        Pin 10: Grid 1       Pin 11: Grid 0

Pin 12: Segment 8    Pin 34: Segment 7    Pin 35: Segment 6,
Pin 36: Segment 5    Pin 37: Segment 4    Pin 38: Segment 3,
Pin 39: Segment 2    Pin 40: Segment 1    Pin 41: Segment 0

Pin 44: Filament 2A  Pin 45: Filament 2B (Tied together)
```

All other pins are either not present or no-connects. While specific pinouts for each VFD device are likely to differ somewhat, the general arrangement appears to be similar - filaments on the ends, grids mostly on the low numbered pins, a gap with no pins or unconnected pins, then the segments on the high numbered pins.

Remove the front panel and with the VCR plugged in, turn out the lights and inspect the filament, several very fine wires running the length of the display. They should be glowing a very faint red-orange. If you see nothing, the filament voltage is likely missing. Filament voltage may come directly from the power transformer (if a non-switching type power supply) or be one of the DC outputs of the supply.

Check around the VFD for the +30 VDC (approximately) or if you have a scope, look for pulses on the pins of the VFD. If the +30 VDC is missing, there will be nothing displayed. In some VCRs like those manufactured by Hitachi, a separate DC-DC converter module provides power for the display only. See the section: Dead clock in Hitachi manufactured VCR.

Look for bad connections, open resistors, blown IC protectors or fuses, etc.

Of course, if the VCR has an on-screen display, you will be no worse off than many newer models that have done away with the front panel VFD entirely!

(From: Paul Grohe (grohe@galaxy.nsc.com).)

The fluorescent display in the VCR's I have seen require three sets of voltages:

1. The filament requires a floating 3 VAC (but see above --- sam).
2. The filament has to be biased at -12 V to -15 V
3. The segments need +20 V to +30 V to light.

The DC-DC converter usually provides a "floating" 3 VAC winding, a low current -12 VDC tap connected to one of the filament leads, and a +20 VDC to +30 VDC segment drive voltage.

If you look really, really closely at the display, you will see the faintly glowing filaments stretching across the length of the display.

It figures that the makers of VFD's would have a nice section on VFD displays. Here are some links to appnotes for driving VF displays. They have a few "tidbits" in them. AN-440 has a nice graphical depiction on page 2.

- AN-371
- AN-440

(From: Mark Zenier (mzenier@netcom.com).)

A DC filament supply can cause a brightness variation across the display depending on the design. And, as I remember it, some of them have lower filament voltages, like 2.5 VAC. A fatal thing to burn out.

The only one I've really messed with was a 32 character, 14 segment character display. It used a 6 volt filament, and 60 volts on the grids and segments/anodes. The filament/cathode was biased 6-9 volts positive, so that when the grids were grounded, they were negative relative to the cathode.

The power supply for this display was rather quirky, it used a H-bridge with emitter followers supplied by the system 12 volts, but the lower drivers of the H were clamped at 6 volts so that it supplied 6 vrms at a high (5-10 kHz) frequency to the filament, offset by the 9 volts, and a transformer, hooked up differentially, stepped that up to the 60 volts for the drivers. A real RFI pain in the ass.

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Play and Record Control Problems

VCR randomly switches speeds, tracking problems, and muddy sound

First, don't ignore the possibility that you are attempting to play an old, worn, or defective tape. This is especially true of rental tapes which have been through who knows what kind of VCR hell. The control and audio tracks - along the edges of the tape - are the first to wear. Weak muddy sound and erratic tracking are also common symptoms caused by old worn tapes. There have even been instances of new name brand tapes which were cut too wide - though this would be extremely rare.

To confirm that it is your VCR doing the dastardly deed, play or record for at least a minute on a tape known to be in good condition. The use REV to back of the tape for about 15 seconds. Eject and open the cassette door by releasing the latch and inspect for edge crinkling.

Any rippling along either edge of the tape is an symptom of a possible problem. It isn't only that the tape does not make good contact with the audio or control head (depending on which edge is damaged) but just an indication that the tape may not be moving through the transport precisely positioned.

Assuming you are having the same problem on multiple tapes and that using a known good (new) tape results in damage:

This is an indication that your tape path alignment is off or your rubber parts (probably the pinch roller) need replacing. The tape is wandering up and down as a result of unequal pull from the capstan due to a glazed/worn pinch roller. There could also be other aspects of tape path alignment like roller guide tilt (which is probably not adjustable), A/C head tilt, dirt, roller guide height (don't mess with it), etc. See the chapter: "Tape Path Alignment and Backtension Adjustment. It could also be worn feet on the roller guide assemblies causing the guides to not be perfectly vertical. Replacement of these parts may be the only cure. Other much less likely possibilities: excessive or varying backtension, tight idler clutch, electronic problems.

For a VCR with very high mileage, it is also possible that there has been a ridge worn in the surface of the control head preventing consistent contact between it and the tape:

(From: Phil Reed (100555.244@compuserve.com).)

> "One thing that can happen is that the control track head gets a ridge on it (due to wear) which prevents the tape making good contact with it. This can make the tracking go mad and sometimes even mute the video. Pausing the VCR overrides any muting, resulting in a clean still picture. Another clue is that some tapes will do it worse than others, this is due to slight variations in tape width or condition."

Other related symptoms include:

- Sound does not always appear at full volume or normal quality for a few seconds after the VCR starts playing. It may vary in loudness during play as well. Slightly changing backtension may make a big difference in audio.

- If your VCR has autotracking, its indicator may be flickering as the logic attempts to solve an impossible problem.

- On HiFi VCRs, there will likely be no HiFi sound as its tracking is even more critical than video tracking.

- Tape speed may be changing resulting in wavering sound or even running (usually) faster than normal. This may be due to the control head not reliably reading the control track.

If you look carefully, you should be able to see the tape wandering slightly producing the muddy sound and erratic tracking. The tape may not be perfectly smooth in passing over the various guides and rollers. Normally, you will almost not be able to tell the tape is moving at all except by examining the reel rotation - it is that mirror smooth.

First, clean the tape path properly, especially the capstan and pinch roller, tape guides, A/C head. Inspect the pinch roller for glazing, cracking, etc. and replace if necessary. See the sections: "General guide to VCR cleaning and rubber parts replacement" and if necessary, the chapter: "Tape Path Alignment and Backtension Adjustment".

Another possibility is that the control portion of the A/C head stack is dirty or defective or there are problems in the wiring or its circuitry. Double check that the tape is in solid contact with the bottom of the A/C head stack (where the control track is located), that the head is clean, its connector is clean and seated properly, and look for any broken wires or bad connections.

VCR plays but at fast forward speed (or beyond)

Normally, speed is controlled via phase locking the capstan to the 30 Hz control pulses read off of the tape via the stationary audio/control head.

On a VCR with autotracking, the autotracking light may be flickering as well.

Possible causes for loss of lock:

- Dirt or bits of tape or oxide on control head - clean and inspect.

- Defective control head. Try making a recording. If recording plays normally on another VCR, then control head is probably OK.

- Tape wandering up and down so that control track is not sensed properly (how is the sound - this would also cause fluctuating or missing sound.) See the section "VCR randomly switches speeds, tracking problems, and muddy sound".

- Mechanical fault preventing firm tape-control head contact such as a stuck movable guide post.

- Mechanical or mode switch problem preventing firm capstan-pinch roller contact. Under certain conditions - possibly at the beginning of a tape when takeup tension is greatest - the takeup reel may have enough torque to pull the tape past the video heads without the capstan controlling the speed as it should.

- Defect in servo or control circuitry or power supply (voltage out of tolerance).

- Bad tape. Don't overlook this possibility especially if it is a old or rental tape. The control track may have gotten erased or warn off - it is at the edge of the tape. Try another tape.

Inspect the tape path really really carefully to determine if there is some obstruction preventing tape-control head contact or other mechanical problems. Try cleaning the tape path and checking the rubber parts. Check power supply voltages if you can determine what they should be (see the section: VCR power supplies. If these procedures to not reveal anything amiss, you will need a service manual to pursue electronic faults.

Tape edge gets creased and/or random switching between speeds

As always, rule out the possibility that this is just a bad tape. There have even been instances of new name brand tapes which were cut too wide - though this would be extremely rare. It could have been creased by someone else's VCR. Try a tape you can afford to sacrifice (though it will still be safely usable) and run it through the VCR. Sometimes, there will be a problem only near one end so you will need to try it at various sections of tape. Record a few minutes and then back it up a bit and inspect for damage by opening the cassette door (press the release on the side). Both edges should be perfectly flat and smooth. If you get similar playback symptoms with this cassette and/or find that the tape is being creased along one or both edges, then it is your VCR doing the dirty work.

When the bottom of the tape gets creased, the control head may no longer align with the control track and you loose servo lock on the sync signal. Your audio may be fluctuating in intensity as well since the audio track is wandering also and the tape may be intermittently going in and out of correct tracking and/or changing speeds. Since the tape can no longer seat stably on the lower drum guide ridge, there could be other problems such as noise bars along the top or bottom of the picture, jumping, etc.

It could be the guide posts or other tape path components, but before you turn every screw you can find and make the problems hopelessly worse, replace all of the rubber parts - belts, idler tire, pinch roller. And while you are at it, give the machine a good cleaning.

A dirty, worn, hard, dried out pinch roller in particular can result in the tape wandering up and down causing tracking problems and creasing the tape in the process. This is probably the most common cause of tape damage assuming the VCR itself has not been abused (i.e., jammed cassette removed using a pair of Vice-Grips(tm).)

With a thorough cleaning of everything before buying the new rubber (which BTW should not be more than a total $10 to $15 from a place like MCM Electronics), you may at least see a temporary improvement in performance - and confirmation of the diagnosis.

You really need to determine exactly where the tape is being creased. Once you do this, you may be able to determine the cause and visually verify whether the problem is affected by any of your adjustments or probing.

Some other possibilities include:

- Worn feet on the roller guides causing them to not be precisely vertical. Sometimes there are adjustments for tilt; usually there are none. Sometimes replacements are readily available (especially if this is a common problem with your model).

- Cassette not seating properly. Press down on cassette while playing a known good tape. If it moves, then check for obstructions or foreign objects such as toys or peanut butter and jelly sandwiches! A dirty, oily, or just tired belt may not grip well enough for the mechanism to complete the cassette load cycle.

- Oil seal washer on bottom of capstan has worked its way up out of place. Carefully push it back down and then clean the capstan shaft.

- Various guides too high or too low but this is pretty unlikely unless they have loosened somehow. Don't adjust unless you have a service manual or are absolutely sure that they have changed height.

- Backtension misadjusted (usually too great). If the tape passes around the backtension lever at too straight an angle (it doesn't bend enough), in addition to the possible incorrect (excessive) backtension, it may simply not seat properly when passing around the subsequent guidepost or impedance roller (that white plastic wheel that doesn't seem to serve any purpose). One or more guide posts or roller guides may be binding.

(From: Raymond Carlsen (rrcc@u.washington.edu).)

There is a simple way to determine if the tape is skewing or has a tendency to do so... just reduce the back-tension by holding the arm so the tape is not as tight around the drum. If there is any tendency of a worn pinch roller to skew the tape, that will show it up quickly. I make my test tapes on an old linear stereo VCR and record two different tones on the two audio channels. When I play that tape back on a VCR with linear mono audio (all of them now), the two tones will play with equal volume if the audio head height is correct AND the tape is not skewing up or down. I can determine what's happening by ear, without even looking at the tape, and before the tape is damaged. Note: there are some machines that tend to skew even if the pinch roller is good. Those require more aggressive alignment procedures than the service manuals usually supply. Almost everything on the take-up side of the tape path can be "adjusted" for the really stubborn ones (even shims to tilt the capstan rotor), but in a few cases, there is just no way to get it perfect. With machines getting cheaper and cheaper, I don't spend any time on dogs unless it's a high end deck and the customer knows what it's worth.

(From: Vern (vgdeuel@ticnet.com).)

Tape damage along the top edge usually indicates too much back tension which, among other things, can be caused by the P2 roller not turning freely. Using a Tentelometer, check the back tension at the full erase head; it should be about 30 grams. Then check the tape tension just before the A/C head. If it's up around 80-100 grams or so, change the P2 roller and even the P3.

(From: Jerry G. (jerryg50@hotmail.com).)

Take a careful look at the capstan shaft and see if the capstan (where the pinch roller touches) is very clean. If it has black or brown markings (coating) on it, you must clean it off very well. Use alcohol and a Q-Tip. Take care to not scratch the shaft.

If the rubber pinch roller is shiny, or looks dried out and or cracked, change it. This area other than the reels is a prime cause of speed problems. The tape when under normal torque can be slipping between the pinch roller and the capstan shaft.

Recording stops at random times on previously used tapes

Symptoms may be that the tape counter stops moving and/or the VCR enters stop mode and shuts down. Assuming this is not a mechanical problem - bad idler, belt, etc., make sure you don't accidentally have an 'insert editing' mode enabled. Insert editing uses the previously laid down control track as the timing reference. This provides clean glitch-free transitions between scenes. Insert editing will not work at all on a new or bulk erased tape. If you routinely use your cassettes over and over, there will be varying amounts of previously recorded material - with control tracks - on the tapes. At some point your recording may start to use tape beyond the recorded sections and - presto, no more control track. Poor VCR is confused and aborts.

Record (or play) stops after 15 minutes (or 30 minutes, etc.)

Make sure you are using the proper record button. Most VCRs have a OTR (One Time Record) or 'quick record' feature which starts just like normal record stops after a multiple of (usually) 15 minutes depending on how many times you press the button. The (normally) red button should be used for unrestricted untimed recordings.

Some VCRs also have other timed modes - sort of like the timed off function of a clock radio. Pressing the 'Off-T' button adds time to record or play in 15 minute increments and then the VCR shuts off.

Tape counter is erratic

The result may be inconsistent positioning of the tape if you use the counts to locate programs. It might also result in the VCR aborting PLAY, REC, FF, REW, or search modes if it thinks that the counter is not changing as expected - missing pulses or skipped counts.

For real-time counters, this may mean a problem deep in the electronics requiring a service manual. However, if you are attempting to play a tape that has nothing on it, the real-time counter will not change. This is normal as there are no control pulses on the tape.

For non-real-time counters, if the display skips counts or 'free runs' - counts very quickly at certain times, this could be due to a defective sensor or hysteresis circuit. If it counts in the wrong direction, a logic problem is indicated as direction is determined by the microcontroller being aware of what mode the VCR is in - there is likely no actual direction sensing on the reel.

See the section: A HREF="#vcrrrotstst">Reel rotation sensor testing for further information.

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Video Play and Record Problems

Video playback problems

If the VCR works in all respects when tuning broadcast or cable channels but playing a tape results in no picture, a very snowy picture, or just a blue screen, there may be problems with the video heads, the lower cylinder, head preamps, or other video electronics. Testing most of these is beyond the scope of this document and will require a service manual and test equipment. However, you can do a decent job of determining if the video heads are likely to be at fault.

Sometimes, when snow or serious video noise suddenly occurs while playing a rental, old, or damaged tape, it means the video heads have picked up some oxide and are no longer making good contact with the tape. Letting the VCR play a newer tape for a few minutes may clear this if it is minor. However, video head cleaning (using a cleaning tape or the manual procedure described in the section: Video head cleaning technique) will probably be needed. But, first start with the section: Snow on one or more speeds and NEVER NEVER attempt to clean the video heads without using one of the recommended techniques - you can easily destroy the heart of your VCR! Also, never attempt to play or record on a spliced or seriously damaged tape as this can also result in destruction of the video heads.

Video record problems

If attempting to record results in unexpected behavior, there could be a variety of causes depending on what you get for playback:

- Attempts to record are ignored by the VCR or cause the cassette to be ejected.

  This may mean that the record protect tab on the cassette is broken off or the record tab sense switch is dirty or bad.

- Record (either manual or timer) stops at random times - possibly with flashing display and/or ejects cassette.

  This could be the result of a dirty or defective record sense switch or misalignment preventing proper engagement with it. Some VCRs check for the record tab constantly while others just check when the REC button is pressed or the timer initiates record.

  It could also be a defective reel or tape end sensor halting record though these would likely affect playback as well.

- Playback results in video snow and whatever was on the tape, if anything, is gone.

  This means that the old recording is being erased (if there was one) but nothing or too weak a signal is being written by the video heads.

  This could be due to a variety of electronic faults as well as marginal or bad video heads.

- Playback results in a picture but it has a wiggling rainbow pattern running through it.

  This is normal at the start of a recording made on top of an old recording if your VCR does not have a flying erase head. However, it should wipe down the screen in a few seconds and disappear.

  If it does not go away, then your full width erase head is not working.

- Playback results in a flickering picture alternating between good video and snow at the frame rate (about 30 Hz for NTSC).

  This could mean that one of the two heads used for record is dirty or defective.

- Playback results in proper video but the previously recorded or no audio.

  The audio dub switch (if any) may be in the wrong position or the audio circuitry may be defective.

- Playback results in a picture which is cycling in brightness or flashing.

  This likely means that you are attempting to record (copy) a Macrovision(tm) or some other copy-protected tape or your cable or satellite company is transmitting copy-protected video.

  Info on Macrovision can be found at:

  - S.E.R FAQ Macrovision Page

  - Macrovision Web Site

  Some of the new digital DBS satellite receivers output a Macrovision copy protected TV signal so you can't tape the movies from them either.

Newer VCRs will generally not record successfully. Some older VCRs will record without problems. See the section: Why VCRs will not copy (Macrovision) copy protected tapes. (8mm VCRs may record the entire signal and therefore be able to playback successfully. However, attempting to copy the 8mm tape onto a VHS tape will result in the same problem.)

Problems with playback of self-made recordings

This someone unusual possibility deals with the case where a tape can't be viewed properly using the same VCR on which it was recorded.

For 2 head VCRs:

- Where playback of self-made recordings is bad or noisy (but they play fine on another VCR) and known good recordings made on another VCR play fine on this VCR, the video heads may be worn to the point of being marginal. Since the signal goes through the same heads twice (once for record and once for playback), any signal degradation will be worse.

For 4 (or more) head VCRs:

- In addition to the possibility, above, record and playback may use a different set of video heads and the playback set may be dirty, worn, or damaged. In this case, a recording made on a known good VCR *at the same speed* should also not play back properly.

Snow on one or more speeds

Did the problem happen suddenly? Or develop over time? If suddenly, what were you watching at the time? A (literally) dirty rental movie?

If this VCR has 4 or more heads, SP and EP may use a different set of heads, so certain heads may still be dirty or bad. If the machine tracks perfectly in EP, then alignment is probably fine - EP is more critical as to alignment as the EP track is 1/3 the width of the SP track.

Have the video heads been cleaned using the proper procedure (not just a cleaning tape - see the section: Video head cleaning technique).

New video heads may fix this, though it can be caused by other problems such as weak read electronics. See the chapter: "Video Heads and Upper Cylinders".

You should also check the backtension adjustment - if too loose, head to tape contact will be compromised. Try increasing it momentarily by pushing the backtension lever slightly to the left while the tape is playing. The usual way to adjust backtension without a backtension meter and service manual is to look at the image just before vertical retrace at the bottom of the screen - this is normally not visible unless you can reduce vertical size or play with vertical hold to get the vertical blanking bar to appear. Of course, most modern TVs don't have any such controls! This is the head switching point and when the backtension is properly set the image above and the bit of image below this break will be approximately aligned.

If increasing backtension helps, either the heads are marginal or the back- tension was low. However, low backtension will usually show up as a waving or flagging effect at the top of the picture.

Video turns to snow some time after vide head cleaning

What this means is that you are watching your favorite movie and in the middle of the most exciting scene, and your picture turns to snow or a blue screen. You performed what you thought was a thorough cleaning and then it happened again.

OK, well, if it is indeed your most watched tape, THAT may be the cause (especially if it happens during the same scene!) or it may be a problem with the VCR:

- Old, well worn, or dirty (the physical kind) tapes can result in oxide being deposited on the video heads even during normal play. After cleaning the video heads using the proper manual technique (see the chapter: "Video Heads and Upper Cylinders", play only newer tapes for awhile and see if the problem returns.

- Was your video head cleaning really done properly? One pass with a wet cleaning tape (assuming you believe in such things) is usually enough but not always. A manual head cleaning is best.

- If your VCR has an automatic head cleaner - remove it! The little foam wheel can just as easily put dirt back onto the video heads as remove it. Especially, after IT collects a fair amount of debris.

- Your video heads may be worn. Vides heads that clog up on their own is one possible indication that replacement is needed. See the chapter: "Video Heads and Upper Cylinders".

- The backtension may be too high. This can sometimes be remedied by a proper cleaning of the reel and felt band. See the section: Backtension adjustment.

The most likely cause if you rent movies or have a collection of older well used tapes is the first - your tapes are bad.

One or more lines at fixed locations in picture

This means that there is one or more horizontal lines during playback that are at fixed locations on the screen. These could be the result of electronic problems or marginal video heads but the possibility that should be explored first is that of tape damage.

If a prerecorded tape that plays properly on another VCR, shows the effect on the suspect VCR - AND - then shows the same thing on the other VCR, it is being damaged by something in the tape path.

Open the door of the cassette by releasing the catch on the side. Look carefully at the surface of the tape - it should be mirror smooth all across. If you see any evidence of hair fine (or larger) scratches running the length of the tape these are what are causing the line. This is likely a result of a bit of debris or a rough edge on one of the guide posts in the VCR. The effect on the picture is opposite of the vertical location on the tape - lines near the top of the tape affect the bottom of the picture and vice-versa.

Get a brand new tape or a known good tape (that you can afford to mess up) and test it on another VCR (at the tape speed that is worst, if this matters). Assuming playback is fine, play it on the suspect VCR for a couple of minutes. Pull the plug (DON'T hit STOP) so the transport remains in the fully loaded position. Now, carefully examine the surface of the tape all along the tape path (disturbing its position as little as possible) to identify the location where the damage begins. It may just be a bit of something stuck to a guide post. Has the VCR been cleaned in the last 10 years?

Note: This sort of damage to the tape does not represent a risk to your VCR's video heads so you can continue to use the tape if desired.

Jumpy picture in play

You have a VCR with known good heads that produces jumpy (vertically) video in play that cannot be stabilized with the tracking control. Perhaps you have attempted to adjust the mechanical tracking and maybe some other stuff. Some questions:

- Did you replace the heads? Could you have gotten them 180 degree rotated from the correct position? I don't know what the implications would be on your model VCR, but there is a definite right and wrong on this. It would certainly show up as tracking being way out when attempting to play back tapes recorded on this VCR on another machine.
- Exactly what adjustments did you touch?
- Have you verified that the roller guides are fully engaged against the stops?
- Have you checked backtension?
- Did you touch roller guide height?

This is probably a mechanical problem, most likely an adjustment or fault related to tape path alignment. However, it could also be due to electronic problems with the video or servo circuitry. The vertical sync could be corrupted or the head switching point not set correctly.

The head switching point is 6.5 lines before vertical sync. If this ends up moving into vertical sync for some reason, you will get unstable video. The supply side roller guide height adjustment is also critical and would be the first thing to check mechanical alignment problems are suspected.

However, don't overlook the obvious: your TV is marginal or misadjusted or you are attempting to play a bad tape.

Picture shakes or jumps or has snow in PAUSE/CUE/REV

Note that on a 2 head VCR, it is not possible to display a noise-free picture on a tape recorded at the SP or LP speeds. Therefore, for rental or pre-recorded tapes, what you are seeing may be normal. A 2 head machine should execute these special effects perfectly fine with EP(SLP) recorded tapes, however.

VCRs with 4 or more heads will usually have a V-Lock adjustment - either a knob on the front or rear panel, or sometimes 'conveniently' accessible from under the VCR. Sometimes, a special tool is needed to adjust this control. Where tracking is adjusted with a set of +/- buttons, these may also be used in PAUSE mode. There may be separate adjustments for SP and EP(SLP) speeds as well. In any case, these settings are made while viewing a tape recorded at the appropriate speed in PAUSE mode.

For LP speed - which is being phased out by many manufacturers, at least for record - these special effects usually do not work well if at all. This is basically due to the nature of the sync signal alignment on tapes recorded at LP speed and would require complex circuitry to handle properly at anything other than normal LP play speed. (If you care, the sync tips between adjacent tracks align on the tape in SP and EP recorded tapes but are off by 1/2 line with LP recorded tapes. This results in the tearing seen in search modes with LP recorded tapes.) Since this tape speed is of little true value - it is a compromise anyhow - the added expense has been found not to be justified except on professional machines.

Video search blanks out or doesn't work on recordings made at certain speeds

This may be a 'feature' of your VCR. On some older models, the designers in their infinite wisdom (or that of their marketing departments) decided that no picture or no search capability at all was preferable to a picture with serious noise bars or one which didn't sync properly. This was usually before the days of 4 head VCRs which directly addressed at least some of these issues.

Most 2 head VCRs will work fairly well on EP recordings but show noise bars over about 50 percent of the picture with SP recordings. For those made at LP speed, tearing will occur in addition to noise bars if they sync at all. Few VCRs deal properly with LP search as substantial additional circuitry is required.

In my opinion (IMO), any picture is better than a blank screen or no search capability.

VCR plays pre-recorded tapes but its own recordings are noisy or jumpy

Problems will be similar to the following:

> "I have a General Electric VCR model VG4217 that's displaying the most unusual problems. When I play back a pre-recorded tape from a video store it plays fine. When I play back a tape recorded on the machine I get video noise for 4 seconds then clear pix, then video noise for 4 seconds, then clear pix and so on.
>
> I also noticed that if I have the tape counter displayed on the screen, and when the counter progresses its count, the tape plays properly. Then all of a sudden the counter stops counting and the problem continues again.
>
> I have cleaned heads well, cleaned tape path, and even cleaned the underside of the takeup reel, all to no avail?"

First, make sure the tapes are in good condition. They may have been damaged (edge crinkled) before you serviced the VCR. This is now causing your erratic behavior and there is nothing wrong with the VCR.

Before considering drastic action, record on a brand new tape - from end-to-end if the initial results seem promising. You may have a non-problem.

Try recording you your VCR and playing back on another one. If this works, then bad tapes are the most likely explanation.

If this does not work, there could be electronic problems:

(From: Stephen Isaacs (stephen@myna.com).)

The normal playback of a pre-recorded tape suggests most things are working fine. The self recorded problems point to a faulty control track recording system. bad oscillator, or amp. It is also possible the erase head is not doing its job making it difficult to record a new control track over an old one.

(From: Richard (vcrtips@mail.vii.com).)

Almost all pre-recorded tapes are recorded at the SP speed. If you are like most people, you probably do your recordings at the EP speed (to get as much on the tape as possible). Do you have the same problem if you record at SP? Your VCR probably uses different heads for SP and EP. You may have dirty EP heads, defective EP heads, a head amp problem. Or, there could be a tape tension or other mechanical problem.

(From: Frank D. Ralston (fdr@continet.com).)

Check the following:

- Dirty (or worn) heads
- Low back tension (common problem)
- Tape path alignment (particularly input tape guide)

Incorrect frame alignment or bad video for part of frame

Symptoms like a picture which has a portion that is noisy or missing, or where the picture is split between top and bottom with the vertical blanking somewhere in between may indicate a problem with the PG sensor.

The rotational position reference for the video head drum is usually supplied by a pickup in close proximity to the edge of the lower cylinder (probably) which has a small magnet fastened to it. This generates the so called 'PG' pulse and is used by the servo circuitry to properly control the drum rotation and the head switching point.

If this sensor is moved or if there is a fault in the PG circuitry, a variety of record or playback problems can result. Without this reference, the servo circuitry has no way of knowing where the A and B heads are at any given time. During record, this may result in recording video which is not properly lined up with the video tape - a track may consist of the end of one field and the beginning of the next rather than an entire fields as it should. During playback, the head switching point may occur at the wrong time resulting in a partially snowy or missing picture since a head that is not even in contact with the tape may be active. Similar problems may make look like your TV's vertical hold control is set incorrectly with the vertical blanking bar visible at an arbitrary point on the screen.

The assembly on which the rotating magnet(s) are mounted and the upper cylinder may be secured with one or two set screws. If these loosen, the the precise relationship may be lost resulting in a shifted head switching point. It may even be random - changing location each time the drum starts up due to the inertia of the upper cylinder. If this is the case, you will need a service manual to properly adjust the angular location of the magnet assembly unless there are obvious 'timing' marks to guide you.

Beyond confirming that the pickup coil is in close proximity to the drum, the rotating magnet and sensor are secure, and that there are no bad connections or loose connectors, there is not much to be done for these problems without a service manual.

The definitions below are just For Your Information (FYI):

- **PG -** pulse generator. The pulse is derived from the rotation of a magnet on the video head drum past a sensing coil. I suppose this could be done optically as well.

- **FG** - frequency generator. This is a signal (sine or square) derived from the rotation of the video head drum. This may be phase locked to the PG pulse but can be a multiple of the frame rate. This could also refer to the capstan or reel rotation rather than the head drum.

Rainbow pattern in recordings made over previously recorded tapes

Unless your VCR has a flying erase head - located along with the normal video heads on the rotating drum - you will see a faint rainbow pattern near the start when recording over a previously used tape. The reason is that there is a separation of a few inches in the tape path between the video heads and the full width erase head. When you start recording at an arbitrary point, it takes several seconds (actual time depends on recording speed) totally erased tape to make it to the video heads. You are seeing an interference pattern between the old and new video signals. The pattern will slowly wipe from top to bottom as the diagonal tracks of new video intersect more and more of the erased tape.

This effect will not occur (except possibly at the very beginning of the tape) as long as you record from start to end without backing up the tape at any time.

If the rainbow pattern is present whenever recording over previously recorded tapes and does not go away, then your full width erase head is not working. This could be due to an electronic failure or simply a bad connection to the full width erase head. Alternatively, a mechanical problem such as a broken or popped spring or gummed up lubrication might prevent the pivoting full width erase head from contacting the tape properly.

Barber poling - bands of rainbow or color

Some rainbow patterns are normal for the first few seconds of recordings made on previously recorded tapes on non-flying erase head VCRs. See the section: Rainbow pattern in recordings made over previously recorded tapes. However, alternating bands of rainbow or color indicate a fault sometimesreferred to as 'barber poling'.

This is likely an electrical fault in the chroma playback circuitry buried deep in the bowels of your VCR. The chroma reference is not locking or is locking erratically with the chroma signal. Unless you can find some bad connections or other obvious problem, this will be difficult to troubleshoot without schematics. Don't be tempted to twiddle internal controls even if they appear to deal with color - you will just mess things up for whoever finally repairs your VCR!

Flag waving - top portion of picture wiggling back and forth

You have just loaded a videotape sent to you from your long lost cousin and you notice that the top of the picture is wiggling back and forth. This may be a VCR backtension problem but it could be much simpler.

First, if this wasn't the original complaint, make sure the flag waving problem exists with the TV that will actually be used with the VCR - it may just be your test TV or monitor that is unhappy. If the problem does exist on the relevant TV, all modern TVs have a dedicated video channel button(usually channel 0) which has a shorter flywheel line-timing duration allowing the TV timebase to lock up more effectively to unstable video sources such as VCRs. It may be that simple.

(Parts of the following from: Andrew Morphitis, Andrew@andrewsm.demon.co.uk).

This fault is sometimes known as flag-waving when associated with video recorders. If the tape back-tension provided by the tension arm and supply reel-table is not the same as the back-tension provided when the tape was recorded (possibly on another machine) then the field timing of the video tracks being played back will be inconsistent . Your back- tension can be checked using a back-tension cassette gauge (a typical reading would be about 35g-cm for VHS) or you could adjust the back tension using a known good test tape (or reliable pre-recorded tape) until the waving disappears. If your back-tension does turn out to be incorrect and you adjust it according to the manufacturers spec. then all of the tapes you have previously recorded will probably still exhibit this waving problem - adjust to spec. or to your tape library - take your pick.

That's the theory - now the practice. Back-tension refers to the tension of the tape over the head drum, this is provided by the felt covered metal band (tension band) which is wrapped around the supply reel (left-hand reel from the front), the friction providing the tension. There are usually two adjustments associated with back tension and these can be found near the opposite ends of of this tension band, the tension arm operating position and the anchor point of the band. Adjusting the latter position will increase or decrease back tension (you will want to increase your back tension which has dropped due to excessive wear on the belt). If you do give it a bash then be aware that poorly adjusted back-tension can, at worst, give rise to premature head wear. Because of the differences between the back tensions of different machines, all modern TV's have a dedicated video channel button (usually channel 0) which has a shorter flywheel line-timing duration allowing the TV timebase to lock up more effectively to unstable video sources such as video machines. Are you using the video channel? - try playing the video through different channels on your TV.

Why do newer VCRs seem to be worse with respect to flag waving?

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The head fault used to be specified +/- 10 us, then it became 16 us, 20 us and I think we have already seen 22 us. Sooner or later a TV will not be able to follow such large phase jumps before the picture begins. Some TVs can be modified and some can not. The problem is that the line deflection circuit CAN NOT instantly follow a large phase jump, the output transistor would be destroyed at once. It HAS to be distributed over a certain number of lines. You can only hope to distribute the phase jump evenly over as few lines as possible and that there is neither overshoot nor tail to the response. YMMV.

It is logical to see more problems on old tapes or on tapes that were recorded on another machine (especially rental tapes) because the phase jump has everything to do with mechanical tolerances and tape stretch. It should be much better on a new tape that has been recorded on your (his) new machine.

Macrovision anti-copy protection only makes matters worse !

I think I will buy me a nice new JVC S-VHS machine with built-in timebase corrector. Also, our new European Philips chassis has an input IC with built-in timebase corrector. That should help a lot.

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Audio Problems

Total lack of sound on playback from non-HiFi VCR

This assumes audio from the VCR's tuner is fine. If ALL audio is missing, check your external connections (particularly if you use the RCA jacks), try switching to the other channel (3/4) if you use the RF output, and adjust the fine tuning (if any) on your TV.

If this VCR also will not record audio, see the section: No (non-HiFi) sound on new recordings.

The following assumes this only happens when playing tapes:

While playing one that you know has good audio, carefully touch each of the terminals of the A/C head with the tip of a small screwdriver - if the audio circuits are working, the audio head terminal should produce a buzz from the speaker. CAUTION: Insulate all except the tip of the screwdriver to prevent shorts.

- If you get a buzz, the A/C head may be dirty. Try cleaning it with a Q-tip. DON'T touch the video heads.

  Other possible causes: Debris or problem with tape path alignment causing loss of contact with audio head in vicinity of audio tracks, bad audio head (but this would probably result in inability to record audio as well).

- If there is no buzz, something in the audio circuits is bad. Double check that there is no audio switch or mode select that might have changed its setting. For mechanical switches, flip them back and forth a couple times to clean the contacts. Beyond this, additional testing will be needed requiring a service manual with schematic.

Poor quality sound on non-HiFi VCR

There can be several non-electronic causes for poor quality sound on linear audio playback:

1. The audio head needs to be cleaned. A cleaning tape may not be effective. You can use Q-tips and medicinal or pure isopropyl alcohol or tape head cleaning solution. You might as well clean the tape guides as well while you are at it - a speck of dirt can cause the tape to wander and produce erratic sound.

2. The audio/control head needs to be aligned - particularly the azimuth adjustment which is the angle the head gap makes with respect to the direction of the tape's long axis (I hope this is clear). You can do this if you are so inclined. Before you adjust azimuth, a test for this would be to record and then play back a tape on this machine - regardless of how far off the azimuth adjustment is, the recording should sound good (at least as good as one can expect from the linear audio) track. See the chapter: "Tape path alignment and Backtension Adjustment".

3. The audio head (and other parts) needs to be demagnetized - use an audio tape head demagnetizer. Stay away from the video heads. Some demagnetizers are powerful enough to damage them. Make sure the demagnetizer you use has a no sharp ends to damage anything - cover with electrical tape if in doubt. Turn on the demagnetizer and move it slowly near all metallic parts that the tape contacts - guides, levers, erase and audio/control head. As mentioned, do not go near the video heads. See the section: Head demagnetizing.

4. The audio head is worn. If the poor sounds quality really bugs you, these can be easily replaced but they are not cheap since generic replacements are rarely available. Alignment will then be needed.

5. Tape path problem causing bad tape-head contact. See chapter: "Tape Path Alignment and Backtension Adjustment".

6. Your expectations for audio quality on the linear audio tracks on a non-HiFi VCR are unrealistic. The worst will be a stereo VCR in EP mode since the stereo tracks are less than half as wide as non-stereo tracks. Best will be SP non-stereo but even this is very poor for music. Once you get used to HiFi quality, linear audio sounds like crud.

Identifying source of one-channel (non-HiFi) low audio/hum/buzz

Perform the following 'screwdriver and short tests' to narrow down a one-channel low audio problem:

- While the VCR is playing a tape, CAREFULLY touch the tip of a screwdriver (or other metal tool) to each of the pins on the A/C head - you should be able to locate the L and R channels by the buzz resulting from signal pickup from the screwdriver. If the bad channel doesn't respond at about the same level as the good one, there is probably an electronics problem, not A/C head alignment (though a bad A/C head coil is still possible).

- If you can locate the signal ground for the A/C head, CAREFULLY short the output pin of the bad channel head to ground - the hum/buzz/whatever should disappear if there is a head or alignment problem. If it doesn't, there is an electronics problem for that channel.

Excessive flutter on VHS linear (non-HiFi) audio playback

While general quality of VHS linear audio is almost always mediocre, there should not be excessive flutter - wavering in pitch. Certainly it should not be noticeable for speech. How bad music sounds will depend on your expectations as well. Here are some possible causes:

- Dirty/gummed up stationary guides or A/C head.

- Lack of lubrication of the capstan or roller guides.

- Excessively tight idler or other clutch.

- Bad capstan motor, especially if direct drive type, or motor driver.

- Bad pinch roller/bearing. Sometimes aftermarket replacements may be inferior and result in the same or worse behavior. However, usually they are fine.

- Video head drum (upper cylinder) which is mounted off-center or which has excessive runout or wobble. This would most likely show up after the video heads are replaced. Sometimes, this may be detected by resting a dry finger very gently against the rotating drum - there should be NO detectable vibration.

- Servo system problems.

- Power supply problems.

- 'Stiction' between tape and lower cylinder.

- Unrealistic expectations of linear audio quality. Some VCRs are downright terrible, especially at EP speed. This is normal.

No (non-HiFi) sound on new recordings

Sound is fine on pre-recorded tapes or tapes recorded on this VCR prior to the problem developing. New recordings have no sound whatsoever.

Make sure your tape isn't bad. Yes, I know, this is unlikely, but very old tapes tend to lose oxide along the edges and that's where the linear audio goes.

If the previous audio is erased but you now have silence, the problem could be that erase is working but no new audio is being recorded on the tape. First, check any audio mode or dubbing switches for proper settings.

If you are using the RF input, see if the same problem exists with the RCA inputs. Sometimes, dirt/bad connections on the RCA inputs will trick the VCR into thinking you really want to use those instead of the RF. Pushing an RCA plug in and out a few times may clean these off.

If you are using the RCA inputs, make sure the the audio cable is plugged into the proper jack on the VCR and that there is audio from the source (plug it into an amplifier or another VCR to test).

(From: Raymond Carlsen (rrcc@u.washington.edu).)

I first saw this problem in Wards (Sharp) VCRs, then later in some Samsungs. The real problem is a bit of resistance in the connector on the full erase head. The FE head arm swings back and forth when loading and unloading the tape, causing the connections to weaken. That bit of resistance cause the bias/erase oscillator to fail to start up in record mode. If allowed to run that way, it can burn up that transistor and other components on the audio board. Just replacing the bad parts will not fix it for long. Cut off the plug and direct-solder the full erase head wires directly to the head.

End of problem. Done a bunch of 'em.

Audio not present through VCR

Tapes play fine but audio is missing to the TV and when making recordings using the VCR's tuner.

How is the TV connected? Through the RF/antenna input? If through the RCA jacks, of course, it could be a TV/cable problem. Bypass the VCR and check.

For the RF, this could be many things:

1. There may be an incorrect source select or dubbing mode setting or a dirty set of contacts on a related switch. Check your instruction manual and cycle and/or clean the contacts of any suspect switches. Unplug the VCR for a few minutes to reset the controller - it may be in a weird mode.

2. Dirty contacts on the RCA audio in jack - some automatically assume you want to record from there if anything is plugged in. (Or, you may have left your CD plugged into the jack several months ago when you last used it!) Usually, inserting an RCA plug into the jack a couple of times will clean the contacts at least well enough to confirm that this is the problem.

3. Bad cable or bad connections inside the VCR. There is often a separate cable for audio (and video) between the tuner and the mainboard - reseat and/or test it.

4. Electronic fault resulting in not selecting the audio. This will require a schematic.

Previous (non-HiFi) audio is not erased on new recordings

If the old audio track is unchanged - you get the new video but old audio, check that any dubbing switches are set correctly - to enable audio.

If you are getting a mixture of old and new audio, then there could be a problem with the audio erase head (part of the A/C head stack) or its circuitry.

Clean the audio/control head (the stationary head to the right of the video drum near where the tape re-enters the cassette. Check for dirt or tape oxide on or around the audio/control head.

Beyond this, testing will probably require a schematic. However, if you can locate the connections to the audio erase head, use an ohmmeter to test for continuity of the coil. Check with an oscilloscope for the high frequency erase signal during record.

Poor quality sound on HiFi VCR

The VCR may be switching between HiFi and linear audio at random (with the HiFi light also flickering on and off or simply not selecting HiFi audio at all. This may be happening with only one audio channel (usually the right channel in this case).

The sound out of a HiFi (not just stereo) VCR should be virtually indistinguishable from the original and for good quality source material, nearly as good as a CD.

What to look for if it is really playing HiFi (try at slowest tape speed as this will have little effect on HiFi quality but will turn the linear track quality to crud). Use a tape with a musical recording for this:

- Almost no tape hiss (background should be virtually silent).
- Excellent frequency response (treble notes should sound natural).
- Excellent dynamic range (loud louds and soft softs).
- No detectable wow or flutter (no short or long term wavering in pitch).

However, problems are possible:

- Since the HiFi heads are on the rotating video head cylinder, they are subject to the same problems as video heads - and the same difficulties in diagnosing head problems. Dirt, damage, or electronic defects can cause the HiFi sound to be absent or distorted. A broken or badly worn HiFi head will simply cause the VCR to switch to the linear audio tracks. HiFi head alignment is more critical than video head alignment so this may need to be checked.

  Try adjusting the manual video tracking control as this will also affect HiFi audio tracking and see if this clear up the sound.

- As with video heads, poor quality playback of self recorded tapes but fewer or no problems when playing pre-recorded tapes is one sign of worn heads.

  Like video, recording HiFi audio needs to use the heads twice. Thus, a slight loss in sensitivity or frequency response may still enable pre-recorded tapes to work reasonably well but will result in problems of playing back self-recorded tapes. Note that slight tape path misalignment would not affect self-recorded tapes anyhow but would result in poor playback of others - the opposite effect.

- Old, worn, dirty, or bargain basement tapes will have many more dropouts than new name brand tapes. These will show up as noise, streaks, or dots in the picture *and* as pops or increased noise in the HiFi audio output.

- It is possible that only one audio channel is affected. The audio may be missing, scratchy, distorted, or fading in and out. Where problems mainly affect one audio channel, it is usually the right one. One reason for this is that it is recorded at a higher carrier frequency (1.7 versus 1.3 Mhz for the left channel). Thus, problems are more likely to show up in the right channel due to either worn heads or a misaligned tape path. Since some of the audio processing is separate, electronics problems can easily affect one channel as well.

- A whine, buzz, or hum in HiFi audio playback may indicate that the A/C head is too high - recording the control track on top of the ends of the video and HiFi tracks. However, other problems - particularly with tape interchangeability would almost certainly result.

  Note that A/C height doesn't change on its own - someone has likely been mucking with your adjustment screws (and who knows what else)!

  To confirm, record a couple minutes on a brand new or bulk erased tape. If the last 5 to 10 seconds of the recording is clear, the A/C head alignment is at fault since it is writing over the ends of the HiFi tracks 5 to 10 seconds *after* they are laid down and the end of the recorder will be unaffected.

- A hum or buzz may be the result of problems in concealing the head switching point for the HiFi track. This could require an adjustment or be a failure or design flaw. See the section: Hum or buzz in HiFi audio.

- Electronic adjustments or faults in the HiFi audio circuitry could of course also result in record or playback problems.

Help for marginal HiFi heads

Also see the chapters: "Video Heads and Upper Cylinders" and "Tape Path Alignment and Backtension Adjustment".

(From: Jerry ().)

The HiFi heads are more critical than the video heads. If they are warn down a bit, they can be very instable. Sometimes I can get a bit of a better response by increasing the tension arm tension a little. If you do this, you may have to touch up the guides.

(From: Anthony Falvo (afalvo@borg.com).)

I have had good luck making the HiFi tracking point meet the video head tracking point with slight adjustment of the 30 Hz switch point.

hum or buzz in HiFi audio

(From: Liam Keane (106350.3410@CompuServe.COM).)

The noise you are hearing is FM audio track switching noise - from the changeover between the hi-fi audio heads on the head cylinder. The difference between video and audio switching noise is that the video noise can be shoved out of sight in the vertical blanking interval. The trouble with the audio is that our ears listen all the time! Some VCR's exhibit this worse than others. You can try adjusting the switching point to minimize it, but by the same token, some precorded tapes are particularly bad, with Disney tapes being about the worst I have ever heard.

Fluttering or noisy HiFi audio

Where a VCR has seen a lot of use, the video and HiFi audio heads are likely to be worn. However, evidence of video problems may or may not proceed HiFi audio degradation:

(From: (Parker C. (parkerc@halcyon.com).)

Your hifi audio is, technically speaking, not fluttering. The distortion you hear is the head switching noise becoming audible as the hifi heads are wearing out.

On the outside chance you are not dealing with a worn out upper drum, you should first check the video envelope and confirm that your machine is mechanically adjusted correctly - i.e. check that the drum guides have not slipped. Hifi audio would typically become distorted if the tape path is not adjusted correctly. Audio playback level will not help the situation. Hifi Record levels almost never need to be adjusted, unless someone has been tweaking them in the field. (hint, hint).

A note on record levels: occasionally we find that decreasing the video record levels on machines with poor hifi audio recordings will quiet things down for a little while. Did everyone get that? (decreases the video penetration into the hifi region of the tape).

Squealing noise from VCR in certain modes

Unusual noises from inside the VCR may be an indication of a problem or just a badly made cassette - try a different one.

The most common cause for a squealing noise are tired weak belts that are slipping. Less likely is the need for lubrication.

- A squeal when entering play or record mode - with the VCR perhaps aborting the operation - is usually caused by a slipping loading belt.
- A squeal during fast FF or REW may indicate a slipping drive belt.
- A squeal or whine during play or record (perhaps intermittently when the video head drum is spinning)

could be a worn video head drum bearing or dirty or improperly positioned static brush (see also: "High pitched whine from inside VCR").

See the appropriate sections on cleaning, rubber parts replacement, and lubrication.

- A whine or buzz from the audio during playback of tapes not recorded on this VCR may indicate a grossly misadjusted A/C head - the linear audio heads are picking up the ends of the video tracks due to the A/C head being too low.

  Note that A/C height doesn't change on its own - someone has likely been mucking with your adjustment screws (and who knows what else)!

- A whine from the audio (of the TV) while using the VCR may indicate bad grounding of the internal shields, other bad connections, or electronic problems.

High pitched whine from inside VCR

Your first thought is probably of an expensive repair to a motor bearing or replacement lower cylinder. If there is a high pitched whine coming from inside the VCR when in PLAY, REC, or other mode which spins the video heads, you may simply have a dirty or improperly positioned antistatic brush.

There is usually a metal strip with a carbon contact pressing against the center of the video drum spindle either above or below the deck. In rare instances, the brush may be BETWEEN the upper and lower cylinders requiring more disassembly. It is very common for it to vibrate is just the right way to sound like a cat being strangled. Gently press on this strip or lift it off of the spindle while you hear the sound. If the whine disappears, cleaning and slight repositioning of the strip should be all you need to do. Do not remove this strip - it is needed to ground the rotating drum to prevent static buildup and video noise problems (see the section: Firing (static) lines in picture during playback.

Note: You may find that if you measure the resistance between the brush to the chassis that it is far from 0 ohms - perhaps in the 10s or 100s of K or higher. This is perfectly normal (as long as it isn't infinity!) as static doesn't take much current flow to be eliminated.

Tapes play back in a foreign language

> "Have recorded tapes with a Mitsubishi U52 that play back in English on same, but play back in Spanish with some other VCR's. What's up?"

(Portions from: David R Mulligan (skipper@interlog.com).)

It sounds like you are recording the SAP audio channel on the mono audio track, but normal on the HI-FI track. This would indicate that your television station broadcasts a Spanish dub over the SAP channel for those who prefer that language.

Check the position of the audio playback source select. Also, any problem with the HiFi record or playback would also result in the VCR defaulting back to linear track playback.

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Signal and Interference Problems

VCR color problems

There are two typical situations:

- Playback is always in B/W.
- Record is B/W but playback has normal color.

If you can play pre-recorded tapes in color but tapes recorded on this VCR do not play back in color, there may be several possible causes. The simplest is that your input signal is too weak - a misadjusted antenna or cable with a large number of splitters - and the VCR's color killer thinks there is no color. Sometimes the threshold for detecting the color signal is set higher on the VCR than the TV which you are using to monitor the recording.

Some questions:

- Is the color TV's fine tuning set correctly?
- Does it play pre-recorded tapes in color?
- Does the tuner output produce color?
- Does the video output work in color?
- Is the problem the same for all recording speeds?
- Do the tapes you record on this VCR play in color on another one?

If the answer to all but the last question is 'yes', then the problem is most likely in the video/chroma circuitry associated with recording function. It could be as simple as the color killer setting being too low.

Possible sources of problems with color recording:

1. Weak signal - check and/or adjust antenna.
2. Color Killer set to low.
3. Problems in tuner - does the video output work in color from the tuner?
4. Problems in chroma circuits.
5. Sometimes, marginal heads - less likely if it plays in color.

If recording works fine as indicated by tapes made on this VCR playing fine on another one but pre-recorded tapes do not play back in color and the VCR works fine in all other respects there could be several possible causes:

1. Weak chroma signal level from VCR.
2. Color Killer set to low on TV.
3. Problems in chroma circuits.
4. Marginal or dirty video heads.

Note that in all cases of missing color, checking with another TV and/or adjusting the TV's controls should be tried first as slight differences in signal levels between tuner and playback may cause a TV with marginal settings (fine tuning, color killer, chroma circuits) to switch unexpectedly between color and B/W.

RF signal problems

First determine whether there is a problem with broadcast or cable, playing tapes, or both. If it is only broadcast or cable, then your source may be at fault. If it is fine with the VCR off but noisy when using its tuner, the problem could be in the tuner itself.

Verify that the direct video output (RCA jacks) works properly with a pre-recorded tape. If this is noisy as well, then there are problems with the video circuitry or video heads.

If there are problems with the Channel 3/4 output but the direct video outputs are fine, then suspect a weak or dead RF modulator. This is a little metal metal box with the Antenna In and TV Out connectors. It has circuitry which switches between the VCR's internal video signal and the antenna input. It also converts the video baseband signal to the channel 3/4 output required by the TV.

Before you conclude that the RF modulator is to blame, check that the channel and fine tuning of the TV are properly set and that there are no other problems with the TV. Test the VCR with another TV. It could be that the signal from the VCR is just a little weaker than it is used to be. Try moving the channel 3/4 switch back an forth - it may have developed a bad contact. Try the other channel (3 or 4) - it may work better. Try moving the VCR away from the TV - sometimes interference from the TV will degrade the video quality.

If you do conclude that the RF modulator is at fault, generic replacements are available from the parts sources listed near the end of this document or other electronics distributors for less than $25. Replacement is straightforward since there are only a couple of soldered connections but getting to the unit physically is sometimes a challenge.

VCR will not tune broadcast or cable

Are you sure that the input signal is making to the VCR? Does the pass- through connection work? Double check the connections. Connect the cable you have on the ANTENNA IN of the VCR directly to the TV. Make sure it's center pin is not bent over or broken off. Try a new cable. Is the tuning mode switch (broadcast, CATV, etc.) set correctly on the VCR?

If the signal is preset into the VCR, there still may be a bad connection inside preventing it from making it to the VCR's tuner. Sometimes, there are RCA style plugs inside that work loose.

Otherwise, the tuner of the VCR is not working. This could be because it is broken or power to it is bad or missing. If all other functions of the VCR are working, it is likely (though not guaranteed) that the power supply is fine. There could be bad connections or dirty connectors as well.

Beyond probing for bad connections and verifying your antenna hookup, there is not much that can be done without a service manual and test equipment.

If the problem is that it won't tune upper cable channels, that may be by design. Older VCRs - despite being called 'zillion channel cable ready', may not be able to deal the upper channels of modern cables systems:

For example, a typical older 110 channel cable ready VCR is able to receive only these: Cable: 14-36, A to W, 95 to 99, A-5 to A-1, VHF 2 to 13, and UHF 14 to 83. Total: 110 Channels. The only way around this is to get a cable box capable of receiving all of the channels that your cable company provides and set your VCR on channel 3 or 4, or buy another VCR that will tune in all of the cable channels.

Interference patterns such as parallel or diagonal lines

This may be due to the proximity of the VCR to a TV or other component, outside interference, or a fault in the VCR.

Determine if it in the video signal or is it only present when the VCR is close to or sitting on/under the TV? If so:

- Have you rearranged your setup recently? It is common for TVs and VCRs to interfere with each other's operation. Your only easy fix may be to shuffle the components in your entertainment center.

  One simple test to see if it is the TV doing the interfering is to record a program partially with the TV off and then with it on - without changing anything else. If the quality of the recording is noticeably worse with the TV on, you know what is at least partly to blame.

  It is probably interference from the TV's switching power supply, deflection, or other circuits getting into the low level video circuits of the VCR. Either the TV or VCR or both are inadequately shielded. Hey, but the makers saved a few cents!

  Is probably isn't the cables but see if moving them around changes anything. If it does, then better (shielded) cables might help.

  It might be worth trying a position a grounded copper sheet between the TV and the VCR. I don't know how much if at all it will help.

Does it happen when watching from the antenna/cable or only when a tape is playing or recording?

- Interference patterns on cable may indicate a problem with the cable company or the hookup. It may even be system wide and under investigation - such temporary service problems are not uncommon.

- If you are using one or more splitters to distribute the signal to multiple locations, be aware that each one introduces some signal loss and eventually this results in noticeable degradation making the system more susceptible to even low level interference which might otherwise be undetected.

- Interference patterns while using the antenna may indicate just generally poor reception. Try repositioning the rabbit ears or outside antenna (if you have that option. Also check the connections and wiring - all the twisting and maneuvering can break or damage antenna cabling.

  If you live in an apartment complex - especially newer building of steel or steel reinforced concrete construction - reception may be inherently dreadful. Many of these offer a rooftop antenna feed or cable and for good reason. Try relocating the equipment - sometimes a different part of the room will have fewer problems.

- Interference patterns only on recorded tapes that was not there in the original program may indicate a problem in the record circuitry of the VCR or interference from the TV (only if on).

- Interference patterns only on playback of tapes regardless of where they were recorded may indicate a problem in the playback circuitry of the VCR or interference from the TV.

Did this just start suddenly without you changing *anything*?? Does it now happen at all times of day?

- If it does not happen all the time, try to determine what is common about when it does occur. Consider other sources of interference - local ham radio operators or other transmitters, light dimmers, compact or other fluorescent lamps, vacuum cleaner - even your microwave oven. Although less likely, it may be a neighbor's appliance doing the interfering.

- To eliminate the VCR as the source of the problem, you may need to take it on a field trip to a friend or relative in a different neighborhood. If the patterns are still the same, it is probably a fault in the VCR and not outside interference.

Proximity to other equipment

Depending on the combination of VCR and the TV (or other A/V equipment), there may be situations where either the VCR will not operate normally. For example, placing the VCR directly underneath the TV may result in erratic behavior or noise or other patterns in the video (playback or record as well). All this means is that there is some RF emission from the TV that is getting into the logic or video circuitry of the VCR. While shielding is possible in theory, the only easy solution is to rearranged your setup to they aren't so close together. There is really no way to know which models are subject to these problems or which configuration(s) of equipment will be best without trying them.

Firing (static) lines in picture during playback

These may be described as static or short bright or dark lines in the picture. They usually have a sharp start and may trail off or stop abruptly. They may be occasional (once every few seconds) or frequent (multiple instances per video frame). Also see the section: Are your video heads really bad? for video head problems as large quantities of firing lines may be due to dirty, worn, or defective video heads.

First, try a different tape - preferably a new recording made on a different VCR or a new commercial video. It is possible that these streaks are simply due to dropouts on the tape - missing bits of oxide or dirt causing momentary loss of video signal. Old, worn, or cheap off-brand tapes are particularly prone to dropouts.

One characteristic of dropouts is that they may span video lines as well as video frames. If your lines are very short and random, they may be caused by a dirty, missing, or improperly positioned video drum static brush. In most VCRs, you will see a metal strip with a carbon contact pressing against the center of the video drum spindle either above or below the deck (or in rare instances, BETWEEN the upper and lower cylinders). The brush is there to provide electrical contact between the rotating video drum and the stationary lower cylinder and chassis. This is necessary since the bearings on which the upper cylinder rotate may not provide adequate contact and any static buildup caused by the spinning head cylinder rubbing against the tape may discharge through the bearings resulting in these firing lines. Carefully remove the static brush and clean the end of the spindle and carbon contact. This may be all you need to do to remove the static lines from your picture.

(From: Michael James (michaeljjames@biglake.com).)

The following is for a JVC based deck which is often used by Philips. You need to use GREAT care as this requires removal of the drum motor and it's mounting. This will affect the switching point which will cause the picture to roll uncontrollably or to have noise at the bottom of the picture.

Symptom - White dashes across the screen.

Remedy - Very carefully note the position of the drum motor with relation to the shaft running through the drum assembly. Remove the screws holding the drum motor. Note the position of the brass bush and loosen the Allan nut holding it. Remove the video heads and clean the excess grease off of the static discharge brushes. If the fault persists replace the brush assembly with a new brush

If you do not feel confident that you can do this take it to a repair shop, this job should take no longer than 1 hour to complete.

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General System Problems

Multiple system problems

Most VCR problems will be limited to a specific subsystem - video, audio, tuner, servo, control. When multiple seemingly unrelated problems occur at the same time, suspect a power supply problem since multiple systems may be fed from common power supply outputs.

There are always several different voltages used within a VCR - if one of these dies, some subsystems will work but will not receive the proper signals from the dead parts. So, nearly any kind of behavior is possible.

Therefore, the first test is to determine, if possible, that the power supply outputs voltages are correct - both with power off and power on.

Power supply problems - unit totally dead/major system problems in all modes

Power supply problems can range from intermittent behavior due to slightly out of tolerance voltages, hum, or noise to a totally dead VCR. Multiple system failures can result if one or more of the half dozen or so voltages used within the VCR are incorrect or missing.

Some power supply problems are caused by power surges. These may result in a totally dead VCR or in overstress and subsequent failure of various components. A power strip with a circuit breaker, even with surge protector is not a reliable protection against power surges especially during lightning storms. The only sure protection is unplugging electronic equipment during storms - but then, what would your insurance agent have to do?

Fuses and IC protectors in VCRs

A variety of protective devices are used in VCRs.

Of course, where the VCR is stone dead, check for a blown line or secondary fuse in the power supply. Occasionally, a fuse will blow due to a power surge or for no good reason and a new fuse is all that is needed. However, this is usually not the case and a new fuse will blow immediately. There is a chance that additional damage may result - proceed cautiously. If the fuse element is vaporized - black or silver coating on the glass, a short in the power supply is likely. However, a violent surge on the power line can also result in such a symptom.

Various subsystems of the VCR may be protected by individual fuses as well. Sometimes, one of these will blow resulting in a variety of multiple systems problems but not a totally dead VCR. Look for fuses on the mainboard as well as the power supply.

IC Protectors (ICPs) may be present on a single chip or small subsection of a circuit. Most common types are miniature fast acting fuses. Typically, they come in a black TO92 or rectangular .1"x.3" plastic case with two leads. Test these like a fuse - an IC protector should be a short if good.

In some cases you may find a PTC (Positive Temperature Coefficient resistor - resistance increase dramatically due to excessive current heating the element) type of fuse or IC protector - these are self resetting once the overload has been removed. However, this also means that testing with power off will show low resistance even if a fault still exists (unless you test immediately). Measuring voltage across such a device with power on is one way of identifying a problem. One common form of this device appears as a little metal metal sandwich - the two plates are separated by the active material.

VCR power supplies

Reread Safety info before tackling any power supply problem in a VCR!

VCRs typically use one of four types of power supplies (There are no doubt others):

1. Power transformer with linear regulator using 78/79XX parts or discrete components. The power transformer will be large and very near the AC line cord.

2. Power transformer with hybrid regulator like STK5481 or any of its cousins - multioutput with some outputs switched by power on. If it has one of these, check ECG, SK, or NTE, or post to sci.electronics.repair and someone can probably provide the pinout. Again, the power transformer will be large and very near the AC line cord.

3. Small switching power supply. Most common problems: shorted semiconductors, bad capacitors, open fusable resistors. In this case there is usually no large power transformer near the line input but a smaller transformer in a more central location.

4. Combo of the previous - these are less common. An input power transformer may supply low voltage to a switcher.

5. Camcorders and portable video camera-VCR combos include a battery charger and run all normal VCR (and camera) functions off of the battery. The required voltages are derived using DC-DC inverters.

First try to identify which type you have. Here are some general comments for each type:

1. Troubleshooting is quite straightforward as the components are readily identified and it is easy to trace through from the power transformer, bridge or centertapped full wave rectifiers, regulators, caps, etc. The circuitry is not usually complex and the most common failures tend to be quite obvious. It should be possible to determine the correct output voltages from basic circuit principles.

Start at the line cord - if there is infinite resistance between the two prongs, there is a problem in the primary side of the transformer. A fuse may be blown, the transformer primary may be open (or a thermal fuse under the outer layers of insulation may be blown), or there may be bad connections between the line cord and the transformer. If this checks out, there may be a problem on the secondary side - bad rectifiers, transistors or IC regulators, or bad connections. It is unlikely that the secondary winding of the transformer itself is bad.

See the document: Notes on the Troubleshooting and Repair of Audio Equipment and Other Miscellaneous Stuff for more info.

2. Failures of one or more of the outputs of these hybrid regulator blocks are very common. Use ECG/STK/NTE cross reference to identify the correct output voltages. Test with power switch in both positions. Any significant discrepancy indicates a likely problem. While an excessive load dragging down a voltage is possible, the regulator is the first suspect. See: "VCR Power Supply Regulators" for pinouts of some of the common ones. The correct output voltages will be specified by on the regulator pinout. Replacement cost is usually under $10. If you find *no* voltages on the regulator at all, go back and check starting at the line cord as above.

3. Switching supply problems are tougher to diagnose but it is usually possible without service literature by tracing the circuit and checking for bad semiconductors with an ohmmeter. Common problems - dried up capacitors, shorted semiconductors, open startup resistors, and bad solder joints. For a sample circuit, see the document: Various Schematics and Diagrams which includes an example of a switching power supply found (with minor differences) in many models of Panasonic (and clone) VCRs.

   In a supply that is dead - has blown the main fuse - check **all** semiconductors, capacitors, and resistors as a failure in one may damage others and just replacing the first one you find that is bad may result in it just blowing immediately. Fusable (flameproof) resistors (blue or brown body or boxy ceramic power type) may open up if there was a shorted switching transistor. Power resistors supplying current for the startup circuit may open from age. See the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies for more detailed information. Correct output voltages can be determined with some work - tracing the circuit. However, it is usually safe to assume that there should be at least one around 5 to 6 V output for the logic and one or more others at 12 V or higher for the motors and other electronics.

   Note: The initial test in (1) for power transformer based supplies of checking between the prongs of the line cord cannot be used with a switcher - it will likely always read open even if the supply is perfectly good.

4. Problems in either the power transformer/rectifier/filter capacitor section (usually no regulator) or switching supply are possible. However, they can pretty much be dealt with independently. Note: the switching supplies used in these usually run off of a lower voltage input than the more common off-line non-isolated type making them somewhat less hazardous to your health to work on. See (1) to (3), above.

5. Problems can occur in either the battery charger or power supply section. Short running time on battery alone is usually caused by a bad battery. If possible, try a known good battery or battery eliminator first to determine which it is. The older style portable units were quite reliable and easy to service. However, modern camcorders are so jam packed with microminiature surface mount unmarked circuitry that troubleshooting and repair is definitely not fun. Not to mention the joys of just getting inside with only a finite use of expletives.

Always check for the possibility of bad solder connections as well.

Internal fuse blew during lightning storm (or elephant hit power pole)

Power surges or nearby lightning strikes can destroy electronic equipment. However, most of the time, damage is minimal or at least easily repaired. With a direct hit, you may not recognize what is left of it!

Ideally, electronic equipment should be unplugged (both AC line and phone line!) during electrical storms if possible. Modern TVs, VCRs, microwave ovens, and even stereo equipment is particularly susceptible to lightning and surge damage because some parts of the circuitry are always alive and therefore have a connection to the AC line. Telephones, modems, and faxes are directly connected to the phone lines. Better designs include filtering and surge suppression components built in. With a near-miss, the only thing that may happen is for the internal fuse to blow or for the microcontroller to go bonkers and just require power cycling. There is no possible protection against a direct strike.

Most VCRs have their own internal surge protection devices like MOVs (Metal Oxide Varistors) after the fuse. So it is possible that all that is wrong is that the line fuse has blown. Remove the case (Unplug it first!) and start at the line cord. If you find a blown fuse, remove it and measure across the in-board side of fuse holder and the other (should be the neutral) side of the line. With the power switch off, this reading should be very high. With the switch on, it may be quite low if the VCR uses a large power transformer - a typical primary resistance is 15 to 30 ohms.

Some VCRs may be outside this range but if the reading is extremely low, the power transformer could have a partially or totally shorted primary. If it is very high (greater than 1 K ohms), then the primary of the power transformer may be open or there may be blown thermal fuse under the insulation wrappings of the transformer windings.

If the VCR has a switching power supply, see the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies.

If the resistance checks out, replace the fuse and try powering the unit. There will be 3 possibilities:

1. It will work fine, problem solved.

2. It will immediately blow the fuse. This means there is at least one component shorted - possibilities include an MOV, line filter capacitor, transformer primary.

3. It will not work properly or still appear dead. This could mean there are blown fuses or fusable resistors or other defective parts in the power supply or other circuitry. In this case further testing will be needed and at some point you may require the schematic.

Use of surge suppressors and line filters

Should you always use a surge suppressor outlet strip or line circuit? Sure, it shouldn't hurt. Just don't depend on these to provide protection under all circumstances. Some are better than others and the marketing blurb is at best of little help in making an informed selection. Product literature - unless it is backed up by testing from a reputable lab - is usually pretty useless and often confusing.

Line filters can also be useful if power in you area is noisy or prone to spikes or dips.

However, keep in mind that most well designed electronic equipment already includes both surge suppressors like MOVs as well as L-C line filters. More is not necessarily better but may move the point of failure to a readily accessible outlet strip rather than the innards of your equipment if damage occurs.

It is still best to unplug everything if the air raid sirens go off or you see an elephant wearing thick glasses running through the neighborhood (or an impending lightning storm). Generally, the backup battery or supercap will retain the clock and programming information long enough to ride out a typical storm.

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Miscellaneous Problems

VCR poops out after a couple of hours

What could be the cause of the video dying on a VCR after it is playing for a couple of hour? Here are some questions:

Do all modes 'go out' or just PLAY?

Does it happen suddenly or just gradually worsens until it is total snow? Or, do you get the 'blue screen' if it has this function rather than snow?

Does the tuner still work?

Conversely, does PLAY work but not the tuner?

Do other functions like FF and REW always work?

How is the time it sits turned off related to how much on time you get?

Have you verified that the TV is fine?

Is it possible that the VCR is covered up/closed in/installed with inadequate ventilation?

It could be a loose connection or bad component. The usual way to narrow down the possibilities is to use what is called 'cold spray' or 'circuit chiller' on the appropriate sections of the circuit board until you locate the component that is failing with when it gets hot. I once had a VCR that needed a little fan blowing on it to keep it happy - much easier solution than actually hunting down the fault.

If play or record just stopped and the tape unloaded, it could also be a mechanical problem like a marginal idler tire, idler clutch, or worn belt.

VCR blows fuse once in a blue moon

These are the kinds of problems that put gray hairs on parts of your body you didn't think could grow hair (hey, maybe that is good).

First confirm that the correct fuse type and value was used for this particular model and revision number.

Of course, measurements of the supply current on the bench show a wide safety margin (i.e., 2:1).

I don't suppose there was any mention of what was being done when it stopped working?

While monitoring the current, try really exercising the FF and REW, switching between editing/tape movement modes, performing FF and REW to the end of tape stops, etc. These are where I would expect to see current spikes. It may be some peculiar combination of actions that results in a momentary jam or conflict.

Unless of course it is just some cosmic connection that takes place every 3 months!

VCR was dropped

So your cat decided it was time to practice the long-jump and didn't quite pick a stable destination. Your VCR is on the floor, Tabby is in the basement, and what to do?

Overall, VCRs are quite tough. However, falling in just the wrong way can do substantial and possibly not immediately visible damage.

If you take it in for service, the estimate you get may make the national debt look like pocket change in comparison. Attempting to repair a VCR that has been dropped is a very uncertain challenge - and since time is money for a professional, spending an unknown amount of time on a single repair is very risky. There is no harm is getting an estimate (though many shops charge for just agreeing that what you are holding is a VCR!)

This doesn't mean you should not tackle it yourself. There may be nothing wrong or very minor problems that can easily be remedied.

First, unplug the VCR even if it looks fine. Until you do a thorough internal inspection, there is no telling what may have been knocked out of whack or broken. Electrical parts may be shorting due to a broken circuit board or one that has just popped free. Don't be tempted to power the VCR even if there are no obvious signs of damage - turning it on may blow something due to a shorting circuit board.

Then, inspect the exterior for cracking, chipping, or dents. In addition to identifying cosmetic problems, this will help to locate possible areas to check for internal damage once the covers are removed.

Next, remove the top and bottom covers and front panel. Check for mechanical problems like a bent or deformed cassette basket, broken or cracked plastic parts, and anything that may have shifted position or jumped from its mountings.

Carefully straighten any bent metal parts. Replace parts that were knocked loose, glue and possibly reinforce cracked or broken plastic. Plastics, in particular, are troublesome because most glues - even plastic cement - do not work very well. Using a splint (medical term) or sistering (construction term) to reinforce a broken plastic part is often a good idea. Use multiple layers of Duco Cement or clear windshield sealer and screws (sheetmetal or machine screws may be best depending on the thickness and type of plastic). Wood glue and Epoxy do not work well on plastic. Some brands of superglue, PVC pipe cement, or plastic hobby cement may work depending on the type of plastic.

Cycle the cassette loading and tape loading mechanism manually by turning the appropriate motor shaft, if possible. Check for free movement of the various parts of the tape transport.

Inspect for any broken electronic components - these will need to be replaced. If the fluorescent panel is broken, you can run the VCR without it but of course will not be able to see any front panel displays. Check for blown fuses - the initial impact may have shorted something which then blew a fuse.

There is always a slight risk that the initial impact has already fried electronic parts as a result of a momentary short or from broken circuit traces and there will still be problems even after repairing the visible damage and/or replacing the broken components.

Examine the circuit boards for any visible breaks or cracks. These will be especially likely at the corners where the stress may have been greatest. If you find **any** cracks, no matter how small in the circuit board, you will need to carefully inspect to determine if any circuit traces run across these cracks. If they do, then there are certainly breaks in the circuitry which will need to be repaired. Circuit boards in VCRs are never more than two layers so repair is possible but if any substantial number of traces are broken, it will take a great deal of painstaking work to jumper across these traces with fine wire - you cannot just run over them with solder as this will not last. Use a fine tipped low wattage soldering iron under a magnifying lens and run #28-30 gauge insulated wires between convenient endpoints - these don't need to be directly on either side of the break. Double check each connection after soldering for correct wiring and that there are no shorts before proceeding to the next.

If the circuit board is beyond hope or you do not feel you would be able to repair it in finite time, replacements may be available but their cost is likely to be more than the VCR is worth. Locating a junk VCR of the same model to cannibalize for parts may be a more realistic option.

Once all visible damage has been repaired and broken parts have been replaced, power the VCR up and see what happens. Be prepared to pull the plug if there are serious problems (billowing smoke would qualify). Determine if it appears to initialize correctly - without shutting down. Play a garbage tape to determine if there are any problems that might damage the tape. Watch and listen carefully for any evidence of poor tracking, video noise, tape speed instability, or weak or muddy audio that might indicate that tape path alignment requires further attention. Listen as well for any unexpected mechanical sounds that were not there before.

Very likely, the VCR will be fine, you can replace the covers, and now find a more secure spot for it to prevent this sort of event in the future. Use your own judgment with respect to the cat.

VCR or camcorder went to the beach (sand and/or surf)

Someone took your camcorder to the beach this summer and now it has sand or perhaps salt inside. Or, that cup of tea on top of the VCR wasn't as stable as you thought. Now, it behaves, well, strangely. Can this possibly be fixed? Will it be worth the effort or expense?

Unless this is a really sophisticated (i.e., costly) unit, I doubt whether it will pay you to take it anywhere for repair. Even if it is successfully repaired, its reliability may be questionable. Furthermore, as with equipment that has been dropped or physically abused, few repair shops will be inclined to touch the job. They really don't like challenges of this sort.

That leaves you!

If anything got wet with saltwater and it has been just sitting, you can probably forget it. Without immediate attention (and I mean immediate, not later, not tomorrow, NOW!), saltwater corrosion can set in very quickly and attacks electronic components, circuit board traces, cable wiring, and mechanical parts. The only thing worse might be a peanut-butter-and-jelly sandwich 'played' in your VCR. On second thought, that probably would not be all that bad.

Although it is probably too late, the first thing to do when electronic equipment gets wet is to remove the power source - pull the plug or remove the batteries. Don't be tempted to apply power until you have determined that everything is completely dried out inside and out.

DO NOT use strong solvents anywhere! These may attack various plastic parts or cause internal damage to electronic components.

The following was written assuming sand, salt, and liquid contamination everywhere! Modify based on your specific situation.

Mechanical intensive care:

1. Disassemble as much as possible - sand and surf (or other liquids) find their way into the tiniest nooks and crannies. You need to get it all.

2. Make a drawing of the belt routing, remove the belt(s), wash and dry them, label and set them aside.

3. Use a soft brush (like a paintbrush) to dust out as much sand as possible. Hopefully, you can get it all this way. A vacuum cleaner with a wand attachment may prove handy to suck out sand. Sand will tend to collect on lubrication, especially grease, which will need to be completely cleaned out and replaced. Don't use high pressure compressed air, you will just spread it around. Any grease or oil on which sand has collected will need to be totally removed and replace with fresh lubrication.

4. If there is evidence of salt (remember, I said forget it...but), you will need to wash it off. Yes, wash it. Keep water out of the motors. Use low pressure compressed air (a blow dryer on low heat should be fine) to dry so that it does not rust. Ditto if it is still wet with contaminated liquid (we won't say where this came from), wash with fresh water to remove all traces of it as quickly as possible. Then dry completely. Depending on the situation, a final rinse with 91% or pure isopropyl alcohol may be desirable to decrease drying time. This should be safe for most mechanical assemblies. Degreaser may be used if it is safe for plastic and rubber parts.

   Lubricate all bearing points with a drop of light machine oil - electric motor oil, sewing machine oil, etc. (Never never never WD40). Lubricate gears, cams, and sliding parts with a light plastic safe grease such as Molylube.

   Parts like the idler clutch may need to be disassembled to get at the friction felt. Other mechanical parts like cam gears may need to be removed to be properly cleaned. Don't mess up the timing relationships when you do this!

5. Reinstall the belts and reassemble in reverse order.

Electronic intensive care:

1. Remove the circuit boards and label the connectors if there is any possibility of getting them mixed up. If the circuit board(s) are soldered to the rest of the equipment, then you will have to improvise and work

in-place.

2. Wash with water and dry thoroughly. This does work. I use it routinely for degunking remote controls and rubber membrane keypads, for example. I have heard of people cleaning contaminated computer keyboards in their dishwasher! The important objective should be to get corrosive liquids off the components and circuit traces as quickly and completely as possible. A final rinse with 91% or pure isopropyl alcohol will decrease drying time. However, there is a slight risk of damage to sensitive electronic components should some be trapped inside. Pat dry, then use warm air from a hair dryer (or heat gun on low) to completely dry everything. Moisture will be trapped in controls, coils, selector switches, relays, transformer cores, connectors, and under large components like ICs. DO NOT operate until everything inside and out is thoroughly dry.

3. Use spray contact cleaner on the switches and control cleaner on the control and adjustment pots. DON'T turn the internal adjustments without precisely marking the original position - else realignment will then be needed. However, exercise the user controls to help the cleaning process.

Note: drying time may be quite long. For parts with inaccessible areas like membrane keypads, you may need to wait a week before normal operation is restored. Be patient!

Once everything is completely dry as a bone and reassembled, power it up but be prepared to pull the plug or pop the batteries if there are serious problems See if the display comes alive and the transport appears to initialize. Attempt to play a garbage tape to determine if there are any mechanical problems that might damage the tape. Look and listen for any abnormalities which may require additional attention. Then address specific problem areas. Also see the section: VCR was dropped for additional info.

Obviously, this description is very simplistic. The important thing is to get every last grain of sand, salt, and other contaminants off of the mechanisms and circuit boards quickly.

As noted above, moisture may collect inside certain electronic parts and it is essential that these be dried completely before attempting to apply power to the unit. If you do not, at best it will not work properly and you may do additional serious damage due to short circuits.

For the mechanics, the same applies though this is trickier since certain parts need to be lubricated and these may not be readily accessible or obvious. Don't be tempted to overdo the lubrication - too much is worse than too little.

For camcorders, some parts of the optics or enclosed DC-DC converters may be impossible to access and clean of scum.

Dead or missing remote controls or lost codes for universal remotes

See the document: Notes on the Troubleshooting and Repair of IR Remote Controls for extensive information as well as links to the web sites of manufacturers of universal remote controls - these include setup info.

Recovering damaged or broken tapes

So you just pulled your favorite tape from the VCR and there are two tape ends dangling from it. Or, perhaps, your VCR has just munched on that tape and a section is now seriously crinkled. Maybe you haven't been following the recommendations on preventive maintenance; maybe your VCR was just hungry. In any case, what to do? The recording is, of course, irreplaceable.

If it is only slightly crinkled, the tape may be salvageable (though it will never likely play without some dropouts). How serious is 'serious'? Hard to say but ironing may help. See the section: Uncrinkling a crinkled tape.

However, if it is broken - even partially, or stretched and scrunched, I recommend you throw it away (and make sure no one else can pull it out of the trash and ruin *their* VCR!).. An imperfect splice or seriously crinkled section of tape can shatter your video heads - the most expensive single part in a VCR. If it is something you really treasure, than what I would do is to follow the procedure below.

Note: If you have never seen the inside of a video cassette, try the following on a couple you really don't care about first so that if you screw up, there is no great loss. Too bad AOL doesn't send out Internet software on video cassettes, huh?

CAUTION: The video tape itself is really really thin and easily crinkled. Be very gentle when handling it and avoid touching the oxide (dull side) if at all possible.

1. Locate a garbage cassette and disassemble it. Throw away the tape but save everything else including the reels. See the section: Disassembling a VHS cassette.

2. Construct two cassettes from the combined collection of parts you now have. Cut out any sections of tape that got mangled.

   Cassette 1 has the first section of tape (before the break) and uses one empty reel from the garbage cassette for the supply reel. Rewind this to the beginning.

   Cassette 2 has the second section of tape (after the break) and uses the other empty reel from the garbage cassette for the takeup reel.

   Use the little plastic plugs that came from the garbage tape reels or some adhesive tape to connect the tape to the reels.

3. If the break is at one end, you can just reconnect the bulk of the tape to the reel and dispose of the original leader. Just don't rewind or fast forward all the way to the end as the automatic end sensor will not work (for the particular end that has been repaired). What will happen is that instead of the sensor stopping REW or FF (as appropriate), the tape will run to the end and the VCR will then shut down when it discovers that the tape isn't moving. This can put additional stress on mechanical parts and/or rip the tape from the reel. Serious damage to the VCR isn't really that likely.

4. Copy to a good cassette.

5. Dispose of the original(s) or clearly mark 'DO NOT USE' with a detailed explanation.'

   Filip (I'll buy a vowel) Gieszczykiewicz (filipg@repairfaq.org) is a little more definitive about this: "I find the destruction of it more fulfilling :-) ... put it in a paper bag and smash the life out of it with a big, heavy hammer - or a small ball hammer for an even higher satistfaction ratio :-) "

The idea is to never have a splice in a VHS cassette. (Even a seriously crinkled tape such as might result from a tape eating incident can damage the heads.) It is possible to splice safely but as noted, it can be quite costly if you don't get it quite right.

Uncrinkling a crinkled tape

WARNING: Discarding a seriously crinkled tape is really the safest option from the point of view of the health of your VCR. However, if you really must view it, there are some relatively low risk options. The following only applies if there is absolutely NO evidence of even partial breakage or puncture of the tape's backing (it's OK if some of the oxide has flaked off):

Just winding the damaged section back into the cassette and then FFing or REWing as appropriate to put several layers of tape on top of it may help. Leave it like that for a few days and then carefully return to the crinkled section to see how it is doing. WARNING: Do all this on a VCR that DOESN'T have an instant response transport so that there is no chance of the video heads contacting the damaged part of the tape. You may have to do this a few times.

Passing the damaged section (backing side) around a blunt edge (like a table top) back and forth a few times may help as well.

(From: Paul K. Sagi (paul_sagi@astro.com.my).)

I had a go at a seriously crinkled VHS tape that my mom was wanting to show her class at temple. I put the crinkled section between pieces of the kind of paper that is sold for some kind of cooking use, can't remember what it is called. I then ironed it (heat only, no steam) and it worked OK except a couple of seconds dropout."

(From: Steven Van Assche (steven.vanassche@yucom.be).)

CAUTION: Use with care!!

I use the following: Get your iron, the one used for T-shirts, not your soldering iron! ;-)

What I do:

1. Let the iron warm up.

2. Release the reel latch by pushing something in the hole on the bottom, disengage and lift the lid, and then pull the tape gently out of the cassette. Make sure the *backside of the tape is lying upwards*.

3. Now go in one pass from left to right over the crinkled part with the iron. You can repeat this, if needed. Due to the heat, most crinkles will go away.

Now, to play it safe, copy it to another tape. and mark the old one as damaged.

The most important factor here is heat: Too hot and you will burn the tape instantly while too cold and nothing will happen. It is best to start from cold to warm, and slowly increase the heat until you see an improvement...

Disassembling a VHS cassette

These instructions should enable you to get inside a cassette for the purpose of reattaching a leader that pulled off of one of the reels or to enable you to transfer its contents or a portion thereof to another shell or vice-versa.

1. Peel off the label on the side or carefully slice down its center line with a knife or razor blade. This is necessary to allow the cassette halves to be separated.
2. Place the cassette upside-down and remove the five (5) phillips head screws and set aside.
3. While holding the cassette together, place it label side up on a clean surface.
4. Gently remove the top (along with the hinged door) to reveal the interior.

At this point, you should see something that looks like VHS Cassette - Inside Top View.

When you reassemble the cassette, take care to avoid crunching the tape under the hinged door - depress the unlock button on the side and lift it clear if needed.

Cassette rewinder problems

Cassette rewinders typically consist of a low voltage motor powered from a built in transformer or wall adapter, a belt, a couple of reels, and some means of stopping the motor and popping the lid when the tape is fully rewound.

Note that some designs are very hard on cassettes - yanking at the tape since only increased tension is used to detect when the tape is at the end. These may eventually stretch the tape or rip it from the reel. As noted, I don't really care much for the use of tape rewinders as normal use of rewind and fast forward is not a major cause of VCR problems. Sluggish or aborted REW and FF may simply indicate an impending failure of the idler tire or idler clutch which should be addressed before the VCR gets really hungry and eats your most valuable and irreplaceable tape.

Problems with tape rewinders are usually related to a broken or stretched belt or other broken parts. These units are built about as cheaply as possible so failures should not be at all surprising. The drive motor can suffer from any of the afflictions of similar inexpensive permanent magnet motors found in consumer electronic equipment. See the section: Types of Motors in VCRs. A broken belt is very common since increased belt (and tape) tension is used to switch the unit off (hopefully). Parts can pop offof their mountings. Flimsy plastic parts can break.

Opening the case is usually the biggest challenge - screws or snaps may be used. Test the motor and its power supply, inspect for broken or dislocated parts, test the power switch, check and replace the belt if needed. That is about it.

Why VCRs will not copy (Macrovision) copy protected tapes

> "I've got one of the Damark ones and it does work for Macrovision protection, depending on the input deck. My 10 year old Panasonic VHS Hi-Fi (No MTS tuner, Dolby(tm) B linear stereo non-Hi-Fi audio too) works fine as an input deck, while my new JVC Hi-Fi doesn't. Why some input decks work and others don't is my question. Anyone know? Is there added circuitry that the newer decks have to defeat the stabilizer boxes?"

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

JVC owns the patent for VHS. JVC has made a deal with Macrovision that from a certain date in the past *no* VHS recorder licensed by JVC shall be able to record any video signal that contains Macrovision's copy protection pulses. Any video recorder from before that date (VHS or other) might well work OK on the altered video signal! The copy protection pulses upset the video AGC and H-sync. TV's usually don't have a video-AGC.

Thus the whole idea of the Macrovision method is to disturb the video AGC that is inside every VCR - the manufacturers even *must* make the video AGC sensitive to those pulses!

In the TV, the horizontal sync processing may be disturbed by the Macrovision pulses. Indirectly that also disturbs the DC clamping circuit. So you may see horizontal phase as well as brightness disturbances at the top of the picture.

The stabilizer box removes the extra pulses and makes it into a normal video signal again. No VCR should ever know the difference, so they should all record properly again.

At the same time, all TV's are required to ignore the copy protection pulses. As a TV-designer I can tell you that this is sometimes far from trivial. Not in the least because in the beginning we were not included in "the deal". There may be TV's around whose brightness and/or sync will be disturbed by the Macrovision pulses. Officially, this is the reason for existence of the stabilizer boxes: to view better, not to copy better. Unofficially, they are sold for copying, of course.

Keep in mind that the Macrovision 'standard' (pardon me) has been improved several times. Old decoders may not be able to cope with newer tapes. In order for the decoder to key out the pulses in the vertical blanking interval, it must first synchronize properly itself. That process too may be disturbed (by extra pulses on newer tapes to older decoders).

Those Macrovision a**holes are smarter than you think. Unfortunately, their signal may also disturb some TVs which are used legitimately. And then it becomes *our* problem too.

The next step will be that digital-TV decoders will output an analog TV signal with Macrovision copy-protection pulses so that you may watch but not record your pay-per-view program. Same problem, same solution ...

And I thought that PAL/SECAM/NTSC were *standards*, sigh ...

VCR AGC and Macrovision copy protection

(From: Mark T. O'Bryan (obryan@gumby.cc.wmich.edu).)

Look at it this way. The reason that you see changes in brightness is that the "protection" signal that is added makes the unit's AGC (auto- matic gain control) think that the level has shifted, when it hasn't. So it adjusts to compensate.

So if you have an older VCR without AGC (or a mild application), it may not be affected as much (or at all, after passing through a "stabilizer" box). If the sensitivity of the AGC is high (like it is on most JVC's) and the response-time is short, any small amount that leaks through will still cause problems.

For those familiar with the electronic circuitry in VCRs, both the time constant in the RC circuit for response-speed, as well as the AGC sensitivity can be adjusted by manipulating simple resistor values. I don't have any specifics on this (and it varies on different machines), so don't bother asking for it :-).

But at least you now know why some decks react differently.

Problems with closed caption decoding

> "I've just started to use the closed caption feature of my TV and have a problem with pre-recorded video tapes, and am wondering if it could be the VCR. The problem is simple: about half the tapes I've watched displays the CC information incorrectly (many missing characters and/or lines), or will not display it at all. Sometimes I can improve the CC display by adjusting the VCR tracking to the point where the picture starts to become fuzzy, but for the most part it remains garbled and uncorrectable."

Of course, as with so many other problems, poor quality or well worn tapes can result in erratic closed caption decoding. Therefore, I would not recommend diving into the bowels of your VCR before trying out some other tapes.

(From: Thomas D. Kite (tom@olive.ece.utexas.edu).)

Sounds to me like the head switching point is too far down the screen, i.e. the point at which the VCR switches between the video signals from the two heads is too late. You can check this if you have a TV with vertical hold.

Set the hold to give a stationary or slowly rolling picture so that you can see the head switch, which will appear as a tearing of the picture. This should occur during the blanking period, but I suspect that your VCR is switching sometime later. If so, open it up and look for a preset on the main board labeled 'Head SW PT' or something like that. Twiddle it so that the tearing backs up the screen into the blanking part (again, do this while the picture is rolling slowly). Hopefully, this will mean your VCR has done its switching by the time it gets to Line 21, and the CC information will be intact.

(From: Richard Beeler (vcrmonthly@earthlink.net).)

This could be Copy Guard on tapes interfering with the closed caption decoding. We had one that was doing the same thing on some pre-recorded tapes and not others. We finally had to add a 'video stabilizer' between VCR and TV - that corrected the problem.

F-connector broken off rear of TV or VCR

Sometimes this just happens due to poor manufacturing and a slight tug. However, usually, there has been some severe trauma - like the TV or VCR falling off a shelf while still attached. When else would it fall off a shelf? :-)

I recently repaired a Panasonic VCR with a dangling F-connector. It required removing the cover, main board, unsoldering the A/V block and part of the power supply, just to get at the RF modulator. Then it was a simple matter of resoldering the center conductor to the printed circuit board (fortunately, nothing else was damaged) and the shell of the F-connector to the metal box.

From: Glenn Watkins

We get a lot of sets with broken "F" connectors broken off - both VCR's and TV's. The job can be quite involved depending on the exact set. It may take an hour just to open it, remove the tuner or RF modulator and open the case. Then if you're lucky, there is no additional damage inside the unit due to people probing with pencils, screwdrivers, etc.

On some TV's including Sharp, there is a antenna(cable) isolation device that connects between the tuner and antenna. This device comes in a few flavors and is very easy to install if broken. I've seen them as cheap as $4.95 each mail order.

Whirring sounds from VCR when tape inserted

The most likely cause is that your VCR uses an "instant start" transport and the sound is from the video head drum spinning. The drum starts spinning as soon as a tape is inserted and until several minutes after the last tape motion ceases (PLAY, REW, CUE, REV). It's possible that due to wear, this sound may become louder over time but should never get to the point of being annoying. If there's a high pitched whine, the problem could be the "static brush" associated with the head drum. See the section: High pitched whine from inside VCR. Control/power supply faults can result in the head drum spinning when it's not supposed to on non-instant start VCRs but there would almost certainly be other more serious problems.

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A Few Model Specific Problems

Dead clock in Hitachi manufactured VCR

The clock display is dark but other functions are normal.

Your VCR probably was made by Hitachi (Sears is one of several brands that may be manufactured by Hitachi). If so, probably your DC to DC converter went bad.

Please note that the the converter is close to the front of the VCR and not on or near the main power supply board.

Also check the IC protector (possibly ICPN5) as it may have blown. You should also replace the two 47 uF 50 V and the 100 uF 35 V capacitors near the DC to DC converter. These are known to go bad resulting in failure of the DC to DC converter.

Complete repair kits are available from suppliers like MCM Electronics. These will include all components likely to have gone bad.

For some models:

(From: Sire Johnathan (sirejohn@bbs-la.com).)

Behind the Channel selector is an upright PCB. on the upper inside corner find a 1/2" sq. transformer can with top hole and slotted core adjust.

The schematic nomenclature is T101 or T102. Next to it, find a TO-220 power transistor. Replace the Pwr Xstr, filter caps in secondary side rectifier with DOUBLE the voltage ratings, and a small choke (L1?) that feeds primary power to the power transistor (fuses open). When working properly, current draw through primary circuit should be less than 200 mA.

JVC tracking problems and dropped parts

You have a JVC VCR, 1990 or so vintage and it upped and died on you.

JVC, huh? How did it die? What are the symptoms? Major tracking problems? Eats tapes? JVC VCRs of that era tend to shed parts in the tape loading mechanism - easily fixed. Unless it is a serious electronic problem (there is a minor one which results in similar symptoms - see below), a service manual may not help. And even then, it may not have the information you need.

Check the roller guide assemblies (see the sections: "Parts of the tape transport in a VCR" and "General tape path alignment problems").

There are two types of failures that occur frequently on various JVC models:

1. If one of them flops around (they normally will be loose except in the fully loaded position but should not come off the track), then it has lost the brass guidepost underneath. Remove the bottom cover and you should see it drop out. Without the guidepost, the roller guide will not seat properly and tracking will be way off. Use a dab of Epoxy or superglue to replace the brass post fully against the shoulder in the cast roller guide base. Just popping it back in, even if the post appears snug, will result in a callback. If this is done carefully, tape path realignment should not be needed.

   Alternatively, replacement roller guide assemblies are available.

   WARNING: do not attempt to load a tape if a roller guide assembly can be lifted off of the track - it may smash the rotating video heads - very expensive lesson. Of course, it may already be too late :-(.

2. If a roller guide does not seat fully against the V-Stopper (the end piece) but the brass pin has not fallen off or loosened, then a linkage pin may have loosened. This is plastic pin which is the hinge for the linkage which moves the roller guide assembly. I have used a tiny screw from the top to firmly reattach this pin. Clearances are really tight so if the screw head sticks up more than a mm or so, it will restrict movement of the roller guide assembly resulting in loading and/or unloading problems. Alternatively, a dab of plastic cement may work. In either case, tape path realignment should not be needed.

To get at the bottom of the roller guides or hinges, you will probably have to convince the VCR to start loading a tape and then pull the plug just as the mechanism is in a position where you can get to it.

- Another common cause for a band of video noise at the top or bottom of screen on some JVC models: Defective capacitor (may be C6, 3.3 uF, 50 V) on drum motor resulting in bad PG pulse. It looks like a tantalum cap but a regular electrolytic should be satisfactory. Even Radio Shack will likely have a replacement.

  In some severe (or shall we say, strange) cases, good and bad/no video may occur randomly each time the VCR enters PLAY mode but will remain that way until the tape is unloaded.

(From: Mark Shoberg (mewzaq@webtv.net).)

When replacing the 3.3uf cap on the motor board (this is for the older bottom mounted types) just cut away the plastic piece covering it a little bit. This way you don't risk damaging the video heads and it is easier as well.

(From: John Poulton (John@TellyCare.freeserve.co.uk).)

This is a very common problem on these machines. To check it out carry out the following check:- Set the machine to play a pre-recorded tape. While observing the picture on screen, stop the head drum rotation by pressing your fingers on the top surface of the drum for a fraction of a second. The instant the drum stops, release it and let it start up again.

This must be done very quickly, otherwise the machine will shut off. If you find that each time this is done the picture re-appears in a different state, it means that the 3.3uF capacitor on the board of the head motor is faulty. It can be replaced without removing the deck from the cabinet if a small section of the plastic base is cut out.

Magnovox tracking problems and dropped parts

(From: Frank Fendley (frank.fendley@datacom.iglou.com).)

There were more Magnavox models made by JVC in the early 90's than many people realize. The following models were all made by JVC:

VR1835, VR3440, VR9020, VR9040, VR9140, VR9142, VR9160, VR9162, VR9240, VR9241, VR9260, and VR9362.

All used the same chassis which JVC used in their HR-Dxxx series of VCRs.

See the section: JVC tracking problems and dropped parts.

Panasonic error codes

I'm not sure for which models these are valid.

(From: John (johnbrewer@webtribe.net).)

01 - Drum motor stopped
02 - Tape reel stopped
03 - Mech stopped during loading to drum
04 - Mech stopped during unloading from drum
05 - Capstan rotation fault
06 - Mech stopped during tape-in/eject

Most of these faults are caused by either the mode switch or that horrible plastic thing on the end of the loading motor shaft.

A number of Panasonic and other Matsushita brand clones use a switching power supply which has a couple of common failure modes.

- Blown fuse and shorted switchmode transistor and possible other failed parts. Replacement of the obvious shorted or open parts usually cures these. Test all semiconductors and fusable resistors - do not assume that a single part is bad. If you just replace the first bad part you find, it may just be blown again by other bad parts.

- Low output voltages. If the 5 V (approximately) outputs measure low, 3.5 V, for example, then there is a leaky capacitor in the power supply startup limiter. A common part number is C14 or C21 (depending on model) which is 1 uF, 50 V. Almost any reduction below 5 V will cause problems.

- The primary and secondary side filter and other electrolytics may lose capacity resulting in hum or ripple and regulation problems. Replacing all electrolytic capacitors in the power supply is probably the best solution.

The same power supply is used with minor variations in a wide variety of Panasonic (and clone) VCRs from the 1980s and 1990s (and may continue to this day). Depending on the specific model, there may slightly different output voltages and number of outputs but the general organization is identical. These use discrete components throughout with feedback from the primary output (5 to 5.2 V depending on model) using an optoisolator to essentially short out the drive to the main chopper transistor (Q1) when the output equals the desired voltage. The most common problems found with any of these supplies is dried up electrolytic capacitors. Generally, the first to go will be C16 and C17 on the +5.1 VDC line and/or C21 in the feedback path (actual part type and number may vary slightly with model). Symptoms will be either that the primary output is somewhat low (4 to 4.5 VDC) or that the supply has gone overvoltage and blown the protection zener (D15) resulting in a high pitched whine as the chopper struggles to drive current into a short circuit (this usually doesn't damage any other parts if caught in a reasonably timely manner). If any capacitor related problems are found, it is a good idea to replace all the electrolytics in the supply. Model specific capacitor kits as well as total rebuild kits are available from places like Studio Sound Service and MCM Electronics.

- Get the schematic for the typical Panasonic VCR switchmode power supply in PDF format: VCRPS-SCH.

Some of the sources listed in the section: Suggested Parts Suppliers sell power supply rebuild and capacitor kits. Unless your power supply is missing, one of these kits will probably fix it - and all you need to know is how to solder!

Also see the section: Quick tips for troubleshooting Matsushita/Panasonic SMPSs.

Quick tips for troubleshooting Matsushita/Panasonic SMPSs

This general approach applies to most switchmode power supplies found in Matsushita manufactured VCRs (includes Panasonic, some Quasar, RCA). Symptoms may be a totally dead VCR, unresponsive front panel/remote but working display, poor or erratic play/record, and/or random shutdowns.

1. Measure all the output voltages. You should see a bunch of high ones (e.g., +15, +45, +31, etc.) and 2 or 3 that are in the range: +5 to 5.2 V.

2. If there are no +5 to 5.2 V outputs but some in the +2 to 4.4 V range, you most likely have bad electrolytic capacitors - usually either the 1 uF, 50 V (excess electrical leakage) in the feedback and/or the 330 or 1000 uF, 6.3 V filter capacitors on the +5 to 5.2 V line (greatly decreased uF value).) A capacitor replacement kit (about $7, see the sections starting with: "Suggested Parts Suppliers") is the easiest solution since other electrolytic capacitors are likely on their way out as well. If you opt to order the capacitors from a general electronics distributor, make sure to obtain 105 DegreeC rated parts.

3. If supply is whining, you have a blown 18 V zener (the original is a fat glass diode coded with brown and gray bands) probably in addition to bad capacitors. This zener protects the VCR from overvoltage due to regulation failure (also caused by bad capacitors).

4. If it is totally dead with a blown fuse, then a complete rebuild kit (not just the caps, about $14) will probably fix it and/or see the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies - check all semiconductors for shorts, resistors for opens, etc. Q1, the main switchmode transistor on the heatsink, will be shorted, its emitter resistor may be open, and other parts may have failed as well.

5. To test the power supply outside of the VCR (recommended but not essential since the 18 V zener does a pretty good job of catching overvoltage!), you need a load on the +5 line such as a 20 ohm 2 W resistor. I use a Variac and series 40 W light bulb just to be doubly safe.

Multiple system problems with various RCA, GE, and Samsung VCRs

Symptoms include anything from erratic behavior to acting totally dead. There are many models for which the info below applies.

(From: Ken Koskie (aw345@lafn.org).)

This may be one of the RCA VCRs plagued with intermittent diodes. RCA recommends replacing the following diodes; D108, D109, D110, D112, D114, D1103 and D1104. Their part number for the diode kit is 201066.

> "I am currently working on a GE VCR Model VG-4016 with the following problem. When the tape is inserted it loads fine the head starts spinning but it doesn't play because the capstan is not turning. If you push play a second time it start to play but is in the X2 mode so its going to fast."

(From: Frank Fendley (frank.fendley@datacom.iglou.com).)

Common solution for this - replace D108, D109, and D110 - even if they test good with a meter. ECG125 works well for this (2.5A/1000PIV). While you are at it, also replace D105, D106, D111, D112, D113, D114, using the same replacement. Samsung must have purchased 40 billion bad diodes when they built these units. Funny thing is, they almost always test OK with a meter but replacing them fixes the problem. Apparently they go open under operating voltage, but not under the lower voltage provided by a meter.

Alternate solution (fairly uncommon) - replace IC201.

(From: Mark Z. (zmachar780@aol.com).)

If this model is the type I think it is, there is an open diode along the inside edge (toward the mechanism rear) of the top circuit board. There is actually about 7 diodes which tend to go bad in these due to underrating. Five are in the area I mentioned, that is two along the edge at the middle of the board, and three further back, and two are located under the power transformer. Other problems, such as no display or no power, will occur if any of the others go bad. Suggest you replace them all; Any decent 1N4007 or such will do fine. Radio Shack has "2.5A 1kV" diodes which would be fine.

For some RCA VCRs with somewhat similar symptoms:

(From: TVman (tvman@newwave.net).)

For the RCA VR321 which appears dead, clock display may come on after a few minutes, Q1 runs hot: Replace: C09 (22 uF, 16 V) non polarized capacitor in power supply.

(From: Chuck Yung (cbelect@pce.net).)

For the Samsung VR3711, there are a total of seven diodes that should be changed, they are: On the main board: D108, D109, D110, D112, D114; In the power supply: D1103, D1104.

Samsung (and clone) power supply problems

(From: Gilbert (osmyn@together.net).)

Many Samsung VCRs, (and possibly other makes) use a DC to DC switching power supply built onto it's own separate, shielded PCB which plugs into the main circuit panel, and is secured in place by two or three screws. On this power supply, located right next to the switching regulator transistor (Q1) there is a 16 V, 22 uF, non-polarized electrolitic capacitor which frequently fails, probably due to constant exposure to the heat generated by Q1. (Refer to Sansung VCR Power Supply Parts Location.) When this capacitor is faulty, the VCR's flourescent display will usually flash about once per second when the set is first plugged in, and possibly after some time, the display will become steady and the unit will function normally. In extreme cases where the capacitor is completely open the display may never light up at all. If the power supply is removed from the VCR, and tested under a no-load condition, all voltages will likely appear normal, giving the false impression that the VCR is overloading it. When working on this panel, please bear in mind that it is directly connected to the 120 VAC power line, and therefore presents a significent danger of electrical shock - BE CAREFUL.

Erratic behavior of Sharp VCRs

Two words: Mode Switch (at least with older models, see below). Whenever you have problems that seem to come and go or go away temporarily with repeated attempts to play or enter some other mode, the problem is very likely a dirty (or worn) mode switch (may be called the 'mechanical state switch' by some.

The chassis of Sharp VCRs come in several flavors. Here is a description of two of them with respect to getting at the mode switch:

- Newer models (e.g., VC-A607) have the mode switch as part of a modular loading motor assembly. This is found on the top in the far right corner of the transport. It is mounted by 3 screws, easily removed. There are no timing relationships to get messed up as long as you don't try to cycle the mechanism while disassembled. Therefore, it can be removed and replaced without concern for gear timing. The link between the mode switch and drive gear is keyed so it will go back together properly.

  To access the mode switch, unplug the connectors, remove the single belt that drives the eject mechanism, and remove the 3 screws. It should now be possible to detach the entire assembly. Underneath, you will see a disk with a keyed center hole - this is what must be replaced with the same orientation as it was before removal. The disk snaps off easily revealing the tracks and contacts of the mode switch. Thoroughly clean and slightly increase the spring pressure of the contacts. Replace in reverse order. Make sure the post slips into the keyed hole as you replace the assembly and double check that it is seated before tightening the screws.

- Older models (e.g., VC7864U) are a bit trickier. The mode switch on these models is sandwiched between the loading gears and a mounting plate - all parts of what I will call the 'loading gear assembly' underneath the tape transport. To access the mode switch, this entire unit needs to be removed and partially disassembled. The gears operate the roller guide loading mechanism, and a couple of cam operated levers which are conveniently hidden when it is removed or reinstalled. It is driven by the loading motor via a couple of idler gears.

Timing marks: There is at least one critical timing relationship that needs to be preserved when the loading gear assembly is removed. I recommend that you put your own timing marks on all gears before loosening the 3 screws that anchor this unit. You will need to unsolder 4 connections as well before it will come free. Once the bottom of this unit is accessible, the mode switch can be snapped apart and cleaned.

I believe this is best done with the VCR in the unloaded and ejected state. However, there are still a couple of levers that will need to engage properly when the loading gear assembly is replaced. These press on internal cams that are hidden when everything is together. Much fun.

(From: Lill Tommy (tommy@caves.net).)

For newer models like the Sharp VC-H956, it may act like a mode switch problem but it isn't and you need to change the takeup and supply reel LEDs and cam switches and D706 to D709. (Sharp part # for D706 and 707 - RH-PX0252GEZZ; for D708 and D709 - RH-PX0253GEZZ).

Late model Sony VCR munches tape on eject

Symptoms are that upon eject, a loop of tape may be hanging out and possibly held by an arm inside the deck. The cause is gummed up lubrication on the pivot of that 'half loading arm' on the right side of the transport. It is supposed to help pull the tape out of the cassette during loading and then spring back when unloading. If the lubrication gets sticky, it does not spring back and grabs onto the tape during eject. Remove the half loading arm by unscrewing the locking nut. Count the revolutions of the nut as you do this since it sets the height which is somewhat critical. Clean the bearing and shaft and then lubricate it with a drop of light oil or a dab of light grease.

If you forgot to count the turns or the nut had originally loosened up, just center its height within the range over which the tape moved stably past the first fixed guidepost and/or A/C head. Then confirm reliable loading and unloading with several different tapes. Try using forward and reverse search to assure that the tape isn't moving up or down on the guides. Make sure there is absolutely NO tape edge damage.

Someone gave me a fancy Sony HiFi VCR with the request "I will pay up to $150 to fix it. Circuit City said that it could not be repaired for less than $250 because my kids had gotten into it and recommended replacement" (I wonder why). It was the stupid loading arm. Obviously, the grade-A techs at Circuit City were either under orders not to suggest repairs if they could get away with it and/or had never even taken the top off of the thing because the owner had mumbled something about his kids.

I could have made a bundle off of that. I could have had a nice VCR for nothing. I just gave it back and told him about the bit of cleaning and drop of oil.

(From: Sire Johnathan (sirejohn@bbs-la.com).)

I recall well from counting turns until that elastic nut lifts off the stud is very repeatably 6.5 - 6.75 turns. Checking it with the Sony height specs is always within limits. Don't forget to check the smooth running of tape over this 1/2 load pre-threading guide pin in the reverse scan direction. The tape should maintain same height when changing rapidly between FWD SCAN and REV SCAN. A worn conical pinch roller can cause tape height shifting and tape edge-rippling or top-slacking because the pinch roller becomes the primary tape guide in REV SCAN. Changing quickly between REV SCAN & PLAY modes while monitoring normal linear audio treble and tracking can reveal any mis-skewing of the tape path as it 'returns into the groove' in PLAY mode. Sony pinch rollers are notoriously short-lived causing most tape edge-rippling and mistracking. BEWARE of 3rd party substitute parts as they are frequently out of tolerance and poor bearings necessary for Sony mechanisms.

Sony VCR error codes

(From: VCRMonthly (vcrmonthly@aol.com).)

Later Sony VCR's have "emergency" codes that show up in the Fluorescent Display on certain failures. The code shows up in the "seconds" position and they are as follows:

```
 Code              Problem
-----------------------------------------------
  00         Normal.
  01         Abnormal Take-up reel rotation.
  02         Abnormal Supply reel rotation.
  03         Abnormal drum (head) rotation.
  04         Abnormal forward cam motor rotation.
  05         Abnormal reverse cam motor rotation.
  06         Abnormal cassette loading.
  07         Abnormal cassette unloading.
```

Play a tape until the VCR shuts off and then check the failure code to help diagnose the problem. These codes are cleared when AC is removed or when another function button is pushed.

Some Sony VCRs may use the error coding summarized below:

```
  Error Code       Block              Problem
--------------------------------------------------------------
   00                           No error
   01 - 09        Control motor
                  (encoder)       Unable to detect the position

   10             Mechanism       Loading not completed
   11              (deck)         Unloading not completed
   12                "            No eject
   13                "            End sensor fault (take-up side)
   14                "            End sensor fault (source side)
   15                "            Dew detected

   20              Drum           Drum motor won't rotate
   21                "            Drum servo not locked

   30             Capstan         Capstan motor won't rotate
   31                "            Speed not locked

   40              Reel           Take-up reel FG not locked
   41                "            Source reel FG not locked
   42                "            Measure abnormally ended (whatever this means)
```

Others may use an "hours-minutes" format:

(From: John Poulton (John@TellyCare.freeserve.co.uk).)

The centre part tells which mode the machine was in when the fault occured (the "minutes" part). It is the last part of the code that is important (the "seconds" part).

The code is as follows

Code	Problem
00	No fault
01	Take up reel not rotating
02	Supply reel not rotating
03	No drum rotation
04	Clockwise rotation of capstan motor incorrect
05	Anticlockwise rotation of capstan motor incorrect
06	Cassette loading incorrect
07	Cassette loading incorrect

Sony capstan motor (bearing) problems

A typical set of symptoms and questions:

> "The capstan motor on my Sony VCR has lost the war and is in need of replacement. Based on my Dejanews search on this topic, this is evidently not an uncommon occurrence :(.
>
> My local repair shop diagnosed the problem for $30 and gave me a $200 estimate to fix it. 3 questions:
>
> 1. Is this reasonable?
>
> 2. Does a capstan motor for this VCR really cost $95?
>
> 3. Given that I'm fairly handy with electronic repair, but inexperienced with VCR repair, is this something that I should attempt without a service manual? In other words, is this a particularly difficult or tricky repair?
>
> To satisfy the curious: the symptoms were a jittery picture on playback of tapes. The problem began with playback in EP mode only (the picture would freeze and hi-fi audio would "ratchet" as though the tape had come to a halt). It progressed until this started happening in SP mode as well. The problem got much worse the longer the unit was running (or the farther into a given tape I watched...)."

(From: Bob Groger (BobG1@msn.com).)

This is a common problem, but you don't need to replace the motor! Sony sell a new bearing assembly for about $25. There is a service bulletin out on this. The bearing housing bends after a period of time from pinch roller pressure. The new one is much stronger. Quick but temporary cure is to grasp the top of the bearing housing with big pliers and bend slightly towards pinch roller. This is NOT a guarantee!

(From: ZMachar780 (zmachar780@aol.com).)

They have a lot of bad capstan motors on these. The bearing collapses a little, then the flywheel scrapes on the drive coil. Sony sells a replacement bearing assembly which would save a few bucks over a cap motor, but frequently the capstan shaft is worn anyway and should be replaced. Sony will ID the part number(s) and sell you the part directly (on a credit card). Call them at 800-282-2848.

(From: Willis Chung (nikonkidf3@aol.com).)

This is the classic Sony capstan motor bearing problem. The capstan motor is a direct drive unit with a large flywheel/magnet assembly mounted just below a set of flat coils. The bearing that the capstan turns through is also part of the bracket that supports the motor. With time, the bearing wears out, allowing the capstan to tilt ever so slightly. This tilt causes the capstan flywheel to come into contact with the coils, causing a scraping sound, intermittent pauses, and eventually causing the motor electronics to die.

Stop using the VCR now to prevent damage to the motor's electronics. The capstan motor bearing can be replaced without having to replace the entire motor. The bearing is available direct from Sony for about $12, but the entire motor costs about $45 to $55.

For the SLV-575, the part number for the bearing assembly is X-2625-269-1. However, replacements for other VCRs have different part numbers - best to check before ordering.

Replacing the bearing is straightforward, and anyone can do it (well just about anyone!).

1. Remove top and bottom covers with machine unplugged

2. Unplug connector cable to capstan motor circuit board

3. Unscrew motor from chassis (3 screws accessed from top of chassis.

4. Remove capstan flywheel and shaft from motor (just pull to separate it from the rest of the motor)

5. Unscrew capstan bearing from motor assembly (3 screws)

6. Assembly is reverse of disassembly.

7. Play junk tape to see if there is any folding of the upper or lower edges of the tape, especially just past the capstan. You may need to make some adjustments to the metal guides to the right of the capstan.

8. Make comments to people around about cheap motors, using harsh language.

The repair is easier to do than to explain!

(From: David A. Sanders, II (capeone@aol.com).)

The bearing part number for the Sony SLV-R5UC VCR is X-2625-356-2. The motor part number is 8-835-350--02. Check the winding on your motor. Many times when the bearing fails, it allows the magnet assembly to rise, which in turns starts to cut into the windings.

Symphonic/Funai brand vcr won't rewind or fast forward

(Portions of the following from: blatter@amiga.icu.net.ch ((Martin A. Blatter))

Belts and idler tires are always the first thing to check for this sort of problem but older Symphonic/Funai VCRs (Those without the 'quickstart' type mechanism) also have a small rubber bumper/stop for the brake levers, etc. on top of the deck by the tape reels. It wears out and then the lever catches don't engage properly. The old mechanism was replaced by a compact direct drive type which is mounted directly on the PCB in 1993 (at least on the European PAL models).

Part #8059-02-23 is available at electronics distributors such as Fox International in Ohio or MAT Electronics in PA. Symphonic/Funai Corp, 100 North St, Teterboro, NJ 07608 phone 201 288-2606. Alternatively, just wedge a bit of plastic inside the rubber bumper to fatten it a bit or just turn it around to expose the unworn side. This works just as well as a replacement part.

Additional Symphonic/Funai comments

(From: Tony Buffone (uproc@Aol.com).)

On the subject of the funai type rubber bumper problem I would like to give an additional symptom of that problem. After repairing hundreds of these units one goofy symptom I've found is the fact that customers may complain that the machine will eject a tape that is fully rewound and will play a tape if it is anywhere else on the tape. The FF/REW problem may or may not show up at this time. Also note that the best cure is the original part from symphonic. I have found that generic bumpers from MAT or MCM for example have cost me callbacks because there just not cut perfectly.

(From: Matthew L. Kruckeberg (MKRUCKEBERG@pol.org).)

I have run into a few of these Funai mechanisms where the replacement rubber bumper is too thick causing the mechanism to lock up in various positions. If you still have the original one try reinstalling it backward and see if your problem goes away. I would not recommend turning the bumper around permanently since the repair is short lived due to deterioration of the rubber but it will generally work at least for test purposes.

Zenith model VCRs with erratic tracking of rental tapes

> "Has anybody had any experiences with a Zenith VR2422HF VCR having auto-track problems with certain rental tapes? This is the second one I've had in the shop where it will switch back and forth between sp and SLP speeds. has anybody seen any mods or heard anything?"

This is a common problem with certain Zenith VCRs. It is caused by the copy guard present on certain rental tapes. Zenith will modify these VCRs at no cost. The modification inverts the sync pulse by adding a transistor, a resistor and modifying the circuit board. If the model number starts with VRJ or VRL (possibly others as well), this is likely to apply.

If you don't want to do the modification yourself but really want to sound like you know something, suggest that the problem is covered by Zenith Field Service Bulletin #94-16 :-).

Two very similar modifications follow:

(From: Guitarzan (guitarzan@aol.com).)

Locate IC201 on left of top circuit board and IC 202 on right. Cut the trace between IC201 pin 56 and IC202 pin 17. I've found it easier to remove the wire jumper directly beside pin 56 as this leaves a place to mount the transistor.

Install a general purpose NPN transistor (ECG123A, Zenith 921-2161 or 921-2134, or 2N2222) with base to IC201 pin 56, emitter to ground, collector to 10K 1/4 W resistor, other end of resistor to W2H5, or another +5 V source. The current drain is very minimal so pick the most convenient source of +5 V.

All this does is invert the servo pulse and keeps the circuit from becoming 'confused'. If only it would do the same for me.

Fire it up and all should be well. Try an EP tape, if its installed incorrectly, EP won't track at all.

(From: Brian Hughes (bkhughes@usa.net).)

Required parts: Small signal NPN transistor (ECG85, ECG2357, KRC103M), 10K 1/4 W resistor.

Locate IC 201 on the main circuit board, cut the trace between W2C4 and IC201 Pin 56. Solder resistor between W2C4 and W2H5. Solder transistor as follows: Base - IC201 Pin 56, Collector - W2C4, Emitter - IC201 Pin 5.

Insulate all exposed leads (I like hot-melt glue, it secures things in place as well.) Finis.

Why it works: Many pre-recorded tapes have timing marks inserted in the control-track signal. These extra pulses confuse the servo circuit in these machines. This modification inverts the signal before it reaches the servo so that it is not detected.

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Video Heads and Upper Cylinders

What is a Video head?

The flying video heads in a VCR or camcorder are the actual transducers which scan the tape during REC and PLAY. The head drum or upper cylinder, as it is often called, spins at 1800 RPM (for NTSC, actually 29.97 Hz) with one complete rotation representing a video frame (525 lines in the US consisting of 2 fields which are interlaced). The result of the spinning head is to provide an effective head-tape speed of over 24 feet/second needed to achieve the required video bandwidth.

The actual video heads are the nearly microscopic transducers that contact the tape and magnetically record or playback the video information. The upper cylinder is the entire rotating assembly including the video heads. The heads are aligned and locked in place on the upper cylinder at the time of manufacture and this alignment should never be touched.

(Note that the terms 'video heads' and 'upper cylinder' are often used interchangeably but strictly speaking this is not correct.)

The heads themselves are made from ferrite which is an extremely hard ceramic magnetic material which is also very fragile. The head chips can be seen at the very bottom of the rotating upper cylinder. The actual construction is of a 'C' shape with a very small gap between the arms of the 'C' - about 1 um or so. This is filled with with a non-magnetic material to force the magnetic field out of the head into the tape and to prevent material from collecting in the gap. A few turns of fine wire form the coil of an electromagnet for recording and as a pickup coil for playback. If you look at a head chip from below (on a cylinder that has been removed) you can see the coil and the shape of the core, though you will not be able to tell if a head is bad or worn by this inspection unless there is obvious damage). A powerful microscope is needed to even see the gap.

VCRs are described as having '2 heads' or '4 heads' or whatever. This actually refers to the number of head gaps and not actual head chips though usually this is the same number. However, two head chips may be placed very close together and thus appear to be a single head when in fact there are a pair of head gaps. Therefore, without a close examination, there may only appear to be 2 heads when in fact there are 4 - in 2 pairs. You are not being short changed.

Two heads are required for any play, record, or search function. Usually, these are exactly 180 degrees apart - directly opposing one another on the upper cylinder. With 4 head (or 3 head or 5 head) VCRs, various combinations of heads are used for each mode to optimize record or playback video quality by selecting a pair of heads with optimal widths and other characteristics. These may end up not being exactly 180 degrees opposed requiring video delay line to line up the two video fields in a video frame properly. This complicates head testing as it is not always obvious even which set of heads is used in any given mode.

An additional pair of opposing heads is required for HiFi VHS audio and another one is present if the VCR has flying erase head. Usually, there is only a single flying erase head - it is double width and clears a pair of tracks (fields) on each pass. So, there may be up to 7 (or even more) heads competing for space on the upper cylinder!

Also, see the section: Video head construction.

(From: Andy Cuffe (baltimora@psu.edu).)

It's impossible to use more than 2 heads for normal playback. If you look at the theory of VCR operation you will see why this is so. VHS camcorders do use 4 heads for normal play, but thy do that to reduce the size of the head drum. On an NTSC 4 head VCR 2 heads are used for SP (2hr) and the other 2 are used for LP (4hr) and EP (6hr). All 4 heads are used for still, slow and search (it picks the head with the highest RF output). On my Sony SL-HF1000 you can actually see a difference in the pattern of switching points in search depending on the tape.

On a PAL machine 2 heads are used for SP (3hr) and 2 heads are used for LP (6hr). All 4 heads are used for still, slow and search just like in NTSC. The only difference is the that the head gaps are designed for PAL tape speeds. A good 2 head should look almost identical to a good 4 head.

Video head construction

The actual video head chips themselves are mounted just about flush with the lower edge of the spinning assembly called the head drum or upper cylinder. They are made of ferrite - an extremely hard but fragile material. In terms of physical strength, its properties are similar to glass. The head actually consists of the core, pole pieces, and gap filler molded as a single unit and fired at high temperature along with the coil wound on the core after firing. This 'chip' is then glued to a metal support which is screwed to the bottom of the drum. A screw presses against this support from above and is used at the factory for final head height adjustment on the drum.

CAUTION: Do not touch these mounting screws or the height adjustment screw accessible from above the drum. It is virtually impossible for these to become loose or misadjusted on their own and alignment in the field is not possible except by trial and error.

These structures may be viewed under a strong (e.g., 10X) magnifier though the actual record/play gap between the pole pieces will not be visible except under a powerful microscope. It is filled with a hard non-magnetic material in any case.

The thickness of the ferrite chip is about .1 to .15 mm but the width of the active part of the pole tips narrows down to around .03 mm. This is one of the dimensions that is optimized for various special effects in VCRs with more than 2 video heads.

The gap azimuth angle of + or - 6 degrees (for VHS) is implemented by actually twisting the pole pieces during the molding process. This is actually visible if you look carefully with the magnifier even though you cannot actually see the gap. (The azimuth angle has obviously been exaggerated in the diagrams below due to the limitations of ASCII art.)

The coil used to generate the magnetic field during recording and to sense the magnetic field for playback consists of a dozen or so turns of fine insulated wire with a typical resistance of 1 to 1.5 ohms.

HiFi audio head construction is generally similar except that the gap azimuth angles are +/- 15 degrees instead of +/- 6 degrees.

Damage to the core, pole pieces, or coil, and oxide on the surface or clogging inside of the core can be seen with the magnifier in many cases.

Diagram of single video head

The diagram below shows a typical single video head as would be found on a 2 head VCR. Two of these (with opposite gap azimuth angles) would be mounted exactly 180 degrees apart on the upper cylinder. This is a view as would be seen from the bottom of the upper cylinder:

```
           ____________________________
          |                            |
          |           _______          |
Coil+ o---------------+      |         |---o Coil-
         +------------+     +-----------+
      .  +------------+     +-----------+  .
      .  +------------------/          |   .
      .   |           \  /             |   . Side of upper cylinder v
-----------\____________||____________/-----------------------------------
                     -->||<-- Record/Play gap, width about 1 um
```

The same head viewed from the edge:

```
           ______________ _____________      Bottom of upper cylinder v
------    |_____________//_____________|    ----------------------------
      |                                    |
       -----------------------------------
          |<---------- 1/8" ---------->|
```

Diagram of double video head

The diagram below shows a typical double video head as would be found on a VCR with more than 2 video heads if video heads are grouped together. The quite visible space in between the two head chips should not be confused with the actual microscopic record/play gaps in the pole pieces even though the total width of the two head chips (1/8") is about the same. For a 4 head VCR, there would be two such assemblies (with opposite gap azimuth angles for each head) mounted 180 degrees apart on the upper cylinder.

This is a view as would be seen from the bottom of the upper cylinder:

```
                           Coil1+ o o Coil2+
              ____________________ | | ____________________
             |                    || ||                    |
             |          _______   || ||   _______          |
  Coil1- o---|         |     +-----+ +-----+     |         |---o Coil2-
            +------------+    +-----+ +-----+    +------------+
         .  +------------+    +-----+ +-----+    +------------+  .
         .   |          \----------+ +----------/          |   . Side of upper
         .   |            \  /    |   |   \  /             |   . cylinder v
      --------\_____________||___/-----\___||_____________/---------------------

                        -->||<--       -->||<-- R/P gaps, widths about 1 um
```

The same head viewed from the edge: Bottom of upper

```
              _______________ _____     _____ _______________      cylinder v
      ---    |______________//_____|   |_____\\______________|    ----------------
         |                                                     |
          ----------------------------------------------------
             |<----------------- 1/8" ----------------->|
```

Photo of a typical upper cylinder

Here is a photo of a typical 6 head upper cylinder from a JVC HiFi VCR. This unit was damaged by the infamous "floating roller guides syndrome" and one of the head chips is smashed.

- Typical 6 Head Upper Cylinder

Note that the two video heads in each pair are close together and have opposite azimuth angles. This permits them to both be active during special effects modes - whichever one has the stronger video signal is used. Being close together, you might mistake them for a single video head and think you were short-changed and only got a 4 head machine!

The actual head gaps are way too small to be seen in even the closeups but the pairs of coils on each ferrite core are clearly visible.

Upper cylinder (video drum) diameter

For most regular VHS VCRs, someone in their infinite wisdom picked 2.45". Yes, there are probably good reasons for this - a compromise between tape track length, writing speed, and so forth. Or, maybe it was the size of the engineer's nearest handy juice can lid. :-)

For camcorders where compactness is important, the drum diameter is reduced to 2/3rds of this or 1.65". However, in order to record and playback properly, 4 heads equally spaced around the circumferance of the drum with alternating azimuth angles are required in all modes. The drum speed is also increased to 3/2 of the normal 1800 rpm or 2700 rpm. If you work this out, you will find that this results in exactly the same writing speed and track length when successive heads for each video field are located 3/4ths of the way around the drum (instead of half way as with normal VHS). These will have the required alternating azimuth angles. This uses a 270 degree wrap (the tape must wrap 3/4ths of the way around the drum as opposed to the normal 180 degree wrap for VHS).

(From: Andy Cuffe (baltimora@psu.edu).)

Beta camcorders used a half sized drum with what looks like one head (actually 2 heads very close together). It required a non-standard video signal from the camera and used almost 360 degree wrap.

How do the signals go to/from the upper cylinder

The rotating upper cylinder and stationary cylinder form a transformer - the space between them is very small and coupled the signals between the primary and secondary ferrite cores. Each of the heads for R/P video, HiFi audio, and flying erase, are electrically independent. The cores are arranged coaxially which should get to be pretty tight for a 6 or more head VCR!

Are your video heads really bad?

No picture (total snow or a blue/black screen depending on model) or a snowy picture in play modes and/or failure to produce a good recording may indicate dirty or bad video heads. First, make sure that the VCR's tuner and RF modulator are working by viewing a broadcast or cable channel. Next, refer to the section: Video head cleaning technique and follow the instructions carefully. If there is no change even after a couple of cleanings, then your video heads may have problems. Of course, if your inspection reveals any physical damage, you will need a new set of heads (new upper cylinder).

Indications of a bad video head include:

- Any visible damage to the ferrite chips. Heads nearly always appear in opposing pairs on the upper cylinder (head drum). Any visible discrepancy between the chips in a pair is probably damage. Sometimes 1/2 of the core breaks off leaving the windings dangling. Common causes for this damage are improper cleaning techniques or the use of damaged or spliced tapes. Use a magnifying glass and bright light to examine the heads but do not touch!

  By the way - improper splicing of broken video tapes is a good way to break video heads. Any kind of splicing should be avoided if at all possible. (See the section: Recovering damaged or broken tapes.)

- Excessive video snow which cannot be eliminated by the tracking controls. The appearance may also be of trailing lines or bullet shaped streaks particularly following highlights.

  Note: in rare instances, similar symptoms are the result of a static brush not making proper contact with the shaft of the spinning drum. See the section: Firing (static) lines in picture during playback.

An image where more or less good video alternates with snow at a 30 Hz rate means that one of the 2 heads in a pair is probably either dirty or bad. If your TV has a wide range vertical hold control (yeh, right, give me a time machine), then you may be able to display both fields on the screen at the same time.

- Excessive video snow or no picture (total snow or blue/black screen depending on model) for some playback speeds (SP, LP, EP, X2, still, slow, etc.) since different sets of heads (in 4 head or more) machines are often used for different speeds. If this is due to wear, then it would probably gradually deteriorate and not happen suddenly.

- Inability of certain internal adjustments such as backtension to eliminate erratic tracking problems may indicate a worn video head. Horizontal bands of video noise may come and go at various places in the picture depending on what speed is being used or the playback location on the tape (beginning, middle, end). These may come and go in a periodic cycle.

- Need to frequently clean the video heads even if you are only using new good quality (name brand) tapes. Video heads are normally self cleaning but very worn heads can tend to collect tape oxide resulting in a noisy, snowy, or totally missing picture.

- You have just been playing a rental, damaged, or spliced tape and you notice any of the above symptoms.

  The video heads may have picked up some oxide and are no longer making proper contact with the tape. Letting the VCR play a newer tape for a few minutes may clear this if it is minor. Otherwise, video head cleaning (using the proper technique!) will be needed. However, seriously damaged or improperly spliced tapes can result in serious damage requiring video head (upper cylinder) replacement.

If your VCR has HiFi audio, similar symptoms may apply to the HiFi audio heads on the rotating drum. Noisy or loss of HiFi audio or erratic switching between linear and HiFi audio may be due to bad HiFi audio heads (but could also be a tracking problem since HiFi audio tracking can be even more critical than video tracking).

However, many other problems can result in similar symptoms - video head diagnosis is one of the most difficult to make (except for physical damage).

Some pros claim to be able to determine if a video head is worn by feeling it with a finger. I can guarantee that you will not be able to do this, so the set of guidelines given above is the best to go on.

More on evaluating video degradation

(From: Frank Fendley (frank.fendley@datacom.iglou.com).)

It depends on what's wrong with the picture. If you are getting "highlight streaking in high luminance areas" (meaning that white objects in the picture seem to have "tails" trailing off to the right of the object), then a new head would help immensely. If there are random lines in the picture (especially on tapes you have recently recorded on that machine), then a new head will most likely help.

If the picture just isn't as sharp as the VCR next door, then a new head probably won't help much. Technology has improved picture quality considerably since your VCR was manufactured.

One recommendation - if you want the best picture quality from *any* VCR, forget about recording programs in SLP or LP. The SLP (or EP) speed should be banned and made illegal - the picture and audio quality are terrible. LP should only be used on programs which exceed 2 hours. You should use SP speed on everything you record if at all possible.

Effects of video head wear on HiFi audio

(Portions from: Peter (peter@puttonen.com).)

The HiFi audio is placed on the tape first to a depth of 4 microns. The video head follows with video RF, which overwrites the audio to a depth of 1 micron. Some of the original audio is erased, but 3 microns worth should still remain. (This is why there can be interaction between audio and video on some HiFi VCRs.)

A problem starts with head wear. As the head wears, the magnetic field it generates actually increases. The video goes deeper than 1 micron, erasing more of the HiFi audio. As the video goes deeper, tracking also becomes more critical for the audio. However, self recordings should still have optimal tracking assuming there isn't something wrong with the servo systems.

A temporary solution is to reduce the video record current, but this does not replace the worn head material. The real solution is to replace the head drum or buy a new VCR.

Need for video head cleaning

When should you clean a video head? Only when symptoms point to a problem with the head. See the section: Are your video heads really bad?. Periodic cleaning is not necessary and may cause excessive wear if done with a head cleaning tape, especially the dry kind which may be excessively abrasive. Frequent cleaning by hand, while not damaging, still represents a slight risk since you never can tell when you might do something you will regret!

VCRs should be cleaned periodically, but video heads usually do not need periodic cleaning as the spinning heads performs a self cleaning function. If it ain't broke, don't fix it.

Automatic head cleaners

I do not see any advantage in buying a VCR which claims to have automatic video head cleaning. Healthy video heads are basically self cleaning in any case. The automatic head cleaner is a foam roller that contacts the rotating heads for a couple of seconds when the tape is loaded. In my opinion, this is worse than useless as any crud collected by this foam may just be redeposited on the heads during the next cleaning cycle. So, if your VCR has this 'feature' and you experience symptoms of dirty video heads after each tape, remove the 'feature' and performance will improve :-).

As noted below, there is a slight risk that at some point they may actually destroy the video heads - no doubt timed to be 1 day after your warranty runs out. In addition, they do nothing to clean those portions of the VCR that really may need periodic maintenance like the rubber parts, A/C head, and tape guides.

The only benefit of an automatic head cleaner is to the manufacturer of the VCR as it increases their profit margins!

(Portions from: Joseph E. Fealkovich (jef812@ix.netcom.com).)

I would pull those 'automatic head cleaners' out and let the customer know about it. I hate those things, they do more trouble than good. The least they can do is redistribute the garbage back onto the heads, the worst, actually catch on a head and tear it right out of the drum, (I've seen this happen on a Goldstar VCR). When new, they do a fairly good job 'dusting' off the video heads, but they wear out quickly, (they work every tape loading and unloading cycle), and can seriously ruin the heads.

Furthermore, they clean only the video heads when they work; they do absolutely nothing for the grooves cut into the drum, I'll say that's the most important part, as the grooves form an 'air bearing', where the tape floats on the drum, without that that effect, the heads can wear out prematurely due to the tape sticking to the drum. My opinion on 'self cleaning' VCR's is, they've done just about everything dumb and automatic on these VCR's.

Video head wear and instant start VCR tape transports

While it may seem that this design - where the tape remains in contact with the video heads even during FF and REW is a bad idea, additional wear, if any should be minimal and not worth worrying about.

Even if the tension is maintained (which is probably not the case), the worst will be the same wear as an equivalent time in normal playing. Most of the wear is from the spinning head-tape contact. Whether the tape is moving at 0.3 ips or 100 ips is mostly irrelevant.

However, there will be additional wear of the roller guides and anything else the tape contacts but even this shouldn't be a concern. I've never heard of a VCR failing due to worn roller guide rollers. :)

Note that this approach is driven by the desire for rapid response, not laziness on the part of the engineers. It is more difficult to design a transport that performs FF and REW effectively while the tape is in the loaded configuration.

How NOT to clean your video heads or a very expensive lesson

The following is a true story. Don't let it happen to your VCR!

Read the section: Video head cleaning technique before breaking out the pliers and sandpaper (well almost).

(The following is from someone who not surprisingly would rather remain anonymous).

> "Thanks a lot for the FAQ on VCR repair (unfortunately too late --- sam). I now realize that I have made a boo-boo of quite unprecedented magnitude!! You're not going to believe this... (I'm almost too ashamed to admit to this!).

My friend asked me to clean the heads on his VCR. I got out my isopropyl alcohol spray (good) and my cotton buds (not good!).

I proceeded to scrub the upper drum furiously, getting lots of lovely black deposits on the cotton buds. I, ahem... also scrubbed vigorously around the four little 'recesses' positioned around the bottom of the drum. When I spotted a little bit of metal sticking out of one of the recesses, I got out my tweezers.....

(You can stop reading here if it's too painful!)

...and poked around, thinking 'this will cut the tape to ribbons if I don't get it out'. After succeeding in removing the offending piece, I noticed a very fine copper wire emerging from the hole too.... OUT IT CAME (with the tweezers of course). I checked the other three holes and succeeded in removing some more shrapnel from one other.

Guess what? It wouldn't play properly after this.... but the sound was OK.

To be fair, I was fairly sure I'd screwed up big time when I saw the copper wire... but of course it was far too late by then.

I admitted to my friend that I thought I'd broken his video head and that I would replace it for him. Thinking that heads cost around the $30 mark, according to most of my catalogs, I was horrified when I got a price for his particular model.... $162.00 + 17.5% tax and postage..... However, this was much less than what the original manufacturer wanted: #350!! Well, I finally found a replacement for $85. Still, an expensive lesson."

Video head cleaning technique

CAUTION: Read the following in its entirely to avoid an expensive lesson.

As noted, improper cleaning can destroy your video heads. The head chips are very fragile and just rubbing them in the wrong direction (NEVER use an up-and-down motion) can break the chips off requiring replacement of the entire upper cylinder assembly - one of the most expensive parts in your VCR!

Manual cleaning using the proper head cleaning sticks is best but requires that you gain access to the interior of your VCR - i.e., take off the cover.

If you do not want to do this, you can try a commercial wet cleaning tape. These is some slight risk, however. The material used in some of these may have an excessively coarse fiber structure which can catch a video head and break it off. I have not seen this happen nor could I recommend a specific brand as there is no way of knowing what their current product uses. I do not recommend the dry type at all as these are almost always much more abrasive and may cause premature wear of your video heads especially if used regularly. When using the wet type cleaning tapes, follow the directions and - very important - wait sufficient time for everything to dry out or else you will have a tangled mess inside your VCR.

Regular video head cleaning should not be needed! Therefore, the regular use of a cleaning tape is not recommended. As noted, some cleaning tapes will cause excessive wear to the video heads and no cleaning type can adequately deal with other parts of the tape path anyhow. If you find yourself needing to clean your video heads frequently, the video heads may be worn, the backtension may be set too high, or you may be playing old or dirty (literally) rental tapes.

To clean by hand, you will need what are called 'head cleaning sticks'. These are covered by chamois and are safest. DO NOT USE Q-TIPS (COTTON SWABS). These can catch on the ferrite cores and damage them or leave fibers stuck in the heads. Q-tips can be used for cleaning the other parts like the rollers and audio/control head as described above but not video heads.

To use the cleaning stick, moisten it with head cleaner or alcohol. Pure isopropyl is best, however, the 91% medicinal stuff is OK as long as you dry everything pretty quickly. Don't flood it as it will take a long time to dry and you run the risk of any water in the alcohol sitting on surfaces and resulting in rust (very unlikely, but don't take the chance).

Gently hold the flat portion of the chamois against the upper cylinder where it is joined to the lower (non-rotating) cylinder. Rotate the upper cylinder be hand so that the heads brush up against the moist chamois. DO NOT MOVE THE HEAD CLEANING STICK UP-AND-DOWN - you will break the fragile ferrite of the heads - $$$$. Side-to-side is OK as long as you are gentle.

(The following tip from: Steve (sreed@amsupply.com).)

> "A good quality automobile chamois (the real thing, not the fake stuff), cut up into 1 to 2" squares, is far

> cheaper and easier to manipulate than the sticks. After cleaning the heads, the chamois square can be re-moistened with cleaning fluid and used to clean the A/C head, rollers, guides, etc.
>
> There is another advantage to this approach. The chamois sticks can on some occasions "catch" on a video head, because the chamois area is small and the edges are rigid. Using a larger cut-up square of chamois eliminates this problem because the edges of the chamois are away from the rotating head and you're simply holding it against the drum with your index finger."

I know people who use a piece of moistened typing paper, a business card, Mr. Coffee filter paper - or even their Mark-1 thumb for video head cleaning but I would not recommend these for a general service procedure at least until you gain some experience with the use of chamois first!

(I suppose the only real requirement to prevent damage is that the material have a fine enough structure and not have fibers that can get stuck in the heads. So, the short list of acceptable materials is quite long - some more effective than others. My concern for a general recommendation is that people's interpretation of these requirements can vary quite a lot. If a novice comes to me and asks what to use, I will say 'cleaning sticks'. Once they understand the characteristics of the heads and their mounting, they are free to use whatever works.)

Depending on how dirty your heads are, a couple of passes may be enough. Let everything dry out for at least 1/2 hour. This may need to be repeated for stubborn clogs. However, one pass will often do it. As noted, under NO circumstances should you be going up and down even though you might think this would work better given that the head gaps are vertical (or nearly so). Aside from the possibility of breaking the head chips completely, there is no need. The head gaps are solidly filled with a material of similar hardness to the ferrite. Stuff can't get trapped in the gap - only on the surface, above or below, and inside the winding area. Look at a head chip closeup under a microscope sometime. :)

In addition, inspect and clean the drum itself staying safely away from the video head chips. The five fine grooves in the drum help control the air bearing that the tape rides on and helps to stabilize tape motion. These should be clear of dirt and tape oxide (DO NOT use anything sharp - the moistened head cleaning sticks will work).

Rob's alternative video head cleaning techniques - use with care

(From: Rob-L (rob-l@superlink.net).)

As an alternative, I'd use a *dry* bit of paper. Moderate finger pressure against the whole side of the drum, overlapping to the motor assembly. Then twirl the drum in each direction a few times. Look at the paper and you'll see exactly where the dirt is coming off. Once you can do this and get no marks, you're heads are relatively clean. A tiny, soft, short brush and a puff of air will dislodge any paper fibers. The paper and its fillers are generally not going to harm the drum/ferrite-chips with this brief contact. And you can pop a tape right in without waiting for solvents to evaporate. Besides, solvents may soften any encapsulants on the chips, and cause residue to get on the polished surface.

Once in a while, I run into a set of heads that seem to be bad, even after cleaning with different methods. This is characterized by poor signal strength in all or part of the picture, sometimes one field only, and sometimes tracking range is extremely narrow as a result. On S-VHS units, S-VHS recordings get noisy and may get blanked, while the same unit will work in VHS with minor tracking problems.

Upon 30x pocket microscope inspection of the heads, I find a speck of what appears to be a cloudy polymer, firmly bonded to the edge of one or more of the chips. How did it get there? My guess: too much solvent - may have dissolved encapsulant and/or dust that was at the edge of the chip.

Solution: *carefully* drag a jeweler's flat-blade screwdriver along the chip (under magnification). Sounds a bit risky, but this has never damaged a head in my hands. Follow this with a final paper-buffing, and usually the VCR is tracking fine, with a much improved picture. Saves mucho bucks. 'Course, sometimes the heads are just plain worn out.

My advice: Invest in a pocket microscope before you start pricing heads.

Expected life of video heads

(From: Jerry Greenberg (jerryg50@hotmail.com).)

The normal MTBF (Mean Time Between Failure) rating for a standard VHS video head is about 5,000 to 6,000 hours on the new machines. This figure will vary from one manufacture to another, depending on the outcome of their own research. This really means that after this amount of time the head normally will be warn past its specs. This means that if you look at the RF envelope on a scope, it will no longer meet the exact specs for its output. it also will not be guaranteed to work anymore.

The actual life is really where it reaches the point where your playback quality is considered unacceptable. This means it can probably last about 10,000 hours in most cases.

What saves a head is that all the tapes used are of top quality, they are not played in dirty or misaligned machines causing creasing of the tape edges, or dirt transfer. The dirt or oxide stain from the tapes can be a bit abrasive on the heads, thus accelerating some wear.

If the heads and tape path are kept clean, and high quality tapes are used in the machine, you should reach a very high amount of hours with the head.

I found that rental tapes are the worst for tape heads. This is because many people play the tapes in dirty or misaligned machines, and or handle the tapes with dirty hands from food.

I had one customer that played a rental tape in a machine, and it started to become unstable during the playback. When I checked the machine, I found peanut butter inside. It turned out that someone had peanut butter on their hands when they handled the tape!

Advanced video head testing techniques

Assuming cleaning does not help and you have the time and inclination, some additional test can be performed to confirm or rule out a bad set of video heads (upper cylinder).

To check the signal from the video heads you need a circuit diagram so that you can locate the relevant test points and expected voltage levels in the head preamp. This will be housed in a metal enclosure, usually right next to the head assembly (at the rear). This should be done with an alignment tape, but any known good recording should provide a reasonable approximation.

Other basic checks such as visual check with a magnifying glass, continuity tests on the heads as well as power supply voltages in the preamp can also help.

If your VCR has 4 video heads (not including HiFi audio heads) and only certain modes or speeds do not work, then the following procedure may permit you to isolate the problem to a head or its preamp. Basically, the idea is to interchange the wiring of the two pairs of heads. While the heads will no longer be optimized properly for each mode, there is a good chance that they will work well enough to determine gross changes. For example, if SP play originally had alternating fields of good and bad video and works moderately well after this rewiring (but maybe with tracking noise), then you know that the bad head is no longer being used for SP play. Since the same head preamps are being used, a bad head must be at fault. Video drums where the heads are wired with flying leads are somewhat easier to cross-wire than those with a PC board. This is not fun and may not work in all cases, but if you are hesitant to risk the cost of a new head, it may be worth a try.

And, once you have looked at your 1000th bad head or so:

(From: Jerry Jansen (rjansen@bcpl.net).)

Try using a jewelers loop, along with a small pencil point flash light. The diagonal formed into the chip is easy to see with the loop. As the chip wears, you will see the angles length gets shorter.

Measuring video head wear

You mean your thumb isn't calibrated to the micrometer (um)?

> "I'm trying my hand at VCR repair. Sony specifies a hand-held device that connects to a non-rotating video head and that measures how worn the head is (Beta machine). I'm trying to imagine how it works. Is it the head gap itself that gets bigger as the head wears?

(From: Raymond Carlsen (rrcc@u.washington.edu).)

There is (was?) a device to check for head wear by measuring the inductance of the head itself. The head must be disconnected from the rotary transformer, of course. Older machines had wires on top of the head that could be easily disconnected (like the Beta decks) without removing it. Heads on some newer machines must be removed from the VCR because the leads are underneath.

Apparently, the inductance of the head changes slightly as the ferrite material wears away. The head gap itself doesn't change as the head wears. If the gap were to open, the head wouldn't work at all, and I assume that the inductance would be significantly different than a used good head. In most cases, the head chip(s) wears to the point that the tip penetration is not sufficient to keep it in intimate contact with the tape. The heads tend to clog more easily as they approach end-of-life.

The inductance type of head tester does have a few drawbacks. It's rather expensive, and to accurately tell how much usable life a head has left using only the tester, you must have a "sample" of exactly the head under test for comparison... each one is different. The measurement is relative, not a "good-bad" reading.

However, I have been using several other methods to test video heads for the last 10 years. Here are some options:

- If the image is good in SP, try search reverse in that mode and see if the upper third of the screen gets noisy. A noise band there can mean the heads are close to worn out.
- Another method (in SP) is to pull the back tension band to the right slightly to reduce the tension. If the image breaks up or goes to snow, that's another indication the heads are close.
- The most critical measurement is tip penetration. I learned to gauge the tip penetration by feeling the rotating head chips as the tape is moving through the machine. A well-calibrated finger placed lightly on the tape on the

exit side of the drum is very revealing. I use a well calibrated finger. Of course you need to know what both good and bad *feels* like, so this may not help. I apply a finger *very* lightly to the tape on the right side of the scanner so I can feel the heads through the tape. The amount of "buzz" gives a pretty good indication of wear. If you can hardly feel it, the heads are close. There is some difference in brands.

- Streaking or comet-tailing on recordings of small bright objects usually means the heads are close to being worn out (gap starting to open up).

- A microscope is good to check for the more obvious broken or chipped head, and to see if a stubborn clog is actually gone.

Different VCR brands will show different results to my finger test: Old Hitachi decks will show bad heads before they actually "feel" worn out. One usually goes first, producing alternating fields of snow and picture. I've seen a few older Panasonics that still worked even when the heads were worn down where they couldn't be felt any more.

How do you tell the difference between worn out heads and a head clog? Clean the heads and try it again. Then feel it. Tentel Corporation makes a test fixture that actually measures tip penetration, but with a bit of experience as a guide, the best test instrument is still the mass of grey mud between the ears.

When a repair job hits my bench, I use a combination of these methods to evaluate whether a machine is worth fixing. If heads are close, I factor the replacement cost into the estimate. I've only seen a few open heads (and rotary transformers) over the years... quite rare. Loss of EP only can be that both EP heads are clogged, but that's not likely if SP works well. Very worn heads tend to clog more easily, but wear will be about equal for both sets of heads. The only exception to that is HiFi machines where the high fi sound gets bad before the picture shows up worn heads. If you suspect an electronic fault, you might try making a recording in EP mode and playing it back on another deck. If only the playback EP mode is bad, it's possibly in the head amp switching circuit and not the heads themselves.

(From: Frank Fendley (frank.fendley@datacom.iglou.com).)

There are two methods (that I know of) which measure wear on video heads.

One is a protrusion gauge, which measures how far out the heads extend past the edge of the drum. Once the heads fall below a minimum extrusion, they are considered worn. It's similar to measuring the tread left on a automobile tire.

The other is a "Video Head Tester", sold for either Beta or VHS models. Essentially it is an inductance bridge. You connect each head to the test leads, calibrate the unit, and then measure the inductance of the head. The theory here is that as the head wears, its inductance goes down due to loss of the core material. Past a certain minimum, the head is declared worn out.

Bear in mind that a head could fail both of the above tests and still give a good quality picture (although it is true that its days are probably numbered).

It is also quite possible that a head could pass either or both of the above tests and be defective.

Are the the testers worth it? In my opinion - probably not, unless you are a real purist and like to have a lot of test equipment.

More than you even wanted to know about video head tip penetration

Remember how I told you never to even think about adjusting the video head chips themselves? Well, it seems some people never listen :-).

(From Jerry Greenberg (jerryg@total.net).)

I researched out tip penetration specs on video heads for VHS and Beta (home) machines. I got a number of people interested in this one to the point that a few machines came off the shelf, and the research began. We had the tools at our disposal to get this done.

The following measurements are in mm (millimeters).

Brand new heads off the shelf in both Beta and VHS were about 0.12 to 0.16 mm penetration.

At about 0.05 mm the video signal starts to degrade. But the head will still record well.

At about 0.02 mm the video is very noisy. If you loosen the head and push it out a bit, you improve it slightly. But, the gap is now wider. Therefore, the signal is a bit stronger (due to the additional penetration) but has more noise. Overall, a slight improvement.

Also the horiz angle of the head effects the switch point a bit. If out, a slight horizontal jitter (flag waving) is noticed, and the PG is slightly out. You can correct with the PG adjust to a point, but the head effective angle from the opposite one must be better than 2 deg.

As the head wears, we found that the head surface leaves the tape too soon, and starts reading the tape too late. If the heads are down to about .05 mm the effective error (both heads summed) is about 2 to 3 degrees. The puts it slightly out of spec for the switch-over point and causes some instability. This problem is also summed because the carrier output is at about 60% of the normal amount. As the head wears from this point, the carrier drops more rapidly. It is not linear. It follows the inverse square law factor.

Highlight tearing and bad video heads

Highlight tearing - trailing lines adjacent to bright areas of the picture - often indicates a worn video head. Sometimes, this only shows up severely for tapes recorded AND played back on the same machine. Why?

(From: Jaclyn (lambert@sos.net).)

The reason why it **appears** to be a record only problem is fairly straightforward if you understand what's up.

When you make a recording with bad or marginal heads the resultant recording is poor. Perhaps a vcr with good heads will be capable of producing an "acceptable" picture, perhaps not. Depends on the alignment and how good those heads are. When you try to play the "poor" recording back on the vcr in question the resulting performance is unacceptable because the heads on that vcr are marginal at best and are simply not going to have the gain required to pull the crappy recording off. Get it? It's a double whammy two fold effect.

Video heads don't just go "bad". They wear down after time and early symptoms sometimes also include poor vertical stability (as is so common in Hitachi VCRs) and snow "lines" which hover about 2 inches from the top of the screen. Occasional loss of horizontal sync is also typical.

Where to obtain replacement video heads

Once you have concluded that a replacement head is required, you need to decide whether you will undertake this yourself or take the VCR to a shop. Video head replacement is relatively straightforward and low risk as long as you are comfortable working on mechanical devices and take your time. A little unsoldering and soldering is usually required.

Electronics suppliers such as MCM Eectronics, Premium Parts, and Dalbani stock a wide range of video heads for VCRs that are more than a couple of years old. (They may not have heads for the latest models.) In some cases, they will offer two kinds of heads for the same model - a generic version and a 'name brand'. Unless you are extremely critical, there is probably no need to spend the extra on the 'name brand' head. There is also no need to pay the premium charged by the original manufacturer of your VCR - it is often priced 2:1 or more over what a generic head will cost with no substantial difference in performance, if any. You may even end up with exactly the same head manufactured on the same assembly line!

Note that currently, the price of many upper cylinders (video heads) for 2 head VCRs is well under $25 so ordering a replacement may be a better investment of time and effort than a long diagnostic procedure especially if the old head has high mileage and video quality has been steadily decreasing.

Upper cylinder not replaceable as a separate assembly?

On some newer VCRs, it seems that in the manufacturer's infinite wisdom (or cost crunching), the normal video head drum or upper cylinder cannot be replaced by itself. Only the entire expensive cylinder unit is available.

Unless you can find a junk VCR (try Allbrand, see the section: Used VCR parts), repair may be too expensive. Just buy a different brand next time, which, of course, may not matter. :-(

Video head replacement technique

1. Do not touch the actual video head chips themselves. Handle the head as little possible. You can touch the upper part of the head cylinder if necessary. One thumb through the center hole with fingers resting on the upper edges works pretty well.

2. Before you unmount the old one, mark or make a note as to its position - sometimes it is possible to mount the new head 180 degrees off from way it is supposed to be oriented causing tracking problems at the least as the opposing heads are not identical. (The azimuth angles are +/- 6 degrees for VHS, +/- 30 degrees for VHS HiFi audio). Also make a note of the wiring if there is any possibility of confusion (i.e., there are individual wires, not connections from below to a printed circuit board).

3. Unsolder the connections between the head and the upper cylinder. There will be 2n solder connections for an n head VCR. (Sometimes there is some kind of connector rather than solder connections, but this is rare.) Examining the new head should reveal exactly where to unsolder. For pins through the printed wiring board type, you should use some kind of desoldering tool - solder pump, SolderWick, or a vacuum rework station.

   CAUTION: Make sure ALL connections are actually freed from the PCB before attempting to remove the old head. Use a pair of needle-nose pliers or other suitable tool to separate the wire from any residual solder. Otherwise, it may rip off parts of the rotating transformer assembly, possibly ruining the entire cylinder unit.

   In rare cases where there are individual wires, a generic replacement head may not be color coded the same or have the wires originating from different places than the original. In this case, you will have to try to determine which physical head chip the wires originally connect to. You must get each of the connections from the lower cylinder to the head in the same physical head as before (though the polarity or phase of the pair of connections to each head should not matter).

4. Unscrew the 2 or 4 philips head screws holding the old head in place. It should be obvious from the new head which screws need to be removed. You may need to remove the static brush if your VCR has one or some other usually obvious stuff to get at it. DO NOT touch any other screws on the head drum as these are critical adjustments one should not mess with.

5. Lift the old head straight up and off. You should not need to use any drastic measures though a little jiggling may help. I have never actually needed a head puller.

   Do not yank or pull hard. The head should come off easily. If it does not, make sure the solder connections have been completely removed. See CAUTION above.

6. Replace in reverse order, solder the connections, replace any other hardware that was removed. Refer to your notes on the position of the old head and/or the color codes (wire colors, dabs of paint, etc.) as to orientation on the drum.

7. Carefully clean any fingerprints from parts of the head drum you touched. Again, do not touch the video head chips themselves. You may use 91% medicinal alcohol, though pure isopropyl is preferred. Avoid rubbing alcohol especially if it contains any additives. Let the machine dry completely.

8. Unless you tweaked any mechanical adjustments, the VCR will very likely work fine assuming the video head was the problem. Try recording and playing back at all speeds as well as playing pre-recorded tapes as well. Carefully examine the video for excessive snow, jittering, or tracking problems. For HiFi VCRs, also confirm that the HiFi audio is solid and stable - that the HiFi light is not flickering in addition to audible dropouts or muting.

   If the tracking is now way off or you experience serious video noise, lack of or erratic color, or bad or missing HiFi sound, refer to your diagram and double check that you didn't replace the head rotated 180 degrees from the proper position by accident. Make sure the drum is seated properly - not on a bit of dirt on one side. DO NOT be tempted to adjust tape path alignment - if the heads were the problem, it should be fine. Also see the section: HiFi/video tracking problems after upper cylinder replacement.

   It is a good idea, however, to perform what is known as the 'Tape Interchangeability Adjustment' (this terminology is used in Panasonic VCR service manuals, meaning is self evident) in any case. This procedure consists of adjustments to the roller guides, other guide posts, and the A/C head. See the chapter "Tape Path Alignment and Backtension Adjustment" or follow the set of steps in your service manual. On rare occasions, some electronic adjustments will also be required to obtain optimum video quality but this is the exception rather than the rule. Tapes recorded at EP speed will almost always be more finicky and may require these adjustments more so than those recorded at SP speed.

How about when the head drum refuses to budge?

(From: Raymond Carlsen (rrcc@u.washington.edu).)

If it's a Samsung based machine, you might need a head puller. I got one at a service seminar many years ago and need it once in a great while to pull a stubborn one, usually a Samsung. Avoid the temptation to pry up with screwdrivers. I've seen the results of such abuse... not pretty. Look for threaded holes in the head drum. That's a clue it needs a puller, which attaches to the head drum and presses downward on the center spindle with a few twists of the handle. The new head (also a tight fit) is seated by alternately tightening the two mounting screws.

You could make a puller with a bar of metal and some long screws. Drill two holes in the bar to fit the spacing of the threaded holes in the head wheel and one in the center between the other two. Tap the center hole (8-32 is big enough). Use screws (small metric) long enough to thread into the drum to attach the bar. Run a screw down the center hole until it contacts the center shaft of the drum. Keep rotating until the drum pulls off.

What if the replacement upper cylinder doesn't work?

There are a number of possibilities and one of the more common particularly with generic replacements is, guess what? A defective replacement!

When replacing the upper cylinder, the orientation and wiring must be exactly the same as the original. For many VCRs, this is automatic since the mounting is keyed and the wiring is via direct printed circuit board connections. However, there are also many where it is possible to screw up either the orientation or wiring or both:

- For lack of color, erratic color, excessive video noise, and tracking problems double check its orientation. Accidentally replacing the head drum 180 degrees from its correct orientation will result in a variety of video quality problems.

- Where individual wires are used rather than soldered connection to a printed circuit board from below, make sure you have attached the lower cylinder terminals to the proper heads. Some generic heads apparently do not have the identical layout. It may be necessary to visually trace the wiring on the old and new upper cylinders to determine which actual video/HiFi audio head chips are attached to which wires. Also don't assume that the wiring color codes are same! However, you are lucky in one respect: The polarity or phase of the pair of connections to each head should not matter!

HiFi/video tracking problems after upper cylinder replacement

Unless you had such symptoms originally where best settings of the tracking control for the HiFi audio and video are at grossly different positions, the problem is with the video head drum itself or its installation.

(From: John R. Hepburn (jhepburn@recorder.ca).)

If you have an oscilloscope and service manual, check the envelopes for maximum output. Audio and video should max at roughly the same tracking position. If they do, forget about heads or any mechanical problems, it is electronic (but probably existed before the replacement - possibly masked by an originally defective set of heads!).

If they do not, then it is probably a drum problem. DO NOT adjust your roller guide height or any other posts! They were in the right position before (unless you have already moved them) so they are in the right position now. Minor post adjustments are OK after heads are replaced, but that is just to peak it out. No serious problem has ever been solved on a VCR by adjusting posts that are in their original position. Remove the heads and check for proper seating. You would hate to make a big deal out of this, only to find one side of the drum was seated on a small piece of residue.

Comments on HiFi tape path alignment

(From: Jerry Greenberg (jerryg50@hotmail.com).)

You should be using the test tape that has both the standard video on it and the HiFi envelope as well. The lateral alignment of the control track head is extremely critical, and should be done along with the guide alignment.

Also the head switching pulse should be checked closely. In some machines the switching pulse is not adjustable. If this is the case, you should be using the original factory replacement head for sure (not a cheaper sub). The universal replacement ones have given me a lot of trouble...

As for the slow speed, there is no real test standard. The slow heads should be accurately aligned from the factory on the drum to match. You cannot adjust the slow speed separately for the tracking. On some very high end machines, especially the older ones, they had a separate head switching adjustment for the slow speed...

Tape interchangeability

Since video heads are not all manufactured exactly the same, there is a slight chance that you will experience problems of playing tapes recorded on other VCRs in yours. However, before adjusting the roller guides or other settings, make sure that the *other* VCR is aligned properly.

(From: John F. Reeves (jreeves@uwf.edu).)

Take an alignment video-cassette tape and verify that the P2 and P3 posts are adjusted properly. you should use a scope and monitor the RF envelope while adjusting the above mentioned posts. Once this procedure is done, make a recording and play it back in another VCR. If it still does not track properly, it may necessary to perform the tape interchange ability adjustment. This adjustment in more critical and more in depth, should be performed be a qualified technician.

What are the symptoms of a video head that is on backwards?

Suppose I screwed up and installed a video head 180 degrees rotated from what is correct. What will happen?

First confirm that it is even possible to do this - some are keyed in such a way that a hammer would be needed.

The effects will depend very strongly on the particular VCR but the following are among the possible symptoms:

- Tracking that is way off for tapes recorded on another (properly adjusted) VCR. It may be so bad as to be beyond the correctable range with the user tracking control. The azimuth angles of the head pairs are opposite of what is expected and this directly affects tracking.

- Noisy picture or no/erratic color in some or all play and search modes. On 4 or higher head VCRs, even opposing pairs of heads have different characteristics so these will not be matched to the electronics with the head on incorrectly.

- Flying erase will not work where only a single flying erase head is used. To test for this (assuming your VCR has a flying erase head), record over an old recording. If flying erase is not working, you will get a rainbow pattern (assuming you get any color at all) which will wipe down the screen over a 10 second or so period (just like a VCR that lacks flying erase). The 7th head in a 7 head VCR is likely a flying erase head.

Can I substitute a video head from another VCR?

The quick (and long) answer is: NO. The heads themselves are in no way standardized. You can substitute a video head drum (upper cylinder) if it is identical - VCRs sold under different labels are often manufactured by the same few companies. Check a cross reference if you have a dead VCR with a good set of heads but not the same model as the one you are trying to repair. As far as the heads themselves, don't even think about attempting to interchange the actual head chips - even if your replacement were physically and electrically compatible, you would never be able to get the alignment within tolerance since you do not have the factory jigs. Not to mention that the head chips themselves are really really tiny and really really fragile and their specifications all vary - head width, azimuth angle, etc. Forget it.

Disassembling the lower cylinder

It is rarely necessary to do this but if you should - from curiosity or anything else - beware that the reference for the #1 head may be a magnet attached to the motor shaft. This may not be keyed and unless you carefully mark everything beforehand, will have no way other than trial and error to get if back at the proper angle.

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Tape Path Alignment and Backtension Adjustment

General tape path alignment procedures

There are separate descriptions of the procedures for adjusting the various components of the tape path - in particular, A/C head azimuth, tilt, and height; and roller guide height. Before you attempt these, you need to determine whether either of these are likely to be your problems.

For really major tracking problems with all tapes, check for broken or missing parts or for problems which prevent proper positioning of the roller guide assemblies during tape loading. Types of symptoms include: broken up picture, snow across part of picture, multiple breaks (sort of like the VCR is in a search mode such as CUE or REV but is not) in picture, totally unstable picture, or multiple of the above. Of course, someone before you may have messed with various mechanical (or heaven forbid, electrical) adjustments without having a clue of what they were doing.

Symptoms of bad A/C head alignment

The following are some symptoms you may experience indicating the need for A/C head adjustments:

- Weak, muddy, or wavering sound. (Azimuth, height, or tilt adjustment).
- Tracking incompatibility between this VCR and tapes recorded on other VCRs - you always need to adjust tracking or keep the tracking control way off center when playing tapes from other VCRs. However, if it is only one other VCR, that VCR may be misadjusted. (Mechanical tracking adjustment).
- Erratic loss of synchronization or frame lock, or speed changes. (Height or tilt adjustment).

Before you try to adjust the A/C head, make sure that there is not some obvious mechanical problem that has shifted its position. There may be a bit of something stuck in the mechanism. If this appeared after you did some work on the VCR, you may have accidentally caught a cable or something else preventing the A/C head assembly from returning to its proper position. This is particularly likely if the problem happened suddenly.

Once you change its settings, any tapes recorded on your VCR prior to these adjustments may not play back properly.

For example, if you touch the A/C azimuth screw to correct a muddy weak sound problem when playing tapes from other VCRs, any tapes previously recorded on your VCR will now sound muddy and weak. You need to decide which is more important - your recorded tape library or compatibility with other VCRs.

Symptoms of bad roller guide height adjustment

The following are some of the symptoms you may experience indicating the need for roller guide height adjustments:

- Video noise at top (supply/left side roller guide) or bottom (takeup/right side roller guide) of picture that cannot be removed with the user tracking control.

- Video noise in various areas of picture that comes and goes in a few second cycle. For example, a few lines of video noise may travel up or down the screen or start at the edges and meet in the middle. (Misadjustment of either roller can cause these symptoms.)

- A jumpy picture - as though the vertical hold control (which most TVs no longer have) is misadjusted. (The supply/left side roller guide is probably misadjusted.)

Before you try to adjust the roller guide height, make sure that there is not some obvious mechanical problem which is preventing the roller guides from seating properly. This is particularly likely if the problems happened suddenly. See the section below on: "Likely causes for sudden change in tracking behavior".

Gently check each roller guide to see if one is loose in its threaded mount. If one turns with finger force, that one is likely the problem AND YOU SHOULD NOT TOUCH THE OTHER ONE! Where both are loose or have been adjusted, it may take quite a bit of trial and error to get them both set correctly again. Try not to make this an issue!

Tape path alignment shifting over time

No, it isn't your imagination. Those wedding videos no longer play on your VCR without adjusting the user tracking control even though you swear they used to.

Considering the precision required to maintain alignment, especially for the slow (SLP/EP) speed, it's a wonder these things work at all! With a track pitch of 19 um (.019 mm) at this speed, a shift by more than the diameter of a human red blood cell (about 7 um) will result in alignment problems. Tolerances of SP and LP speeds aren't quite as bad but are still measured in almost imperceptible fractions of a mm.

Changes in roller guide height is probably the one most likely to occur. Note that many modern VCRs no longer use locking screws so these do eventually loosen and shift position. Wear to other parts like the V-stoppers and tracks on which the roller guides ride, as well as the ridge on the lower cylinder, are also possible.

However, before attempting realignment or replacing expensive components, make sure that the roller guides are seating properly and that a proper cleaning and inspection has already been done.

A/C alignment adjustment locations

While there are many variations on the exact locations of each of the A/C head alignment adjustments, the following description is for one of the most common layouts. See the appropriate sections elsewhere in this chapter for the adjustment procedures for the A/C head.

- A/C mechanical tracking. This is a conical nut on a small shaft fastened to the transport base. It is wide on top and tapers down below. A slot across the top allows the nut to be turned and thus raised or lowered. It's angled side presses against a projection on the A/C assembly base plate. Thus raising or lowering the nut moves the A/C head assembly from side-to-side.

  - When raised (counterclockwise), the A/C head assembly moves away from the video heads increasing the delay between the video and sound.

  - When lowered (clockwise), the A/C head assembly moves toward the video heads decreasing the delay between the video and sound.

  You may need a special screwdriver with a cutout in the middle of its blade (or modify one of your own) to easily adjust this nut.

- A/C head height - A hexagonal nut on a large shaft behind the A/C head. This moves the entire A/C head assembly up and down. A spring underneath provides both the upwards pressure to keep the A/C head assembly against this nut and torque to keep it against the conical A/C mechanical tracking nut.

- A/C head tilt - A Philips screw is directly behind the A/C head on the plate that the head sits on. This adjusts the A/C head forward and backward (with respect to the tape).

- A/C head azimuth - Another Philips screw is to the right or left of the head on the same plate just mentioned. It probably has (had) some red (or other color) paint on it to lock its position. This adjusts the A/C head azimuth angle (side-to-side) with respect to the tape.

- A/C head plate pressure. A third Phillips screw (on the opposite side of the A/C head from the azimuth screw) with a spring under it. This should just be left alone as its only function is to provide downward pressure to keep the A/C head assembly in place as determined by the tilt and azimuth screws and a pivot point underneath near the front. However, if it seems loose, tighten it a few turns clockwise. This should not affect any of the other settings.

Adjustment of A/C head - problems with tracking or sound (linear audio)

If the problems happened suddenly, it is probably not a misadjusted audio/control head but some other mechanical fault - eliminate this possibility before considering A/C head adjustments.

Note: For the procedure below, the linear audio tracks must be monitored. So, if this is a HiFi VCR, select an audio mode that forces the linear audio tracks to be used as output. There will usually be a switch or menu setting for this.

The following will attempt to get your mechanical settings back to something approaching normal even if the audio/control head was tweaked:

I assume that you have cleaned it and replaced any dead rubber parts.

I also assume that someone (we won't name anyone) has tweaked just about every mechanical adjustment.

I would adjust the audio/control (A/C) head as best you can (don't touch this unless you know it was messed up by someone):

- Play a tape that you know was recorded on a good machine. It may be easier to start with a tape recorded in SP mode since this is less critical. Once the basic alignment is complete, go back and fine tune with a tape recorded in EP.

- Adjust the A/C tilt as vertical as you can by eye. If necessary, fine tune it for most stable tape movement - the tape should be at the same angle moving over takeup roller guide, A/C head, and adjacent fixed I guide.

- Adjust the A/C height for loudest sound. At each end of the range of this adjustment, you will lose tracking/sync and tape speed may fluctuate (in addition to the sound becoming weak).

- Adjust the A/C azimuth for best treble (high frequency) sound. This is a precise adjustment - a 1/16 of a turn is significant. There will be a very small range over which the sounds will be clear and natural. A tape with music is best for making this adjustment.

- With electronic tracking control centered, adjust A/C mechanical tracking (usually, a conical nut that moves the entire A/C assembly) until you get the least snow (if you have a picture at this point). Satisfactory tracking may be obtained at several positions of this control. However, only one will produce current video-audio sync. For the others, the words and the picture will be off by some multiple of 1/30th of second.

- You may need to go back and touch up some of these again.

If you are aligning a HiFi VCR, (re)enable HiFi mode and tweak the mechanical tracking to center both video and audio within the electronic tracking range. In some cases (if the rotating video/audio heads were not manufactured perfectly), the peaks may be at slightly different positions and you will have to split the difference in the adjustment.

There can still be other problems in the tape path including the height and angle of the roller guides and the height of the impedance roller assembly (on the left before or after the full erase head.)

Roller guide height adjustment

You can do this by eye. Sophisticated test equipment and expensive test tapes are not needed. One trick is of course not to mess with both guide posts at the same time - but even if you do it isn't the end of the world. This doesn't even require a scope - the video picture is an excellent alignment tool! It does take patience and a steady hand.

Also, have you touched any other mechanical adjustments - other guideposts, etc? Hope not. Also, I assume that any repairs to the guideposts have left them perfectly vertical - if they are tilted, then other tape path instabilities can result.

The following checks and adjustments are made in PLAY mode.

There is a ridge on the lower (stationary cylinder) on which the tape should ride - not above and not below. Play a tape that is in good condition and look closely at its bottom edge to see if it is sitting precisely on this ridge. If it is not, first verify that both roller guides are snug against the 'V-Stoppers' - the brackets at the end of the tracks where the roller guides stop in PLAY and REC. If they are not, then you need to determine what is binding or what has fallen off of the tape loading mechanism. See the section: General tape path alignment problems. Assuming that the roller guides are correctly positioned on the tracks, the first step is to visually adjust the roller guides so that the tape just rides on that ridge on the lower cylinder. That ridge is a very critical part of the guide mechanism.

There will be a set screw to lock each of the roller guideposts from turning. The appropriate one(s) will need to be loosened slightly - just enough to that the post is snug but can be turned by hand. The set screws may require a miniature metric hex wrench. Some just have a square head screw which can be loosened with a pair of needlenose pliers. Adjust each guidepost so that the tape just rides on top of the ridge.

Now, for the fine adjustments. Which part of the picture is bad?

- Left guide -> mostly problems with top of picture.
- Right guide -> mostly problems with bottom of picture.

Misadjustment can also cause a periodic loss of sync on a several second cycle.

Make careful **small** adjustments of each one - then wait for a few seconds for any results to become apparent. Since the tape moves so slowly, it takes several seconds for the tape motion to stabilize to the new guide position. The left guide will affect the top part of the picture (mostly) and the right guide will affect the bottom.

Once you are happy with SP, get a tape recorded on a known good deck in EP (SLP) mode since the tracks are narrower and fine tune it.

Tape path alignment comments:

- An EP recording requires the best tracking, and will thus make the best test source. (But it must have been recorded on a unit that was aligned properly).
- Using forward and reverse search modes helps to narrow the adjustment. The guide height on the "feed" side for whichever direction you're going will have more affect. In other words, tweak one while searching forward, and the other while searching in reverse.
- You could have the tape centered at the middle of the contact path, but too low at one end and too high at the other.
- You could have the entire contact path too high or too low, and be in- advertently "correcting" by misadjusting the tracking control. You could be off by an entire track getting a good but very unstable picture since the ridge is not providing any guidance.

Roller guide tilt: The roller guides (but not the fixed guide posts next to them) should be perfectly vertical. Sometimes there is an adjustment for this but usually not. Roller guide assemblies that have tilt due to wear will need to be replaced.

Likely causes for sudden change in tracking behavior

If it is impossible to find a position of the user tracking control that results in a stable picture, this section is for you. Some amount of the picture may be noisy - top or bottom - or the tracking may be fluctuating with a few second cycle.

Mostly, these symptoms are related to problems with the roller guide assemblies. (though electronic causes are also possible). The roller guides are on the assemblies that move on curved tracks to wrap the tape around the video head drum in play and record modes (and on newer instant start VCRs, other times as well). Each roller guide assembly includes a white cylindrical roller which should turn freely on a metal guidepost, and a fixed guidepost at approximately a 20 degree angle.

1. Roller guides not fully engaged against 'V-Stoppers' (the metal brackets at the end of the track on which the roller guide assemblies move when entering PLAY or RECORD modes. Common causes:

- Obstruction or ridge on track preventing guides from completing their movement. Visually inspect and observe behavior while entering and leaving PLAY mode. Sometimes with use, an edge develops and the guide gets hung up. A fine file can sometimes remove this.

- Parts have fallen off (don't laugh - JVCs tend to do this). Various parts of the mechanical linkage that move the roller guides may loosen with use and either fall off entirely or change position enough to prevent full engagement. Compare left and right roller guide assemblies, they are usually nearly identical in their operation and you should be able to identify parts missing or out of position. These are usually on the underside of the deck and will necessitate removing the bottom cover (unplug the unit!). To gain access to critical parts of the linkage which may be obscured by circuit boards or other components, you may need to power the VCR, turn it on, press PLAY, and then pull the plug just as the roller guides are in the middle of the track and accessible.

  For the JVC problems, the parts are usually either a brass post or a plastic link. The brass post can be glued back in place using a drop of Epoxy. Make sure its shoulder is fully flush with the body of the roller guide casting. For the plastic link, I have used a very small screw to secure it in place from above. Some plastic cement may work as well.

- Tracks on which roller guide assemblies slide are dirty and/or need lubrication. Clean and grease.

- Obstructions such as toys or Cheerios blocking tracks.

Check the roller guides while the machine is playing a tape. They should be firming pressed against the V-Stoppers. Any looseness indicates a problem preventing full engagement. If pushing the offending guide into position fixes the tracking problem, this confirms the diagnosis.

Note that in modes where the roller guides are retracted, the roller guide assemblies are relatively loose and free to move. However, the amount of movement possible should be similar for the left and right roller guides and you should not be able to lift either entirely off of the track - the ability to do so means missing parts underneath the deck. If the missing parts can be located, they can usually be glued back into position.

Warning: if you find a roller guide assembly that can be lifted off the track DO NOT attempt to load a tape - the floppy roller guide assembly can smash into the spinning video heads ruining them - and your entire day.

- One of the fixed guide posts next to roller guides (the ones that are tilted about 20 degrees) have worked loose and fallen off. There should be a tilted guide post next to each roller guide. If one is missing, it has probably fallen into the machine. Immediately unplug (to avoid the possibility of it jamming something and/or shorting components in the electronics). Locate the escaped post - turn the unit upside down, sideways, shake it, whatever until the loose post falls to the table or floor. Glue it back into position with a drop of Epoxy or other household cement.

- The backtension band has come loose or broken. The backtension band provides the force needed to keep the tape pressed against the video and audio head. A backtension lever on the left side just as the tape leaves the cassette is connected to a felt lined metal band that presses against the edge of supply reel. The position of the level determines the tension and is set up with mechanical feedback so that the tape tends to move it against spring force just enough to provide the correct amount. Test by moving the backtension lever a bit in each direction - you should be able to observe the tension change. Backtension bands are easily replaced. See section: Backtension adjustment.

- Mechanical damage due to trauma such as VCR falling off of TV. Cure, if possible, will depend in extent and type of damage.

Backtension adjustment

Most VCRs use a backtension band - a thin metal band with a felt liner - to apply a carefully controlled torque to the supply reel during forward tape motion in play, record, and CUE. A backtension lever or arm contacts the tape as it leaves the supply side of the cassette and provides feedback to control the tension on the backtension band and thus how much it resists the rotation of the supply reel.

If the backtension is too low, poor tape-head drum contact results and you get a noisy intermittent picture.

If the backtension is too high, there will be excessive head wear and in extreme cases, the drum will slow or stop entirely.

Backtension is normally set using a special backtension gauge which you most likely do not have. If you own a TV with a vertical hold control, you can adjust backtension by setting the vertical hold so that you can view the head switching point - just above the vertical blanking bar. Above this point, you see the video from one head and below you see it from the other. When properly adjusted, these two segments should more-or-less line up.

There are two adjustments for backtension: a spring position and the effective length of the band.

To set the length, there is a setscrew which allows the end of the band to be moved back and forth. It is unlikely that you would need to set this unless you have just replaced a band or unmucked someone else's repair attempt. I usually consider the length to be correct when the angle that the tape makes going around the lever post is about 90-120 degrees. In other words, the tape should not be so tight as to not be deflected by the arm but should not be so loose as to be near or at the end of its possible travel.

Then, set the spring force to align the picture above and below the head switching point. If you do not have access to vertical hold, you may be able to set backtension in the middle of the range where flag waving (see the section: Flag waving - top portion of picture wiggling back and forth) is absent or minimized.

No, you don't need a fancy back tension meter

(From: Alan McKinnon (alan.mck@pixie.co.za).)

Well, I'm about to open myself up to all sorts of scathing comments, but here goes: You can get by without a back tension meter. You will notice that just about every VCR ever made puts the back tension pole between a post and the impedance roller. Adjust the pole landing position so that it lines up with the middle of the impedance roller. Check your picture. If you have flagging at the top, or wavy lines, adjust the position. Fiddle it both ways to get the feel of it. Once you have experience, you can gauge the back tension by holding a screwdriver against the tape after it has passed over the full erase head. Your fingers are probably more accurate than most gauges anyway - I've never seen two give the same readings. My meter lies unused most of the time. I've lost count of the number of times I have chased around the VCR only to find my backtension meter was leading me astray.

More on adjusting backtension

(From: Paul Weber (webpa@aol.com).)

The objective of the back tension adjustment is to prevent "flagging" which is horizontal displacement of scan lines at the top of the picture. You can use either B&W or color TV (or video monitor), provided that the unit has an accessible vertical hold (vertical sync) adjustment. You mis-adjust it until the picture rolls half-way and you can see the horizontal sync bar. This lets you see the very top of the picture (just below the bar).

To make the adjustment, you need a known-good reference tape. You might trust a commercially-produced movie, but I'd recommend a real vcr alignment tape if you can find one. If you use a movie, then try four or five different ones to help insure you don't have one made on a defective machine. Adjust your machine so that vertical lines in the very top of the picture are as straight as possible.

As to the specifics of what to adjust on your machine: You didn't mention the make or format of your machine, but I'll wager that the moving arm nearest the feed reel is attached to a felt-covered metal band (the brake) that wraps partially around the feed reel table. With tape loaded and moving, the arm balances tape tension applied by the drive system against tension supplied by a spring. If the tape tension becomes excessive, the brake is applied more; if the tape loosens, the brake is relaxed. Look at the attachment points for the spring attached to the arm. Usually, the back tension adjustment is at the chassis end of the spring. It may be an eccentric post than can be turned with a screw driver or a special tool, or it may be that you have to gently bend the tab. Either way, adjust the spring tension in very small increments, then observe the effect on the picture.

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VCR Sensors and Tape Counters

Tape start/end sensors

VHS cassettes use a clear leader and trailer for the purposes of detecting beginning or end of tape. A light source that pokes up in the center of the cassette illuminates photodetectors on either side of the cassette through passages in the plastic passing through the tape as it leaves and enters the cassette. This is shown in VHS Cassette Showing Start and End Sensor Locations.

The light source can fail - this is common on older VCRs where this was an incandescent lamp but rare on modern VCRs which use a special IR LED. The failure of this light source can produce a number of symptoms:

- The VCR may simply shut down and refuse to do anything. VCRs with incandescent lamps often were able to figure out that the light bulb was burnt out since it was drawing no current and then shut down or flash an error code.

- The VCR may go through the motions of playing a pre-recorded tape thinking that a tape is present because the sensors return signals indistinguishable from what it would see if a tape were present. Eventually, it may give up and probably shut off power.

- The VCR may do strange things when you attempt to load a cassette since the microcontroller is receiving conflicting signals - the cassette is out but the sensors think otherwise.

If your VCR uses an incandescent lamp and it is not lit when power is on, then the bulb is most likely burnt out.

If either sensor fails open, then similar symptoms may result.

If the sensor on the supply side fails shorted, then it will appear as though the tape is at the end. The VCR may refuse to play or FF or will attempt to rewind as soon as a cassette is inserted.

If the sensor on the takeup side fails shorted, then it will appear as though the tape is at the beginning. The VCR may refuse to REW.

In both cases, sometimes you can trick the VCR into cooperating and confirming that there is a sensor problem by pulling the connector for the appropriate sensor once the cassette is loaded.

If you can get at the connectors, you can test the sensors by monitoring the voltage on the outputs.

One test you might try if the VCR attempts to play an imaginary pre-recorded tape as soon as power is turned on is to locate the microswitch for record lockout protection - it will be located near the front (where the record protect tab would be once the cassette is loaded). Press this in while you turn power on. If the VCR now just initializes and displays cassette-in without trying to play, then it really thinks there is a cassette in place most likely due to a faulty sensor.

In some cases, there could be other problems like a faulty mode switch or microcontroller producing symptoms that might be mistaken for faulty start/end sensors.

Start/end sensor testing

The start and end sensors are usually a combination of a light source (IR LED) and IR photodiode. With a little effort, these can be tested for functionality.

- For an incandescent lamp (older VCRs), if it is not lit with VCR power on, it is most likely burnt out. Test with an ohmmeter.

- For an IR emitter, an IR detector like the circuit provided elsewhere in this document or an IR detector card can be used to determine if the LED is operating.

You can also try powering the LED with a low voltage supply and 500 ohm or so resistor using the IR detector to see if it works. Disconnect it from the circuitry first! Try both polarities to be sure you got it right.

The sensors themselves can be tested by disconnecting them from the circuitry and shining an IR source on them (a remote control or incandescent bulb) while monitoring the resistance with a VOM or DMM. Use the polarity which give the higher reading (reverse bias). This resistance should drop dramatically if they are functional.

If the start and end sensor assemblies are interchangeable, swapping them may be instructive. For example, this may shift the symptoms from play to rewind or vice versa.

Tape counters

There are two kinds of tape position counters: reference and real-time.

What I call a reference counter is what all VCRs used up until a few years ago. A sensor counts revolutions of the takeup reel (usually) either directly or via a belt drive. A mechanical or electronic counter displays an arbitrary number which provides some idea of location. Since the rotation rate of the reel is not constant with respect to the actual time of the tape, it is not possible to use this for anything other than a reference. In addition, the tape may slip a bit and be wound tighter or looser depending on whether it was wound in play, FF, or REW. Thus, even the reference is not accurately repeatable.

Failures can be caused by a broken or weak belt for the mechanically operated counter or defective circuitry for the electronic display. A failed sensor would most likely also cause the VCR to shut down and unload the tape as this is what is used to confirm that the takeup reel is rotating and that tape is not spilling into the bowels of the VCR.

Real-time counters - which really are a vast improvement - operate off of the control track pulses from the control head. Tape location is measured in hours, minutes, and seconds though it is still relative and must be reset at the beginning of the tape if an absolute location is to be determined.

The only disadvantages of real-time counters are that:

- They do not operate with a new or bulk erased tape since there is no control track. Thus, it is not possible to leave a specific length section of such a tape unrecorded by using the counter to space over it. You must lay down a control track first by recording something - anything - for the time you want. However, it is advisable that this be a valid video source so that the sync pulses occur with the proper timing.

- The tape must be in contact with the control head for all operations. In principle, this results in more head (and tape) wear though I know of no cases of the A/C head stack requiring replacement because of this design.

Failure of the real-time counter on a VCR that otherwise works normally is quite unlikely and is probably an electronic problem since the control head must be functional for all record/play modes to work properly. However, it is possible that a failure of a half loading arm to fully extract the tape would result in problems in (non-search) FF or REW.

Reel rotation sensors

Reel rotation is detected most often using optical sensors under the reels though some older VCRs may use mechanical or optical interrupters driven off of belts from the reel spindles. The optical approach is depicted in VCR Reel Rotation Sensor.

- There will always be a takeup reel sensor - even on a VCR with a real-time counter. It has two functions: to (1) confirm that the reel is rotating and that tape is not spilling into the bowels of the machine and (2) to operate the (non-real-time) tape counter.

  Failure of this sensor will cause the machine to shutdown almost immediately and will result in a stuck tape counter.

- Some VCRs will have a similar sensor on the supply reel. The output from this sensor can be used to confirm proper rotation of both reels both during modes involving tape motion as well as during the tape load and unload operations. Exactly when each is used will vary by design.

  If your VCR has identical sensors monitoring both reels, swapping the sensor assemblies may be instructive: the behavior will change if one is bad. For example, a VCR that would shut down in a couple of seconds in play mode may continue to operate correctly but now have problems with rewind.

- Some fancier VCRs will display an estimate of tape remaining using the difference in rotation rates of the supply and takeup reels based on assumptions about tape thickness, hub size, and total length (which you may have to tell it).

- Sometimes, reel rotation sensor problems are simply due to accumulated dirt on the reflective surfaces - clean them. In other cases, replacement sensors will be needed. While you are at it, replace both sides where appropriate - most of the cost to you is in your time, the cost of the sensors themselves is modest.

Note that on VCRs with real-time counters, the real-time display as well as possibly the tape movement sensing operates off of the A/C head control pulses. Failure here could be due to dirt, a bad A/C head, tape path alignment problems, or failure of a half loading arm to properly extract the tape so that it contacts the A/C head.

Reel rotation sensor testing

The counters on some VCRs are active at all times - rotate the appropriate reel and the counter will change (count up or down depending on its default mode - the direction of rotation probably will not matter). If your VCR is of this type, testing is particularly easy. Slowly rotate the takeup (usually) reel by hand. The numbers should change several times - probably 4 - per revolution. There should be no missed counts and there should be no positions where the counter free runs - the display increments or decrements on its own very quickly. Any of these could indicate a problem with the sensor or LED, a buffer amplifier, bad connection, or the microcontroller or other IC that actually drives the counter and display.

For electrical tests, first, locate the LED and photodiode. You can tell the difference by testing with a DMM on its diode test scale - the LED will have the higher forward voltage drop. Sometimes, the connections are even marked. What a concept!

Momentarily touch and remove a resistor (1K ohms or so should work) across the sensor leads (while the VCR is in PLAY mode before it quits if needed). This should make the counter change if the the LED is bad or the photodiode is open. Alternately, a remote control may be able to activate it providing pulses that will look to the counter exactly like reel rotation.

If this has no effect, unsolder the sensor (or unplug the sensor assembly from the main board if there is a connector) and try the resistor across the terminals where it was connected. If you now get a response, the sensor was shorted (or the connection was bad).

If you do not get the counter to change in either case, there is a problem with an intermediate buffer amplifier, the electronics on the main board, or a bad connection leading to the main board. You will need to obtain the service manual or trace the circuit leading to where the sensor signal is detected.

It is possible that the counter will only change when the microcomputer expects the reel to be moving, so a test while in STOP mode may not be valid.

An alternative test is to use an ohmmeter across the photodiode on a high ohms scale. Use the polarity which gives the higher resistance and shine a light on the sensor. The resistance should drop dramatically with a bright incandescent light (these put out a good amount of IR). If it is infinite in both directions, the photodiode is open. If it is low in both directions, it is shorted. You may be able to make a measurement while the sensor is still in circuit, though other components may mask the resistance change. As noted, the IR sensor/LED combination is often a pluggable assembly. Using my VOM on a photosensor, I read infinite ohms with no light and 200 ohms with a bright light. However, your mileage may vary.

If you have an oscilloscope, monitor the sensor output. If it is a voltage signal at this point (likely), then you should see it go high and low as you rotate the reel or shine light on it. With the reel rotation, the low and high periods should be roughly equal. There may be a buffer amplifier driven by the sensor - check its output as well. The signal there should be a cleaned up version (low pass filtered and possibly inverted) of the sensor output. In all cases, the signal should be a DC value without noticeable ripple or noise (block external light as fluorescent lamps in particular may add a 120 Hz ripple to your detected signal). Even at transitions between low and high or high and low, the level should change smoothly. You may be able to trace the signal to its final destination, the microcontroller or other large multilegged part, and monitor it there as well.

Play a T120 tape recorded at EP speed near the end of the tape. This will result in the slowest takeup reel rotation. Or, if your VCR has the counter active in stop mode with the cassette out, rotate the takeup reel by hand very slowly.

If the counter skips or 'free runs' at certain positions of the reel, there may be a problem with the hysteresis circuit. If this is external to the microcontroller, a resistor may have opened or there may be some other easily identified bad component. If it is internal to the microcontroller - either an actual circuit or firmware - then replacing the microcontroller may be the best solution unless you want to add your own circuit - I have done this to repair a Sears VCR with an erratic counter problem. It is a simple 1 or 2 transistor circuit (depending on what external circuits are already present).

Monitor the sensor output when rewinding a T120 tape to the very end - this will be the worst case test as the pulses will be at the highest rate. There should be no missing pulses and the high and low times should still be similar. A bad sensor might result in unequal high and low times and dropped pulses at high speed.

Stan's tips on reel sensors

(From: Stan Cramer (stvcrm@Gramercy.ios.com).)

Try removing the take-up reel disk. Look on the bottom surface to see if there are a series of pie-shaped vanes - shiny, dark, shiny, dark, etc. If the shiny vanes get misted with smoke or general grak, the symptom is the same as if the sensor itself is faulty. Use some Windex or some such mild cleaner on the vanes and test the machine again.

On some earlier machines, the take-reel disk might have a series of evenly spaced slots - blank,solid,blank,solid etc.- that interrupt the flow of IR light creating an electronic pulse stream. If your machine has this type of motion sensor, you can try brushing or blowing out the dust that may have accumulated in the small recesses surrounding the IR emitter and receiver devices on the sensor assembly.

If these attempts don't do the trick, you probably have a faulty sensor.

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Motors and Rotors

Types of motors in VCRs

There may be anywhere from 2 to 6 or more motors in your VCR. Some designs use a single motor to power all functions except the video head drum. Others have separate motors for each function. Most typical are 3 or 4 motors. Motors perform the following functions:

1. Cassette loading (front loaders only).
2. Tape loading (position tape around video head drum, etc.).
3. Video head drum rotation (servo controlled).

4. Capstan rotation (servo controlled).
5. Takeup reel rotation (PLAY, REC, FF, CUE).
6. Supply reel rotation (REW, REV).

The video head drum (3) always has its own motor. It is internal to the lower cylinder or above the upper cylinder (except in the very oldest VCRs) and directly drives the spinning upper cylinder.

Most consumer VCRs use a single motor for the capstan and the takeup and supply reels. Some also use this same motor for cassette and/or tape loading. Several possible types of small motors are typically used in VCRs:

Small brush-type permanent magnet (PM) DC motors similar to those found in small battery operated appliances, CD and tape players, and toys may be used for cassette loading and/or tape loading.

1. A similar but larger PM motor may provide power for the capstan and reel rotation and possibly multiple other functions (older VCRs).

2. A single low profile or 'pancake' brushless DC motor may provide power for a direct drive capstan, reel rotation, and possibly multiple other functions.

3. Brushless DC or 3 phase direct drive motors are usually used for the video head drum. Some of the very earliest VCRs used a belt drive for the video head drum.

Testing and repairing small motors

Aside from obvious mechanical problems and lubrication if needed, you usually cannot do much to repair defective motors. If you enjoy a challenge, it is sometimes possible to disassemble, clean, and lubricate a motor to restore it to good health. However, without the circuit diagram, even knowing what the proper voltages and signals should be on (2) or (3) type motors would prove challenging.

The following are some of the possible problems that can occur with the basic permanent magnet motors:

- Open or shorted windings or windings shorted to case.

- Partial short caused by dirt/muck or carbon buildup on commutator.

- Burnt out armature due to defective driver, power supply, controller, or mechanical overload.

- Dry/worn bearings.

An open or shorted winding may result in a 'bad spot' - a position at which the motor may get stuck. Rotate the motor by hand a quarter turn and try it again. If it runs now either for a fraction of a turn or behaves normally, then replacement will probably be needed since it will get stuck at the same point at some point in the future. Check it with an ohmmeter. There should be a periodic variation in resistance as the rotor is turned having several cycles per revolution determined by the number of commutator segments used. Any extremely low reading may indicate a shorted winding. An unusually high reading may indicate an open winding or dirty commutator. Cleaning may help a motor with an open or short or dead spot but most likely it will need to be replaced. Note that unlike a CD player which uses some motors constantly, the small PM motors in VCRs are only used for loading operations and are generally quite reliable unless damaged by other problems.

For more information on small PM motors, see the chapter: "Motors 101" in the document: Notes on the Troubleshooting and Repair of Small Household Appliances and Power Tools.

Capstan problems

Capstans are expensive especially if they are integral with the capstan motor, but unless it is bent (very unlikely), or the bearings are totally shot, or it is direct drive and the motor is bad, the capstan should not be a problem as long as you **carefully** clean off all of the black tape oxide buildup with alcohol and a lint free cloth or Q-tips. Don't get impatient and use anything sharp! The black stuff will come off. A fingernail may help. A dry bearing may need a drop or two of light oil (electric motor or sewing machine oil). Sometimes, there is a bearing cover washer that works its way up and interferes with the tape movement. Push it back down.

Some Sony VCRs have had problems with defective capstan motors resulting in intermittent pausing or stopping of video playback when hot. The entire motor or just the bearing assembly needs to be replaced in this case.

Some capstan motor information

(From: Mike Whitmore (whitmore@jila.colorado.edu).)

VCR capstan motors are servo-controlled to allow precise speed and phase control. Typical signals are:

> VCC - power to chip/motor- probably 9-12 V
> FG - frequency generator output from motor to servo loop
> CTL - control track pulse from Audio/Control head
> F/R - forward/reverse (one high, one low)

There will probably be other connections for a variety of servo voltages, braking, grounds, etc. - You may need to find service literature for this VCR or the datasheet for the particular driver chip to get more info. Data will also tell if motor is 3-phase. This is common for many capstan motors and would require this IC to run it.

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Items of Interest

Why is a tracking control needed

In order for the video to be read off of the tape properly, the spinning video heads must be centered on the very narrow diagonal tracks. The width of these tracks is as small as .019 mm. The actual reference point is not on the video heads but the A/C head - several inches away. The control pulses put down during record are used to phase lock the capstan to the spinning video heads. The distance between the control head and the video heads determines whether the required centering will be achieved. In the ideal world, the distance would be identical for all VHS VCRs - that is the goal. It is part of the VHS specification.

However, whether from wear and tear, or even if the technician doing the setup in the VCR factory had an off day, this distance may not be quite identical on the VCR that the tape was recorded on and the machine being used for playback. Therefore, a way is needed to adjust the effective distance. A mechanical control would be possible but not very elegant. Therefore, an electronic tracking control is provided. This basically allows adjustment of the time delay or phase of the control pulses from the control head during playback. Record tracking is fixed. Actually, there may be as many as three tracking controls: (1) the user tracking knob or buttons, (2) an internal master tracking adjustment, and in fancier models, (3) an autotracking servo system. (Note: tracking is always automatically reset to the default when a cassette is inserted.)

VCRs with 2, 4, 6 or more heads - what is the difference?

A single pair (2) of heads is needed for basic record and playback. With more heads, various aspects of these functions can be optimized to improve picture quality - usually for the special effects like CUE and REV. For example, a 4 heads are usually needed to produce decent quality playback in CUE and REV modes for SP recorded tapes.

Another set of heads is required for HiFi audio.

The only possible difference for record or at normal playback speeds is in picture quality since with 4 or more heads, head widths/gaps can be better optimized for each speed. For example, a wide track width can be used at SP speed and a narrower one for EP speed. Which VCRs do this, I have no idea. In fact, such differences might only be visible to the average viewer in an A/B comparison under controlled conditions.

The stability of the video playback has nothing to do with the number of heads. A jumping picture during playback is due to a servo system problem. With problems of this type particularly on a new VCR commercially recorded or rental tapes, it is more likely that the VCR is having problems with some kind of copy protection scheme.

Which combination of heads are used for what modes?

The quick answer is: "almost any combination which includes at least one head of each azimuth angle on each side of the video drum" :-).

For a 4 head VCR, this may even include all 4 at once. In this case, signals from both heads of the pair on each side of the drum are monitored and the one with the greatest amplitude is sent to the video circuitry. This provides clearer special effects for SP recorded tapes in particular - CUE, REV, SLOW, and PAUSE - where the video heads may be crossing tracks of both azimuth angles. Such an approach may be called a 'double azimuth' design by the manufacturer.

For record and play modes, an opposing pair will be used but which pair will depend on speed - EP, LP, SP.

Thus, almost anything is possible and it gets to be confusing very quickly! Don't count on finding this information in the service manual either.

More on 6 head VCRs

(From: Paul Weber (webpa@aol.com).)

A six head (VHS) vcr has 4 video heads and 2 audio heads on its rotating upper cylinder. The 2 audio heads record VHS Hi-Fi. They are about 1/3 the width of the most narrow video heads (about 6 microns). A four head machine lacks the audio heads and is therefore incapable of playing or recording Hi-Fi. There are also 2 head machines on the market. They use the same pair of video heads for all tape speeds. 4 and 6 head machines use the 28 micron wide heads for SP (highest speed), and the 19 micron heads for LP (middle) and EP or SLP (slowest) speed. Some machines have a 7th head: the flying erase head. It is about 40 microns wide, and when activated, can erase the recorded tracks of both video fields that make up a frame. Most vcrs use all 4 video heads to smooth out the picture when scanning in fast forward and rewind. This is why 2 head machines have much more noise in the picture when scanning.

Machines that have a switch to turn off the 19 micron heads do so in an attempt to improve the playback of tapes made on old 2-speed (SP and LP) machines. These machine had video heads that were something like 22 microns wide, and scanning them the narrower heads of a modern machine sometimes produces unacceptable results.

Compatibility problems between machines are a fact of life because of mechanical differences. Recording at the highest possible speed minimizes problems, but hi-fi audio tracking problems can happen even then because the tracks are so narrow. If you have video tracking problems between 4 and 6 head machines on tapes recorded at the highest speed, it is because of mechanical differences, not because of the number of heads on the machine; the number of video heads is identical. The differences are in the alignment of the audio/control head that controls synchronization of the video upper cylinder, and in alignment of the video heads themselves.

Choice of SVHS or high quality 4 (or greater) head VHS VCR

SVHS won't be better than a good 4 head (+2 HiFi) unless:

1. You use high quality (read: expensive) SVHS type tapes (usually, there may be exceptions and some people claim that premium VHS tapes will work for SVHS recordings if the proper hole is drilled in the case but don't count on it).

2. The recordings are actually made in SVHS mode.

3. They are played back on another SVHS deck.

Since few people have SVHS decks, there is probably little benefit if the objective to to make high quality recordings to share.

I would probably go with a good 6 head (including 2 HiFi) since it will be compatible with everyone.

However, just saying it has 4 or 6 or 25 heads doesn't mean it will produce a high quality result - there is a lot of variation in video and to some extent HiFi audio quality.

About VISS and VASS

I assume VISS stands for "VHS Index Search System" or something similar. In any case, VISS and VASS provide the means to mark the start (usually of a video segment so that it can be accessed quickly later on.

> "How standard is this system? My Goldstar VCR has VISS and now I see reference to an LXI brand with the same system. I've heard of other VCRs with functionally similar features, but never had the opportunity to try exchanging tapes. Do they use the same marks? When my Goldstar finally bites the bullet (beyond my powers to resuscitate it), will the collection of indexed tapes I've built up be useless, or will another VCR with indexing features find the marks that Goldstar put on them?"

(From: Ed Ellers (kd4awq@iname.com).)

VISS is a real standard, issued by JVC in 1986. There is also a VASS -- VHS Address Search System -- using the same techniques, but it was taken off the market in 1988 after a patent infringement suit by a German company; JVC settled that case, but VASS never came back (at least not in North America); JVC later developed a more sophisticated system called CTL Coding, but it's not used on consumer VCRs over here either. VASS records four-digit codes instead of a single index mark; CTL coding records an actual time code on the control track, and also provides for VISS and VASS use.

Incidentally, VISS and VASS work by altering the duty cycle of the 29.97 Hz square wave recorded on the control track; the servos still work on the average phase of the signal, but the changes in duty cycle are decoded into a slow bit stream. Before VISS was developed a number of VHS VCRs had a different indexing system that recorded a low-frequency signal across the entire tape, using a special head on an arm that contacted the tape while it was rewound into the cassette; these index codes could only be placed at the beginning of a recording and couldn't (then) be read except during rewind and fast forward modes. Theoretically a modern VCR could be made to read this signal using the control head, but this would require a special circuit to be added; I don't know of any VISS-capable decks that can do this, and given the small number of recordings likely to still exist with the old index signal it wouldn't seem to be worth the trouble.

How does the "commercial skip" feature work?

(From: Matt Kruckeberg (sackmans@ndak.net).)

My understanding of commercial advance is that the program is monitored during recording for fade to black and silent audio between programming and commercials and between commercials. The microprocessor stores these events in memory until the recording session is over. It then analyzes these events to determine whether an event was part of a group of commercials or just a dark silent passage of programming. The tape is then rewound and the beginning and end of the commercial groups are marked with special start and end signals recorded on the control track, similar to index search marks. During playback with the feature activated the unit will automatically forward search when a start signal is detected and resume normal play when an end signal is detected.

Old clunkers and the march of technology

It always amuses me to listen to comments about how anything older than 6 months (or 30 minutes) should be tossed in favor of some newer, more cheaply made piece of crap. Yes, convenience features and HiFi audio have made newer VCRs a lot nicer in many ways. But for time shifting and the kids, that old clunker will do just fine, thank you. Some of the older VCRs will just keep going and going and going and going with a cleaning and a few rubber parts from time-to-time.

On the other hand, I had to repair my high-end (for 1990) moderately used Mitsubishi VCR because a 10 cent plastic part broke (their cost, my cost - $10) - clearly an exercise in design-to-fail engineering. For about 0.5 cents more, it could have been built never to fail. The replacement part was identical to the original, so I give it about 4 years.

Comments on quality of consumer electronic equipment construction

(From: Stan Cramer (stvcrm@Gramercy.ios.com).)

In recent years, the rapid decline in the quality of construction of VCR's has been widely chronicled here and in other forums. Through all of this criticism, I have staunchly defended JVC as the last bastion of construction integrity! Alas - no more!

Tonight, I had the occasion to open up a JVC HR-J620U and was shocked at what I saw! I am sad to announce that even the once venerable JVC has sold out to the concept of making machines really light and really, really crummy! This new JVC transport is the epitome of designing "throw away" machines - even worse than the transports offered by

Matsushita or Funai! Glaringly absent is the modular power supply. You may no longer fall back on the last resort - replace the power supply! Folks, this is just an unmitigated piece of unadultered crap!

As both a consumer and a VCR technician, I am truly offended by the shoddy construction of all new VCR transports and, in particular, by the caving in of JVC to make machines geared to the lowest common denominator. All of us should be outraged!

(From: Greg Monbourquette (gregm@globalserve.net).)

I too am concerned about the lack of care that the engineers who put these things together take when considering the amount disassembly required in order to only clean a lousy belt. (I'm talking mostly about the RCA/GE models with a plastic plate covering the bottom of the VCR) And yes there was once a time when you could buy/sell a vcr and KNOW that the customer won't have any problems for at least 5 years . I tell my customers all the time when they finally decide that the 15 year old TV that finally died (for the first time) will be replaced by a new one, " don't expect 15 years out of any TV you buy today. Oh well we've (I've) ranted long enough. I now know my feelings aren't only mine.

(From: CLSNOWYOWL (clsnowyowl@aol.com).)

I have been doing repair for 15 years and I can actually tell you that during my career as a technician, I have actually seen the actual quality get worse over time on all electronics devices, including VCR's for three basic reasons:

1. When I first started repair, the VCR's and other devices with a mechanism actually had hard, rugged metal that used to cut my hands when I opened the chassis in getting at the critical components of a mechanism. The gears were also made of a fairly heavy metal. The main gears often did not break or strip. Many of the key problems of those older type devices (namely VCR's) were rubber belts and idlers.

   In today's devices, I see brittle plastic gears that actually break just from use and I can actually bend the metal in the devices with my bare fingers, if I apply any real force at all.

2. I liked the older style tuner that could actually pull in a station, even if you received a partial signal. These tuners had really good quality electronics in them and were fairly resistant to even higher powered signals going into them.

   The newer type tuners actually will only display a channel if a picture actually comes in clearly. If the channel barely comes in or comes in even fairly decently, you get a blue screen.

3. The tolerances of electronics components of 10 + years ago were fairly liberal and allowed for a plus or minus 10% error, which meant that the failure rate of those components in the electrical sections would be much less likely.

Today's devices use components with very strict electrical tolerances of say plus or minus one to three percent (1-3%), which means that in the newer devices, the likelihood of a failure is anywhere between 67%-90% more likely.

It is clear that I have more margin of error on an electronic components from plus or minus 10% or even plus or minus five percent than I do with a component that has a plus or minus 1 to 3%.

So, for these three reasons, the overall quality of the actual manufacture of new electronics devices has gotten significantly worse than a device made back in 1990 or before.

Can I add an S-Video input to my VCR?

Possibly, but why bother? You will most likely be limited by the VCR's circuitry anyhow.

All S-Video means is (1) a special connector and (2) separate luminance (Y) and chrominance (C) rather than composite video.

In a VCR, you will need to bypass the input circuitry and get to the place where Y and C are separate. This may or may not be possible depending on its design.

It is probably not worth it as you will likely not gain much in picture quality but if you really are determined, a schematic will be essential.

If all you want to do is allow for an S-video input, there are single chips which will combine the Y and C into a normal composite video signal.

Can a VHS VCR record single video frames at a time?

It would be nice if it were possible to output still frames from a PC, for example, to record computer animation on video tape. This would permit images to be generated slowly and then played back in real-time.

However, there are a couple of problems with attempting to cleaning record single frames on a consumer grade VCR:

- Without moving the tape, only a single field (of the two interlaced fields in a video frame) can be recorded since the tracks for the A and B heads will be superimposed. I doubt that any VCR not specifically designed for single frame recording has any support for moving the tape in this manner.

- The control and synchronization circuitry to cleanly switch the record for a single frame may not exist. This will depend on the model - the more sophisticated the editing functions that are supported, the more likely that this precision will be supported.

- The VCR must have a flying erase head or you must use new or pre-erased tapes to avoid the rainbow interference on the first few hundred frames of any recording made over old video.

Other than that, there is no reason that the video writing circuitry cannot be turned on during pause - some VCRs will do this if you go into record mode while in pause.

Obviously, anything you can do from the front panel or remote you can do under computer control. There could be hidden functions accessible via a special connector or key sequence but you would need documentation for your unit which may not be readily available, if at all.

Controlling one or more VCRs from a PC

Here is one approach to using a PC to program multiple VCRs. Obviously, the techniques described below can be extended to more complex functions. Feedback could be added to inform the PC of end-of-tape or other fault conditions.

(From: Bill Mohler (bill@cs.oberlin.edu).)

We did a project to control multiple VHS VCRs where time and cost were major factors. Our VCR's were the same brand (assorted models with same IR codes), so we hacked a remote to interface to a PC's parallel port. The basic idea was to have the PC select a VCR then "push" a button for function.

The remote hack was simply an analog switch (TTL input) across the switch contacts and a 754XX peripheral driver to select an IR LED mounted right in front of each VCR's IR window.

The software was simple. We only needed 4 VCR's and 4 functions, so we split the 8-bit printer output into two 4-bit commands ("VCR select" and "function") and "poked" away. Not bad for a days work.

You could use decoders or the printer control port to get the extra "bits" you need.

Using a VCR overseas or vice-versa

Some VCRs and TVs may have a selector switch or be universal but you would have to check the manual.

Power wise using a transformer will probably be fine. The power line frequency is not used for anything in the TV or VCR except possibly the clock on the VCR which will run slow or fast.

Standards differ and you won't be able to watch or record broadcasts/cable unless your equipment supports multiple standards.

Differences in blank VHS tapes between US and Europe

The only difference between using a blank tape purchased in the US then used in the UK is the playing time will be different ie, a T120 (2 hours) from the US will have a longer playing/record time in the UK. This is due to the different head drum speed i.e., 60 Hz (1800 RPM) and 50 Hz (1500 RPM).

Why is a special VCR needed for multiple video standards?

A VCR is not simply 'analog playback' in the same way that an audio recorder doesn't care whether you record classical or rock. The VCR must synchronize to the video timing and demodulate the luminance and chrominance information in order to lay down the tracks on the videotape. There are enough differences among world video formats that while technically possible (and such multiformat VCRs exist) it is not automatic - or free. The video timing and modulation techniques for video formats like NTSC, PAL, SECAM, etc. are sufficiently different that additional circuitry is necessary to handle multiple formats. In the U.S. at least, there is not enough demand

to justify the added expense.

The technology of video recording makes interesting reading and the sophistication of the circuitry and mechanism of a $200 VCR is quite amazing.

TVs are more likely to accommodate difference standards than VCRs. Even a regular TV may be able to be used to play from a different standards VCR. For example, NTSC 30/525 and PAL 25/625 use very similar horizontal frequencies but different vertical rates and color encoding. Playback will be possible (in B/W at least) if the vertical lock circuitry (or the vertical hold control if there is one) on the TV has enough range. A simple color code converter can then be easily constructed using a couple of chips and some discrete parts.

Recording HiFi audio only on a HiFi VCR

The use of a $2 T120 tape with a HiFi VCR permits the recording of up to 2 hours of audio with near-CD quality.

However, some designs require a video input to stabilize the drum speed and possible degradation (e.g., wow and flutter, noise, etc.) of the recorded audio. Some VCRs will work fine without any video. Others need it to stabilize the drum speed from the vertical sync. For best results of audio-only recording, find a source of video-black such as a camcorder with the lens cap on to minimize possible video interference (though this is usually not a problem).

Stereo output from VCR RF connector?

(From: Mike Appenzeller (Michael.W.Appenzeller@lmco.com).)

I don't think any stereo modulators exist, other than very expensive professional models. The processing for TV stereo sound is much more complex than FM stereo, involving dbx companding/NR on the L-R difference signal. Hi-Fi VCRs mix the two audio channels together before feeding a mono-audio modulator.

I laugh at all the people who buy a Stereo TV, HiFi Stereo VCR, then insist on using the Channel 3/4 VCR RF outputs instead of the direct A/V connections.

They are getting MONO Sound!

Dubbing only video and linear tracks on HiFi VCR

"Is it possible to rerecord the video (and linear audio) tracks but preserve the HiFi audio?"

You cannot do this without disabling the erase head(s). If this is done, you will get interference from the previously recorded video - the rainbow patterns present at the beginning of recordings over old material on VCRs without flying erase heads.

Even if it were possible, I don't know how robust writing over the HiFi audio tracks would be - you might get degradation after 1 or 2 dubs.

Can I use an Uninterruptable Power Supply (UPS) to retain the programming?

Some VCRs do not have much of a long term memory should there be a power failure. Can a UPS designed for a computer system be used with these VCRs so that all the programming (and possibly channel settings as well) are not lost every time the power line burps?

A UPS might be a solution but there are some issues to keep in mind:

- If your VCR uses a switching power supply (with no input power transformer), it may be fine as the waveform does not matter that much. If it uses a power transformer, then there could be problems if the waveform put out by the UPS is far from sinusoidal - which it likely is.
- The VCR is a very light load. I don't know if this could be a problem with some UPSs.
- The inverter in a typical UPS may generate Radio Frequency Interference (RFI) but this probably doesn't matter

if it only runs when the power fails and you aren't viewing or recording at the time.

If your VCR recently developed this amnesia, then you might consider attempting to locate the cause (a shorted NiCd backup battery or bad supercap) and correcting it rather than tying up a UPS for this purpose.

Can a VCR be used for computer backup?

The answer is yes but I would not recommend it. In order to provide reliable backup, totally error free storage and retrieval must be guaranteed. This is a non-trivial problem given that the video tape is an analog storage media prone to noise and dropouts. Redundant information would need to be stored and sophisticated error detection and correction circuitry must be included. By the time you are done, the theoretical capacity of a T120 video cassette of, perhaps, 5-10 GB is greatly reduced. Furthermore, you probably want somewhat rapid random access and this **will** be very hard on a consumer grade tape transport designed for movie viewing and time shifting of soaps.

With the cost of reliable tape and disk storage units having enough capacity to backup a 1 GB hard drive available or on the way for less than $200, it doesn't make sense to use a VCR with a totally incompatible format and questionable reliability when you will need it most - in a data emergency.

I have no idea if the following is any good - I kind of doubt it - but various products of this type were developed before devices like cartridge tape (and now the Zip(tm) drive) backup became popular.

(From: Robin Gilham (gilham@stb.dfs.co.za).)

I saw an ad for a plug in card and software only yesterday, claiming 2G of storage on a 240 minute VHS tape. Wait.... yes, here it is.

The product is called "BACKER", and in .nl available from Timtronics (+31-50-314 0937). Comes with interface card and Windoze software, will backup harddisks at speeds of up to 9MB per minute for DFL159 (which is less than US$100).

(From: then@superpallo.cs.hut.fi (Tomi Holger Engdahl).)

The manufacturer of BACKER is Danmere Technologies Ltd and they have WWW-pages at http://www.danmere.com/. What they claim by 9 MB per minute, that is the data rate at the maximum speed, maximum compression and minimum error correction. The uncompressed data rate is 5 MB per minute at highest speed.

(From: Karl-Henrik Ryden (kalle@pobox.com).)

I have one of their cards. It works, but is rather tedious to use. It is kind of like in the old ZXSpectrum/VIC64 days. :-)

How can I use an old deceased VCR as a sophisticated appliance timer?

First, you might be able to repair the VCR and prolong its life. Why are you reading this section and considering such a transgression? Grrrr.

OK, so you really want to just use its timer. There are two things you would have to do:

1. Trick the transport into thinking there is a recordable tape in place even though there is none. Then you don't have to worry about your non-recorded tape from running out or wearing out. This shouldn't be that hard. A

cassette shell may come in handy for this. Depending on the VCR, it may be sufficient to block the start/end sensors. Some may require that the takeup and supply reels (inside the cassette shell or the reel tables of the VCR) be linked with a rubber band or old belt so that one turns the other during initialization.

2. Find a signal that can be used to control a relay, solid state relay, or optoisolated triac. If you are electronically inclined, this should not be too hard. If nothing else, the record LED or any switched power bus would suffice. A solid state relay or optoisolated triac takes a logic signal and will control a resistive AC load. Check the specifications if you want to control some other type of load like a motor or external tape deck. A suitably rated normal relay could also be used but a driver circuit may be needed to power the coil.

   Some (rare) VCRs have a switched outlet in which case this is trivial.

Can I control the tuner from a VCR using my PC?

Perhaps, you have this fantasy:

> "I'm wondering if it's possible to take the tuning circuit (tuner and associated circuitry) out of a VCR and somehow controlling it with a PC (say through the parallel port), and then feeding the composite signal to the input of a video capture card?"

If removed from the VCR, you will need the complete specs on the digital interface between the VCR's system controller and the tuner (assuming it isn't on of those old types selected by mechanical switches!), as well a substitute power supply. This information may not be available even if you purchase the complete service manual. However, you may be able to infer it by monitoring the relevant signals with an oscilloscope or logic analyzer :-).

An easier approach may be to use the entire VCR intact and interface via the front panel (by simulating the Chan +/-, TV/VCR, etc. buttons) or via IR by simulating its remote control.

What is a delay line and where is it used?

The question you originally asked might have been: What is this alien looking thing in my VCR?

The object in question may look like a pentagonal shaped frosted glass slab with two pairs of wires sticking out of adjacent edges. What it is, is an acoustic delay line implementing a one TV line (1H) delay - around 63 microseconds (NTSC). The crystal is a shaped cavity and the polished edges are acoustic reflectors. There are a pair of piezoelectric transducers - one to launch a wave and the other to pick it up. The acoustic waves bounce around in a zig-zag pattern which increases the effective path length, thus the unusual shape.

Uses in a VCR include a comb filter and tape dropout masking.

The comb filter is part of the chroma circuitry and computes the sum of the current and previous video lines during recording and playback. The acoustic delay line therefore implements a delay of exactly one horizontal line. Due to the various games that are played with chroma signal phase in the NTSC-VHS system (as well as Beta and PAL), the end result is that chroma signal amplitude is doubled and crosstalk between adjacent tracks is canceled out. This is because the chroma signal is always exactly in phase between successive video lines but the crosstalk between adjacent tracks is always exactly out of phase. The name 'comb filter' is derived from the shape of the frequency response of the comb filter - its evenly spaced spikes look somewhat like a hair comb and it is used to 'come out' the crosstalk components of the chroma signal.

Another use for am acoustic delay line is dropout masking. The surface of the tape is not always perfect - bits of oxide fall off or slight dips or bumps result in momentary loss of head-tape contact. One way to minimize visible streaks in the video is to replace the lost signal with video from the previous scan line.

Nothing alien about it, just not your everyday electronic part.

Comb filters in camcorders?

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

There is no need for a comb filter in a camcorder!

Signals from the CCD are not first combined into CVBS to then be separated by a comb filter again. That would make no sense.

(However, since modern camcorders are full function VCRs without a tuner, this function may still be needed for dealing with external video input. --- sam)

Other applications for delay lines are drop-out compensation and delay equalization between luminance and chrominance.

Did you ever wonder what happened to the ultrasonic glass delay lines that were once used by the millions in every PAL television, for U/V separation? They were replaced in nearly *all* applications by the Philips switched capacitor delay lines TDA4660(-61,-62).

(From: David Lawson (dlawson@ime.net).)

the color signal(chroma) takes longer to process than does the b/w or luminance channel so to get the color to line up with the b/w picture, the B/W signal has to be delayed slightly.

What are photocouplers and how are they different than optoisolators?

You have probably been unable to sleep at times thinking about this subject!

They are similar - perhaps identical in some cases as the terms both mean the same thing. If there is no optical output/input, then they are likely the same type of device.

Optoisolators are used the switching power supplies to couple the feedback from the low voltage to the line-connected (non-isolated) input.

With 4 leads, these are a combination of a an LED and photodiode or phototransistor.

With 6 leads, there may be additional circuitry providing a logic level output, or base connection to the phototransistor, or just extra unused pins.

Photo interrupters or reflective sensors are used for detecting reel rotation cassette presence, and mechanism position. In this case the optical path - either direct or reflective - is external to the device.

A datasheet will clarify any functional or circuit details.

Photo interrupters or reflective sensors are used for detecting reel rotation Testing is accomplished (1) with a multimeter for shorts or opens on the LED and (2) by providing drive to the LED and checking the resistance of the photodiode or phototransistor with a multimeter - it should go down dramatically if the LED is on.

Also see the sections on sensors and sensor testing.

Why are there so many different designs for VHS transports?

Don't expect an amazing answer - this is a set of questions.

Why are there so many totally different designs to do basically the same thing? I fully understand the pressures of cost and manufacturability. However, it would seem that with VCRs, for example, every manufacturer (of which there are only a limited number who actually manufacture the tape decks themselves) and every couple model years has a totally unique design. You would think that after almost 20 years of manufacturing VHS decks, the technology would be mature. True, there have been advances with respect to quick start, HiFi, and so forth. Nonetheless, the required functions have not changed. And, for that matter, the performance of the typical mechanical deck has not improved that much in the last 10 years or so. If anything, the old designs seem to be remarkably robust. I can keep a 10 year old machine going virtually forever by replacing the rubber every few years. I am not sure that I can say the same of a modern VCR.

Is it only a matter of maximizing performance at a given cost or is there something more? NIH syndrome? Maintaining control over repair parts and service? Or, use of entry level engineers who might provide a new outlook on the design?

Service center honesty?

After taking your totally dead VCR into an authorized service center, it is a month and still no diagnosis. When pressed, they finally 'discover' that a diagnosis has been made and the estimate is $80.

The repair place is jerking you around. It should not take them as long as you have experienced to make a diagnosis - especially if they are authorized and have the service manual. They like the really easy problems like "My VCR started eating tapes last week. Is it hopeless?" 50 cents worth of rubber (idler tire), charge $50 - easy money. And they appear to be heros. To fix the electronic problems you need at least the intelligence of a carrot and time - and time is money. OK, so maybe they give a quick cleaning also.

If it were my VCR, I would bitch, moan, claim poverty, threaten to report them, etc. But, get it back and fix it myself. I assume you checked the fuses. $80 dollars to fix doesn't sound like it could have been much more than a fuse. With the typical markup on parts (4:1 for small parts), those alone could easily push the bill to more than $80. The longer they hold it, the tougher the problem seems so that when presented with the (larger) bill the customer figures it is justified.

VCR repair saga - a shop that hasn't seen this FAQ

The following is a true story. It appears to be an example of incompetence compounded by a lack of basic decency in dealing with the customer. The indented quoted text is from someone who wishes to remain anonymous.

> "Recently my 4-5 year old JVC HR-D910U (Hi-Fi Stereo) VCR stopped loading tapes properly. More specifically, a rubber roller which is lifted up and out of the way when the tape is ejected would come down right on top of the tape after the tape was loaded. This occurred because some metal guide, which moves as part of the loading sequence, wasn't properly pulling the tape out of the way of the (downward

moving) roller. Other than this problem, the VCR performed normally: i.e., if one manually moved the metal guide to pull the tape out of the way and then hit "PLAY", the machine would behave completely normally in all modes until the tape was ejected and another tape was loaded in."

If this were a Sony, I would say that it needed a single drop of oil on the half-loading arm shaft - which causes quite similar symptoms. Possibly the JVC transport is similar.

At this point, there is not much wrong with the VCR - maybe a mechanical problem like a stripped gear or the aforementioned gummed up lubrication. It could conceivably be electrical like a dirty or worn mode switch. However, I would go with something mechanical - and simple to identify and repair.

"I took the machine to a local repair shop that seemed reputable (has been in business for a long time, does the actual repairs for local stores of a large consumer electronic chain, etc...)."

Of course the latter is not a testimonial. Electronics chains make their money from selling new VCRs not from repairing old ones. Therefore, they may have incentives to discourage people from repairing their equipment (though mucking it up is not the usual approach - simply declare it not worth fixing - which is I guess what they did in the end).

"After charging me a $30 estimation fee (to be used towards the repair if I so chose), they concluded that there was something wrong with some gear in the loading mechanism as well as the mode switch. The price for the estimated repair seemed reasonable, and so I authorized them to go ahead. To make a long story short, after about 2 months (!) of waiting (they claimed to have had trouble getting the parts) they reported that they had replaced the parts, but the VCR still did not work. In fact, it now loaded properly, but didn't play well, and in general was confused about what mode it was in. For example, after ejecting a tape, the spindles that insert into the VHS tape cartridge would continue to spin around (as if there were a tape in there in PLAY mode)."

They should have been able to clean the mode switch as a temporary fix and confirmation of the problem. A broken gear would be obvious - they should still be able to produce it for you - not that this would mean very much as there is no way of demonstrating that it originated in your VCR.

Two months is way too long to wait for common service parts.

At this point, the timing is probably messed up - the novice bozo who was assigned to your VCR had not read this document and violated Rule #1: always mark all positions of mechanical components or adjustments before replacing, removing, moving, or changing anything.

"Their claim was that now there was something wrong with the micro- controller on the VCR and that it was putting out some sort of incorrect voltages. Moreover, this problem was allegedly masked by the earlier problems, and only became apparent after they had performed the repairs they had done."

If the microcontroller is messed up, it very likely a result of what they did. Their 'repairs' should not have made the situation worse. It used to be possible to play a tape by helping the loading mechanism to complete its cycle.

"In their estimation, the price of replacing the controller wasn't worth it, and so they wanted to just give me the VCR back, with the repairs that had already done (but keeping the $30 estimation fee)."

A reputable place would give you a total refund, no questions asked. Even if it was your VCR that was hopelessly screwed up from the beginning, it was their responsibility to recognize this.

> "The repair place speculates that some voltage spike must have injured the controller which may have coincidentally resulted in the loading problem. Or, another theory they proposed was that the loading problem caused some motor to over-strain itself in some way which caused an electrical problem which injured the microcontroller."

Balderdash. The original symptoms simply do not support this in any way, shape, or form.

> "My theory is that, since the VCR was normal other than the loading problem described, they must have screwed the machine up during the repair, but do not want to take responsibility for that fact, and after putting in a couple dollars worth of parts are happy to keep the $30 "estimation fee" themselves."

This is much more likely. However, there still may be nothing seriously wrong - the gears may just need to be retimed. This may require s service manual, some consultation with a genuine JVC technician, or even another similar model VCR tape transport to compare it with.

> "So, is their version of the story even remotely possible? If not, I feel that they destroyed a perfectly good machine with a minor problem and I'm wondering what, if any, recourse I might have in this sort of situation."

While anything is possible, I think, to put it bluntly, they do not have a clue. Motors do not damage microcontrollers. There was nothing seriously wrong when you took it to them - it should at least be possible to put it back in that condition. Since they did not do this, whatever they did is now the cause of more significant problems. However, it is quite possible that even these can easily be remedied by proper timing of the gears and mode switch - in addition, possibly, to that single drop of oil.

My recommendation would be to take it to an authorized JVC repair center with this story printed out (not to blame the other people but to give them something to start with). A competent technician should be able to quickly determine what is going on. If they concur with your assessment of the situation, then you can try to get your $30 back from the VCR repair shop from Hell you have not already been credited.

Testing of IR LEDs

The only differences in testing between a visible and IR LED (or IR Emitting diode - IRED) are that:

- The voltage drop across an IR LED will be slightly lower - perhaps 1 to 1.5 V instead of around 1.7 to 2 V for visible types.
- The light is not usually visible to most humans. Thus you need something sensitive to IR. See the section: IR detector circuit or try a CCD camcorder or those IR detector cards. Some people are supposed to be able to detect light well into the IR. I am not one of them.

For in-circuit tests with power applied:

- If you measure 0 V across it, the LED is shorted or the power supply is bad or disabled.
- If you measure greater than 1.5 V across it, the LED is open.

IR detector circuit

This IR Detector may be used for testing of IR remote controls, CD player laserdiodes, and other low level near IR emitters.

Component values are not critical. Purchase photodiode sensitive to near IR - 750-900 um or salvage from optocoupler or photosensor. Dead computer mice, not the furry kind, usually contain IR sensitive photodiodes. For convenience, use a 9V battery for power. Even a weak one will work fine. Construct so that LED does not illuminate the photodiode!

The detected signal may be monitored across the transistor with an oscilloscope.

```
 Vcc (+9 V) >-------+---------+
                    |         |
                    |         \
                    /         /  R3
                    \ R1      \  500
                    / 3.3K    /
                    \       __|__
                    |       _\_/_  LED1 Visible LED
                  __|__       |
       IR ---->  _/_\_ PD1    +--------> Scope monitor point
         Sensor     |         |
       Photodiode   |     B |/ C
                    +-------|    Q1 2N3904
                    |       |\ E
                    \         |
                    / R2      +--------> GND
                    \ 27K     |
                    /         |
                    |         |
      GND >---------+---------+
                   _|_
                    -
```

VHS physical tape format

The general arrangement of audio, video, and control information is shown below for a VCR with stereo audio. This view is from the front (oxide side) of the tape.

Another (possibly better) view is shown in: VHS Tape Format.

```
                    Top edge of tape
  -------   -------------------------------------------  --------
     ^                Right linear stereo                 .35 mm
     |      -------------------------------------------  --------__ (Guard band,
     |      -------------------------------------------  --------     .3 mm)
     |                Left linear stereo                  .35 mm
     |      ===========================================  ========
     |      \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ <-- End of scan,
     |      \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \     Bottom of picture,
   1/2"     \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \     Right (takeup side),
```

```
12.7 mm  \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \     roller guide.
    |    \ Video with HiFi sound \ <-- Tape motion \
    |    \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \     Left (supply side)
    |    \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \     roller guide.
    |    \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \     Top of picture,
    |    \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ <-- Start of scan.
    |    ===========================================  ========
    v              Control track                       .75 mm
-------  -------------------------------------------  --------
                   Bottom edge of tape
```

Note: ==== denotes the .15 mm guard bands between video, and the audio and control tracks. Thus, once the audio, control, and guard bands are taken into consideration, only about 10.65 mm or .42 inches is available for the diagonal video tracks.

For a VCR with HiFi audio, the HiFi audio heads travel the same path as the video heads but record their information just before the video heads pass over the same spot on the tape. Although some of this is then partially erased by the video, enough remains deep in the tape oxide to to permit reconstruction of CD quality sound. The difference in azimuth angles of the video (+/- 6 degrees) and HiFi audio heads (+/- 30 degrees) minimizes interaction. (The audio is also recorded on the linear audio tracks for compatibility with non-HiFi VCRs.)

For a VCR with monophonic audio, the left and right audio tracks and their guard band are combined into a single audio track of about 1 mm width.

Dimensions are most definitely *not* drawn to scale. The Audio and control tracks are very narrow in comparison to the tape width. To get an idea of the actual slant angle of the video tracks, imagine the tape stretched horizontally by about a factor of about 10. (The length of a video track representing one field or 262.5 scan lines is about 3.8 inches.) There are also actually more than a hundred tracks at any given location side-by-side across the less than 0.42" available for the video information. This number of tracks is equal to 175 at SP, 350 at LP, and 525 at EP speed (for NTSC 525/60 - note that this is not a coincidence but that is another story). Think of the alignment precision needed for proper tracking! You can estimate this number by just timing how long it takes for the rainbow pattern to wipe down the screen when re-recording over an old tape at either speed on a VCR without flying erase heads and multiplying this time by 60.

VHS specifications

```
Tape width:     1/2 inch         12.7 mm

Tape length:    240 meters, T120 - 120 minutes at SP speed, most common.
                Other lengths up to T160 and perhaps more.

Tape speed:     SP      1-5/16 ips      1.3125 ips      33.3375 mm/sec
                LP       21/32 ips       .6563 ips      16.6688 mm/sec
                EP        7/16 ips       .4375 ips      11.1125 mm/sec

                (Newer NTSC VCRs tend to only support SP and EP/SLP for
                 record but will play at all three speeds.  All PAL and SECAM
                 VCRs may only support SP and LP for play as well.)

Track pitch:    .058 mm         (SP)
                .039 mm         (LP)
```

```
                .019 mm         (EP)

Track length:   3.8 inches      96.5 mm

Writing speed:  229 ips         5.84 m/sec

Min wavelength: 1 micrometer (.000001 meter or .00004 inches)

Recording density:      (SP) 34K transitions/sq. mm

Recording time: SP      120 minutes     2 hours
(T120 cassette) LP      240 minutes     4 hours
                EP      360 minutes     6 hours

Drum diameter:  2.44 inches (VHS VCRs).
                1.63 inches (VHS Camcorders).

Drum speed:     30 RPS          1800 RPM    (NTSC at 30 frames/s)

Rotation:       Counter-clockwise viewed from above.

Tape movement:  Left-right viewed from front.

Heads (typ):    2 for normal recording/playback.
                1 to 3 optional for SP freeze frame/slow motion, etc.
                2 optional for HiFi audio.
                1 or 2 optional for flying erase.

End sensing:    Clear leader and trailer.

Brake torque:   Supply forward = 450 - 650 g-cm
                Supply reverse = 70 - 130 g-cm
                Takeup reverse = 450 - 650 g-cm
                Takeup forward = 70 - 130 g-cm

Back tension: 20 - 25 g.

Takeup torque:  Play - 80 - 160 g-cm
                FF - greater than 350 g-cm
                Rew - greater than 400 g-cm

Lum. Carrier:   3.4 Mhz

Color sbcrrier: 629 kHz

Azimuth angles: +/- 6 degrees

Frame length:   7.7 inches      196 mm

Field length:   3.85 inches     98 mm

Line length:    .0147 inches    .3723 mm

Skew:           SP - 1.5 H      (sync tips align)
                LP -  .75 H
```

```
                EP -  .5 H      (sync tips align)

Color Vector    A head is + 90 degree/H
     rotation:  B head is - 90 degree/H

Luminance Specifications for various VCR technologies:

 Type      Video Resolution     FM Deviation      Freq. Range
-----------------------------------------------------------------
 VHS         (240 lines)          1.0 Mhz         3.4-4.4 Mhz
 SVHS (*)    (400 lines)          1.6 Mhz         5.4-7.0 Mhz
 Beta1       (250 lines)          1.3 Mhz         3.5-4.8 Mhz
 Beta2/3     (240 lines)          1.2 Mhz         3.6-4.8 Mhz
 SuperBeta   (285 lines)          1.2 Mhz         4,4-5.6 Mhz
 ED Beta     (500 lines)          2.5 Mhz         6.8-9.3 Mhz

(*) The tape for SVHS must have a higher coercivity since the frequency is
    higher (information more dense) and the demagnetizing forces are greater.

Linear audio    .0384 inches     1 mm     (mono, along top of tape)
 track width:   .0138 inches     .35 mm   (L or R stereo, R at top of tape,
                                           .3 mm guard band between L and R)
Audio bias:     67 kHz

Control track:  .0288 inches     .75 mm   (along bottom of tape)

Guard bands:    .0059 inches     .15 mm   (linear audio track to video)
                .0059 inches     .15 mm   (video to control track)
```

Video recording theory

The majority of maintenance and repair procedures on VCRs and camcorders can be carried out without really understanding **how** the video magic is performed. However, if you want to really get into the nitty-gritty or are simply curious, then the following book is for you. However, you probably want to find it at a library - the suggested retail price is $55!

- Video Recorders: Principles and Operation
  Z. Q. You and T. H. Edgar
  Prentice Hall International (UK), 1992
  ISBN 0-13-945890-5, TK6655.V5Y68.

This book includes basic aspects of helical scan video recording; various formats including VHS, Beta, U-matic, and 8mm; as well as advanced principles of video encoding (with equations) relating to the chrominance and luminance recording and playback channels.

VCRs are both NTSC and PAL compatible?

(From: drblake (drblake@bellsouth.net).)

I have found out that VCRs are produced by many manufacturers but if one reads the "Sams' Photo facts" and checks the pin configuration on the LSI, they will notice that there is a leg marked NTSC/PAL with either a low voltage sign over the PAL or the NTSC symbol. In other words they manufacture 1 VCR for both Europe and the US but either put a +5 V. or a Ground (Hi or Low) voltage on the appropriate leg to make it either an NTSC or PAL VCR.

This is obviously to save money and manufacture 1 design for both the US and Europe, but to change the voltage input based on weather that VCR is going to the US or Europe.

I know this because, I shall relate the following story.

Aside from this inconspicuous notation in the Sam's Photofacts library which I have access to, a person came to our shop from Colombia S.A. a few months ago and said he would like his VCR converted back to NTSC !!!.

We told him, "What did you mean"? "It is impossible, these are made either, or but not convertible". He told us that for $27.00 US he had his VCR converted to PAL from NTSC. We opened the VCR to examine it and sure enough there was a small 1" circuit board with a few wires coming from it and going to the main board or mother board of the VCR.

We checked the Sams Photofacts and found hat the board was wired to a leg of the CPU that had the notation NTSC/PAL !!! It was then that it dawned on us that many manufacturers make 1 VCR with Chips that have a leg that can be *TRIGGERED* to either generate an NTSC or PAL signal.

I would like to get some of those little 1 inch boards that they use in South America to convert or Trigger the CPU chips to generate a PAL signal in an NTSC VCR. SONY US, HITACHI US and PANASONIC US deny any knowledge of this but their technical manuals on their VCRs tell a *Different Story*.

Why is it that TV techs in a Banana Republic like Colombia know about the conversion, but the Technical advisors at the corporate service centers in the USA don't know about these "Special Modifications"?

If anyone has any information or experience in how to trigger the chips or if they know where to get the little boards, that modify the vcrs. or how to wire the VCRS so that they can be switched from NTSC to PAL, Please contact me.

Smoke damaged cassettes

(From: xcuseus9@mail.idt.net)

It is characteristic of a house fire to generate 'fire debris', often referred to as 'soot'. Fire debris, thanks to the plastic content of a house and it's furnishings, is an airborne particulate, as small as 1 micron (um, 1/100th the diameter of an 'average' human hair) that has a high petroleum content.

Internal air currents created by a house fire are often high enough that the minutely sized particulate fire debris will find its way into the interior of most consumer electronic equipment. Cabinets, covers, jackets, and the like (unless they are totally airtight), are ineffective in preventing such infiltration.

Fire debris is abrasive. While little or no damage is done to the video tape that is wound tight on the reel(s), the exposed tape could be contaminated, effectively making it as rough as a piece of fine sandpaper. Cleaning videotapes after a fire prevents damage to the video heads when the tape is later played.

Sour grapes?

The following appeared as a reply to a sincere request for help on the USENET newsgroup sci.electronics.repair. The company is unknown and I have deleted the email address - this sort of comment is usually not constructive. However, I include it to provide all points of view. :-) :-(It isn't that the comments are without validity - just the way they are presented.

(From: National Service Manager.)

> "Why do people insist that they have the knowledge to repair something as complicated as an electronic circuit when they can't even program a VCR??. If you are not familiar with switch mode power supplies, don't attempt to repair it. If you are attempting to repair it and know of the consequences and are prepared to pay more for the extra damage you cause, or if your prepared to purchase a new VCR then go for it. But just don't do it to try to save a few bucks. Good luck in whatever you decide to do."

Setting channels on older VCR

Auto tune on a VCR 15 years old? You have to be kidding! These are typically varactor tuners, not modern quartz synthesizers.

Yes, with a model of that era, you have to twiddle each one individually.

Think of it this way: There are 16 or so memory locations each of which can store the tuning info for one channel. You select the memory location, tune your favorite channel in, set its real channel number, and the store that in the memory location. So, when you are selecting channels with the up/down buttons, you are actually indexing into a memory containing both the varactor voltage and your channel number.

The easiest way I have found is to have a TV with its own tuner sitting next to the VCR so you know which channels are which. If you do that, it really doesn't take long.

The details will vary by model but it usually isn't difficult to figure out the procedure with a bit of trial and error.

Another use for dead VCRs

(From: Mark Kinsler (kinsler@bobcat.ent.ohiou.edu).)

We have an huge, old, utterly-inoperative Fisher-Sanyo top-loader VCR that we have kept for many years for the cat to sleep upon. I think the power supply and the eternally-flashing display probably put out about ten watts.

Sebastian the Cat (black-and-white male, long-haired, with the demeanor of a Supreme Court Justice) started the practice when the VCR was a working affair and I'd watch my Mississippi State U. electric power course tapes on it. We brought it with us when we moved to Athens. When the VCR developed sufficiently severe mechanical problems to warrant its replacement we kept it for the cats. On Sebastian's passing, it was inherited by Samantha, the small calico with impeccable white paws and a large attitude. The VCR is now inhabited exclusively by Marmalade, the long-haired orange tabby Mississippi beauty queen who was adopted from a Starkville parking lot.

She's over there right now, asleep upon its silver plastic expanse, curled up with her nose buried in her fluffy tail. It's always 0:00 pm for a cat.

Notes on the Gemini/Rabbit video multiplier

This consists of an RF transmitter and one or more receiver modules to allow a single video source (typically a VCR) to be sent to TVs in other rooms of the house.

(From: Jim Stanisich (jstanisi@isd.net).)

I can tell you about the Gemini. The voltage required is 18 VDC at 300 mA. The three frequency. settings are set at the factory in the 900 Mhz band. You can change these if you wish by removing the cover, and you will see three corresponding trimpots near the front of the transmitter. They can be set anywhere from 900 to 940 Mhz with a frequency. counter. Also by the antenna there is a tin enclosure which is the RF amp. Inside there is a B+ pot and a trimcap. These can be adjusted to produce a output of approx. 7 mW instead of 1 mW. If you turn it up too high the video will distort so watch the received video if you do this to keep it linear.

Note that the access holes in the RF section are covered with solder from the factory. Sometimes they did such a good job you don't even know they are there.

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Service Information

Advanced VCR troubleshooting

If the solutions to your problems have not been covered in this document, you still have some options other than surrendering your VCR to the local service center or the dumpster. Fortunately, VCRs are among the most popular of consumer appliances to be addressed by literature that is readily available - at all levels of sophistication.

If you are tackling an electronic fault, a service manual with schematics will prove essential. Some manufacturers will happily supply this for a modest cost - $20-50 typical. However, some manufacturers are not providing schematics - only mechanical and alignment info. Confirm that a schematic (not just a block diagram) is included before purchasing if possible.

Sams Technical Publishing (formerly Howard Sams) publishes Sams Photofacts service data for almost every model TV that has ever been sold but their selection of VCRfacts is limited and the newer ones tend to have strictly mechanical information. However, they are worth a shot, especially if your local large public library subscribes to the Sams series as many do. Some of the older VCRfacts are quite detailed and complete.

Web resources

Radio Shack has a nice web resource and fax-back service. This is mostly for their equipment but some of it applies to other brands and there are diagrams which may be useful for other manufacturers' VCRs, TVs, CD players, camcorders, remote controls, and other devices.

- Radio Shack Product Support

In addition to Tandy products, there is at least one Sony model. Furthermore, since Tandy does not manufacture its own VCRs or camcorders - they are other brands with Realistic, Optimus, or other Radio Shack logos - your model may actually be covered. It may just take a little searching to find it.

For camcorders specifically:

* Vidcam Video Repair Page

Not much there now but they do have some photos showing the disassembly of a Sony camcorder which might be of use to someone.

Popular books on VCR maintenance and repair

There are a variety of books dealing with all aspects of VCR maintenance and repair. All will cover the basic cleaning and rubber replacement. Some of these only address mechanical problems (but, hey, this covers most failures) while other are heavy into the basic recording theory and electronic troubleshooting. Your local public library probably has some of these in the electronics section - around 621.38 if your library is numbered that way. Technical bookstores, electronics distributors, and the mail order parts sources listed in this document carry a variety of these texts.

If you want to get an idea of what is out there, search for the keywords 'VCR' and 'repair' at http://www.amazon.com/. Several dozen titles are listed. (I have no affiliation with amazon.com nor am I suggesting that you purchase from them, but the search engine is convenient.)

Here are a couple of typical titles which I have used (there are many others and I am not necessarily recommending these above the others):

1. VCR Troubleshooting and Repair
   Robert C Brenner and Gregory R. Capelco
   SAMS, a division of MacMillan Computer Publishing
   11711 North College,Carmel, Indiana 46032

2. Home VCR Repair Illustrated
   Richard C. Wilkins and Cheryl A. Hubbard
   TAB Books, a division of McGraw-Hill, Inc.
   Blue Ridge Summit, Pennsylvania 17294

The following is a recent publication:

3. In-Home VCR Mechanical Repair and Cleaning Guide
   PROMPT Publications (Howard W. Sams), 1-800-428-7267
   ISBN #0-7906-1076-0. $19.95

   From the advertising blurb for this book:

   "PROMPT Publications, an imprint of Howard W. Sams & Company, has released the In-Home VCR Mechanical Repair and Cleaning Guide, a comprehensive guide that anyone can use to fix their own VCRs at home (even start a VCR repair business). Full of illustrations, diagrams, and helpful, step-by-step instructions. ISBN #0-7906-1076-0. $19.95. 222 pages. Call 800-428-7267 to order or for more info."

   (From: Neil Preston (npreston@cctr.umkc.edu, npreston@CCTR.UMKC.EDU))

   If you teach consumer electronics repair, I've run across a text that you should check out:

4. Practical VCR Repair
   David T. Ronan

Delmar/ITP publishers
ISBN # 0-8273-6583-7

I've looked at several VCR repair books in the past, and almost all of them are very weak on the explanation of the mechanical problems in VCRs, which account for 90% of the problems. This text does an excellent job of explaining exactly how the tape transport system works in VCRs and what each part does. It has lots of photos with parts clearly identified. It assumes NO prior experience. I believe I could take a beginner student and let him walk his way through it.

The table of contents pretty well describes it:

1. VCR Operations & Controls
2. Removing covers & getting started
3. Understanding the videotape path (Also with a detailed appendix describing operation of tape load shuttles, video heads & drum, capstan & pinch roller)
4. Video Cassette examination & repair
5. Troubleshooting loader and Transport Malfunctions (Includes timing!)
6. How to perform VCR Maintenance and common repairs
7. How to align tape path and make adjustments
8. Understanding basic electronics
9. How to use a multimeter
10. Electronic components
11. How to solder
12. VCR Power supplies
13. Checking motors, optical sensors & remotes
14. VCR Microprocessors & servos
15. How a TV picture is made
16. Recording on videotape
17. Beyond standard VHS
18. Using manufacturer's Service manuals
19. Common audio and video problems
20. Service considerations: The business side of VCR repairs

This is by far the best book I've seen on the subject.

(Please note: I have no connection with the publisher nor anything to gain by bringing this to your attention.)

For basic mechanical problems, I could not have said the following any better.

(From: scott.holderman@mogur.com (Scott Holderman).)

One of the best I have seen is called:

5. How To Keep Your VCR Alive (VCR Repairs Anyone Can Do)
   Steve Thomas
   Retail Book Sales, Worthington Publishing Co.
   P.O. Box 16691-B, 6907-202B Halifax River Drive, Tampa FL 33687-6691
   (Tel: 813/988-5751)

This book describes in a step-by-step fashion how to repair a VCR without expensive test equipment or special tools. Fixes are described for different machines by brand & model #, and there is also a list of parts suppliers.

I'm not affiliated with these people in any way - just impressed with the book.

Here are a few mnore:

6. All Thumbs Guide to VCRs
   Gene B. Williams
   TAB Books, Inc., 1992
   Blue Ridge Summit, PA 17294-0214
   ISBN 0-8306-4181-5 (paperback)

   This one is even more basic but does cover the most common problems and has illustrated instructions for video hookup, cleaning, rubber parts, cassette repair, etc.

(From: cx163@FreeNet.Carleton.CA (Morton Lee Cohen))

Some of the books that you can find in your local library about the repair of VCRS are listed below. One of the good books is HOME VCR Repair Illustrated. These are all in the EE section: 621.38.

	Author	Date	Title
1	Ronan, David T.	1995	Practical VCR repair
2	Wayne, Victor A.	1992	Operating your VCR.
3	Capelo, Gregory R.	1991	VCR troubleshooting & repair.
4	Wilkins, Richard C.	1991	Home VCR repair illustrated.
5	Thomas, Steve.	1990	How to keep your VCR alive.
6	Brenner, Robert C.	1987	VCR troubleshooting & repair guide.
7	Goodman, Robert L.	1996	Maintaining & repairing VCRs
8	Williams, Gene B.	1993	All thumbs guide to VCR's.
9	Goodman, Robert L.	1993	Maintaining and repairing VCRs.
10	McComb, Gordon	1991	Troubleshooting and repairing VCRs.
11	Williams, Gene B.	1990	Guide to VCRs, camcorders, & home video.

FCC ID Numbers of VCRs

Only a few manufacturers actually produce the vast majority of VCRs. For example, Radio Shack, Magnavox, and Emerson do not make their own VCRs (I can tell you are not really surprised!). Or, how about a brand of 'Pulsar' sold through a store chain with the name of Canadian Tire? Rubber companies really do not design VCRs (even if there is something inside a VCR called an idler tire. :-)

How do you determine the actual manufacturer? For most types of consumer electronic equipment, there is something called an 'FCC ID' or 'FCC number'. Any type of equipment that may produce RF interference or be affected by this is required to be registered with the FCC. This number can be used to identify the actual manufacturer of the equipment.

A cross reference and other links can be found at:

- S.E.R FAQ FCC ID Page

The chart below probably has your VCR so you probably do not need to use the Web resource.

(From: William Miller, ASEET, eagle@trader.com)

This is a chart used to find the original manufacturer of a VCR. Find the FCC-Listed or UL-Listed code (first few digits), then you'll see who REALLY made it!

ORIGINAL MANUFACTURER	UL LISTED CODE(s)	FCC LISTED CODE(s)
Akai	186Z	ASH
Daewoo	41K4	C5F
Fisher/Sanyo	403Y	AFA
Funai	333Z, 51K8	ADT, EOZ, BFY
Goldstar	86BO	BEJ
Hitachi	238Z	ABL, AHA
JVC	439F	ASI
Matsushita (1)	679F	ACJ, AIX, AJU
Mitsubishi	536Y	BGB
NEC	781Y	A3D, E74
Orion-Emerson	44L6, 722	A7R
Philips (2)	645Y	BOU
Samsung	16M4, 414K	A3L
Sharp	504F	ATA, APY
Sony	570F	AK8
Toshiba	174Y, 84X7	AGI, G95

(1) Matsushita is the parent company of Panasonic, Quasar, and Technics (2) (North American) Philips is the parent company of Magnavox and Philco

Sears model series to original manufacturer:

```
564.  -  Sanyo/Fisher
565.  -  Sanyo/Fisher
934.  -  Hitachi
580.  -  Goldstar
274.  -  RCA
626.  -  Phillips (Mag)
```

Determining belt, tire, and pinch roller specifications

Belts are normally specified by their cross section - square, flat, round, and their inside circumference (IC). The IC is used since it is virtually impossible to accurately measure the diameter of a belt.

Assuming you cannot locate an actual part number, determine the type of belt; square, flat, or round. If you do not have the old belt, this is usually obvious from the pulleys. Most small belts (as opposed to V-belts on 1 HP shop motors!) used in consumer electronic equipment are of square cross section though flat types are sometimes found in the main drives of VCRs, cassette/tape decks, and turntables (remember those?). Measure or estimate the thickness.

The IC is always specified with the belt fully relaxed. This can be measured by hooking the old belt on one end of a ruler and pulling it just tight enough so that it more or less flattens out. Read off the length, then double it for the IC. Get a new belt that is 5% or so smaller to account for the old one be somewhat stretched out. Of course, if the belt broke, measurement is real easy. Or, if you do not care about the old belt, just cut it and measure the total length.

If the old belt decomposed into a slimy glob of jellatinous black goop or is missing, you will need to use a string or fine wire around the appropriate pulleys to determine the IC. Reduce this by 10-25% for the replacement. Very often the match does not need to be exact in either thickness or length - particularly for long thin belts. A common rubber band may in fact work just as well for something like a tape counter!

However, there are cases where an exact match is critical - some VCRs and belt driven turntables or tape decks do require an exact replacement for certain drive belts but this is rare.

Some parts suppliers make determining replacement belts very easy with the PRB system in which the part number fully codes the shape, size, and thickness.

Idler tires are specified by their inside diameter, outside diameter, and thickness. Some parts catalogs provide actual size drawings so that all you need to do is match up your old tire to the picture. Since tires do not generally decompose or stretch significantly and hold their shape, measurement is usually quite easy,

Pinch rollers are specified by diameter and height along with bearing inside diameter. The match must be exact so using the original manufacturer's part number is best but generic replacements are available.

Parts suppliers generally provide quite complete cross references to their replacement rubber parts and complete belt kits are available for most model VCRs.

About decayed tan or brown glue on circuit boards and leaking capacitors

Larger components like electrolytic capacitors are often secured to the circuit board with some sort of adhesive. Originally, it is white and inert. However, with heat and age, some types decay to a brown, conductive and/or corrosive material which can cause all sorts of problems including the creation of high leakage paths or dead shorts and eating away at nearby wiring traces.

The bottom line: Most of the time, this stuff serves no essential purpose anyhow and should be removed. A non-corrosive RTV or hot-melt glue can be used in its place if structural support is needed.

One comment: make sure you scrape and clean off all the old glue. I have heard and seen cases where this stuff turns conductive with obvious bad consequences.

Note: do not mistake the hot melt glue or silicone sealer often used to anchor capacitors or other large components to the circuit board for leakage. One tip-off is that leaking chemicals will not tend to climb up the side of a component! However, if it is on the circuit board and decomposed, various erratic symptoms or other failures are possible.

(From: Gillraker (eternity@mail.cybertron.com).)

Extremely common in older Mitsubishi's!!!! Take it off of all your circuit boards, some of that old glue is caustic, it eats into the traces and becomes conductive as previously mentioned...sure way to tell is look at it and see if it is rust colored around the edges....and there doesn't have to be much rust either...that glue still puzzles me at times....even had to replace leads that have been eaten totally away....

(From: Alan Hurst (alan@sastro.demon.co.uk).)

I had a dead display on my Sony SLV-777 (similar to 715 and 747 models) which turned out to be caused by a leaking capacitor in the power supply. The leakage had eaten through two tracks which supply power to the display.

The problem with leaking capacitors on the PS secondary is apparently very common to the extent there is a service kit available from Sony to replace all the capacitors on the secondary side of the power supply and has caused a wide range of strange faults in this range of models.

Where did all the adjustment go?

Like TVs and monitors, newer VCRs have much more of their adjustments done digitally inside complex integrated circuits. What this means is that there may be no easy way to tweak some of the common parameters without either a special remote control or a computer interface and software. Good for the manufacturer; bad for the DIYer and even professional repair person.

For example:

> "Does anyone know which variable resistor adjusts the head switching point in a Sony CCD-F401 camcorder, where it is?"

(From: Paul Weber (webpa@aol.com).)

There is a very good chance that there is no "variable resistor" for adjusting the head switching point or anything else in your machine. Most recent Sonys use are setup entirely with an EEPROM which is programmed with a special wired remote control (RM-95). Even if there is, you are going to need the shop manual, or you run a high chance of breaking something important just taking the thing apart.

(From: Varlod (varlod@aol.com).)

I recently got a job where I will be doing repairs on VCR's. I have been out of the business for a short while. I just got a service manual to repair a Panasonic AG-131 and noticed a few changes. I remember servicing JVC VCR's in the mid 80's and they had dozens of pots on each board. This VCR has none!! The electronic adjustment section of the service manual tells you to put the VCR in the service mode, put in an alignment tape and let the VCR do all the adjustments. This is incredible, are most other newer VCR's the same? Of course I still have to do the mechanical alignment if needed, maybe in a few years that will adjust itself also.

Interchangeability of components

The question often arises: If I cannot obtain an exact replacement or if I have a VCR, tape deck, or other equipment carcass gathering dust, can I substitute a part that is not a precise match? Sometimes, this is simply desired to confirm a diagnosis and avoid the risk of ordering an expensive replacement and/or having to wait until it arrives.

For safety related items, the answer is generally NO - an exact replacement part is needed to maintain the specifications within acceptable limits with respect to line isolation, X-ray protection and to minimize fire hazards. However, these components are not very common in a VCR except for the power supply.

For other components, whether a not quite identical substitute will work reliably or at all depends on many factors. Some deflection circuits are so carefully matched to a specific horizontal output transistor that no substitute will be reliable.

Here are some guidelines:

1. Fuses - exact same current rating and at least equal voltage rating. I have often soldered a normal 3AG size fuse onto a smaller blown 20 mm long fuse as a substitute.

2. Resistors, capacitors, inductors, diodes, switches, potentiometers, LEDs, and other common parts - except for those specifically marked as safety-critical - substitution as long as the replacement part fits and specifications should be fine. It is best to use the same type - metal film resistor, for example. But for testing, even this is not a hard and fast rule and a carbon resistor should work just fine.

3. Rectifiers - many are of these are high efficiency and/or fast recovery types. Replacements should have at equal or better PRV, Imax, and Tr specifications. For line rectifiers, 1N400x types can usually be used.

4. Transistors (except power supply choppers) - substitutes will generally work as long as their specifications meet or exceed those of the original. For testing, it is usually OK to use types that do not quite meet all of these as long as the BVceo and Ic specifications are not exceeded. However, performance may not be quite as good. For power types, make sure to use a heatsink.

5. Switching power supply transistors - exact replacement is generally best but switchmode transistors that have specifications that are at least as good will work in many cases. See the documents: "Notes on the Troubleshooting and Repair of Television Sets", "Notes on the Troubleshooting and Repair of Computer and Video Monitors", and "Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies" for more info.

6. Video heads (and lower cylinders) - generally not possible unless it is a very similar model as even the mounting is usually unique to a particular manufacturer and it may change from model to model. However, since, multiple brands may be manufactured by the same company, substitution may sometimes be possible - check a cross reference (e.g., your parts supplier's catalog) for compatibility.

7. A/C and full erase heads - may be possible if the mountings are reasonably compatible. However, there could be other unknowns like coil impedance drive requirements. The connectors are not likely to be similar.

8. RF modulators - there is a certain amount of standardization. Therefore, if you have one that fits (or you can make it fit), this is worth an attempt.

9. Motors - small PM motors may be substituted if they fit physically. Capstan motors - especially the direct drive type - are probably not interchangeable.

10. Sensors - many are sufficiently similar to permit substitution.

11. Power transformers - in some cases, these may be sufficiently similar that a substitute will work. However, make sure you test for compatible output voltages to avoid damage to the regulator(s) and rest of the circuitry.

12. Belts, tires, and pinch rollers - a close match may be good enough at least to confirm a problem or to use until the replacements arrives.

13. Mechanical parts like screws, flat and split washers, C- and E-clips, and springs - these can often be salvaged from another unit.

The following are usually custom parts and substitution of something from your junk box is unlikely to be successful even for testing: SMPS (power supply) transformers, interstage coils or transformers, microcontrollers, other custom programmed chips, display modules, and entire power supplies unless identical.

Suggested Parts Suppliers

For general electronic components like resistors and capacitors, most electronics distributors will have a sufficient variety at reasonable cost. Even Radio Shack can be considered in a pinch.

However, for consumer electronic equipment repairs, places like Digikey, Allied, and Newark do not have the a variety of Japanese semiconductors like ICs and transistors, or VCR specific components like RF modulators, idler assemblies, belts, tires, pinch rollers, video heads, etc.

See the document: Major Service Parts Suppliers for some companies that I have used in the past and others that have been recommended.

For VCR parts in particular:

```
 Studio Sound Service            (Rebuild kits for many popular VCR switchmode
                                   power supplies, VCR parts, some components.
  U.S. Fax: 1-812-949-7743         They will be happy to identify specific VCR
  Email:                           part numbers as well based on model and
   studio.sound@datacom.iglou.com  description as well - see below.)
  Web: http://www.iglou.com/studiosound/
```

See the additional comments below about Studio Sound Service. (I have no affiliation with this company but have purchased parts from them.)

Also see the documents: "Troubleshooting of Consumer Electronic Equipment" and "Electronics Mail Order List" for additional parts sources.

VCR service parts and assistance for the do-it-yourselfer

(From: Frank Fendley (studio.sound@datacom.iglou.com).)

If you work on VCRs occasionally, for yourself or friends, you know that most VCR problems are mechanical in nature, and usually require a replacement idler, belt kit, or other small mechanical part. Most of these parts are inexpensive, but you run into a problem when you try to order from electronics distributors -- most require a $20 or $25 minimum order.

Studio Sound (see the previous section for contact info) stocks a large selection of VCR parts, including belts, idlers, gears, mode switches, semiconductors, etc, and will ship direct to you with no minimum order! Our prices are competitive with electronics distributors such as MCM and others, but you can order as little as one belt, and we'll ship it. Just the cost of the part, plus $5.00 shipping is all you pay. Many distributors charge $6.00 or $6.50 shipping, in addition to the $20 or $25 minimum order!

We'll even help you determine which part you need, if you don't have the part number - at no extra charge.

Need a part for a VCR? Fax or Email the information to us, and we'll respond with a price quote before you order. We accept check, money order, Visa or MasterCard - sorry, no CODs. Send all of the information you have (make, model, part description, part number if you have it), plus a return e-mail address or fax number, and we will be glad to give you a quote on your part. Don't wind up paying $25.00 plus shipping to get a $3.00 part! Let us help.

We also stock a large selection of Panasonic switch mode power supply rebuild kits, and have just added Samsung power supply rebuild kits to our line.

Used VCR parts

Perhaps they would get more respect if they were called 'previously owned' or 'broken-in' VCR parts. :-)

The following companies are sources for inexpensive used VCR parts:

- Allbrand Audio and Video Parts
  368 Ball Hollow Road
  Pulaski, Tennessee 38479
  Phone: 1-615-427-6262
  Email: allbrand@juno.com
  Web: http://www.usedvcrparts.com/

  Huge quantities of used and rebuilt VCR parts. A lower drum for a two-head machine usually goes for around $15. Major parts come with a 30 day warranty. Well, it beats no warranty, I guess!.)

- VCR Parts and Help for the Do-It-Yourself Technician. They will provide quotes (and assistance in identification) on new and used VCR parts via email. Site includes some information on VCR cleaning and troubleshooting.

These are even better than junk yards as they do the searching and pulling for you. For major subassemblies in older VCRs, this may be the only realistic economical option even if the original part is available from the manufacturer.

Other Sources

(This section from: ac557@detroit.freenet.org (Ted C. Gondert).)

Look in the Thomson (a.k.a. RCA and GE) "VCR/Camcorder Sourcebook" TCE publication # 1J9780 available from your local Thomson distributor. Publish date October 1994 (maybe newer version is out now) This book lists the most common parts for many brands and models of VCR and tells which Thomson or SK parts fit. Also has some solid state parts listed crossed to Thomson part #. RCA VR470 uses belt #192179 or SKBK0516 and pinch roller #202113. Similar to VR450 through VR475, made by Hitachi.

Service manuals for RCA/GE/Thomson are available from Thomson Consumer Electronics publications, P.O. Box 1976 Indianapolis IN (317)-267-5799. Or maybe their at 10003 Bunsen Way, Loisville, KY 40299.

Microfiche for VCR is about $10. Older model series are available by the year for good prices. I bought 1985 to 1990 for $50 or so. I have the microfiche for RCA VR470. Also looked through my file cabinet and found a printed service manual for VR470 in excellent condition, only used once. Have extra microfiche set for 1985 vcr including models VLT250 to VLT470, VLT600HF to VLT700HF, VLP800 to VLP970HF. I'll sell those service manuals for a good price maybe $15 or so? (will pay for shipping). Or I'll check with local high school electronics class if they want them. Don't know if they are still fixing vcr or not, last time I talked to instructor he said it was too many problems and they were getting away from repair.

Tandy (Radio Shack) can order PRB belts and have a CDROM to look up model # belt guide. For just one set of belts, Radio Shack is much more accessible to people then mail order with $20 minimum orders and shipping/handling.

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-- end V3.17 --

Sam's VCR FAQ Components

HTML, Diagrams, Photos, and Schematics

For contact info, please see the [Sci.Electronics.Repair FAQ Email Links Page](#).

Introduction

This is a complete list of the files which constitute Sam's VCR FAQ (Official name: Notes on the Troubleshooting and Repair of Video Cassette Recorders).

Note: There are additional diagrams and schematics included within the HTML file itself. Those that are listed here are only the ones that are in .ps, .gif, .jpg, or other graphics or compressed format.

Sam's VCR FAQ Components

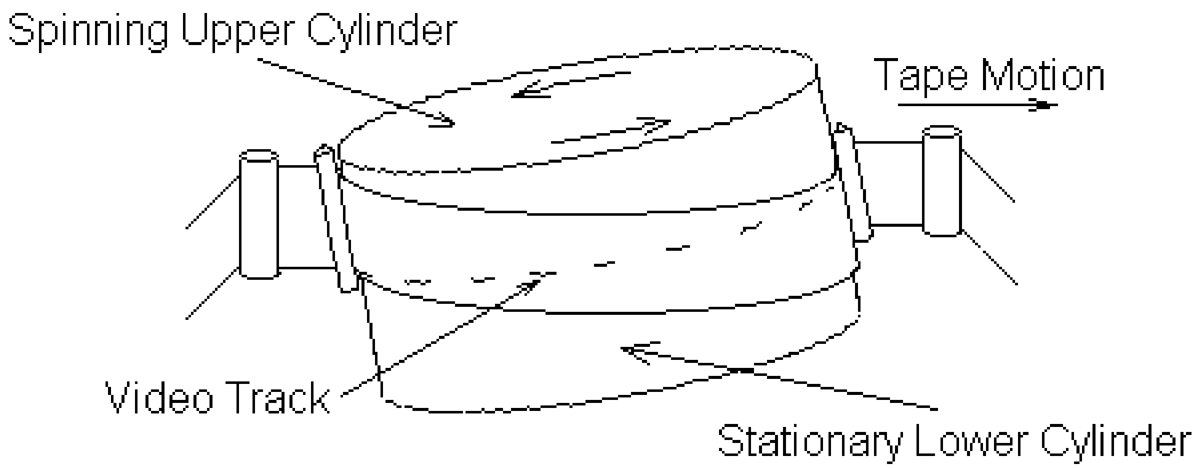
- Sam's VCR FAQ Components (This file, vcrfil.htm).

- Sam's VCR FAQ (vcrfaq.htm).

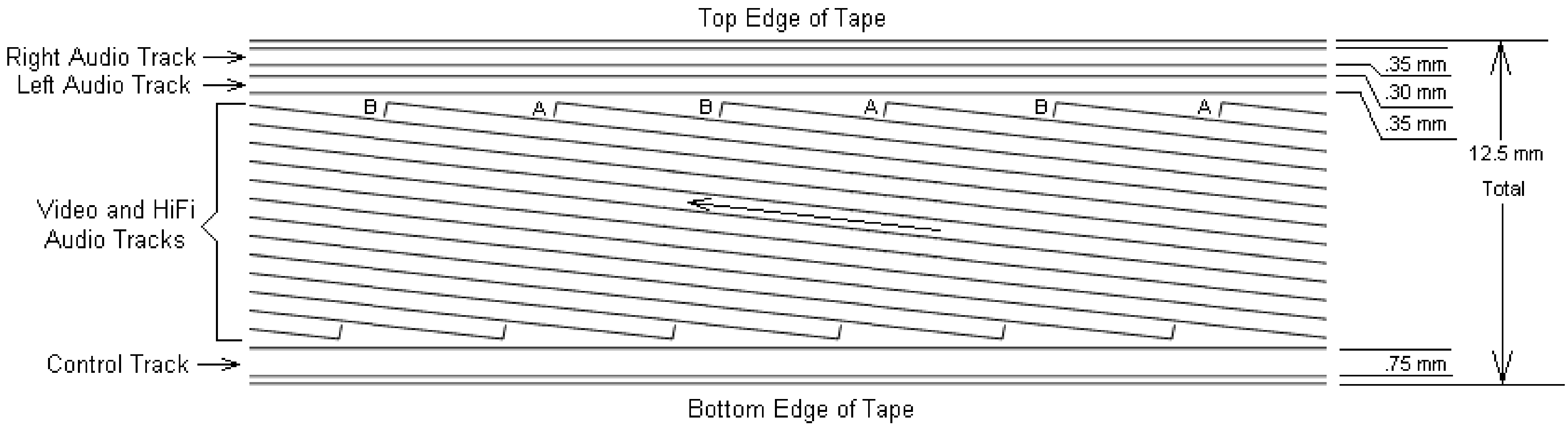
    - Helical Scan Video Head Assembly (heliscan.gif).
    - VHS Tape Format (vhsfmt.gif).
    - VHS Video Head Pair Azimuth Angles (azimang.gif).
    - Typical VHS VCR Tape Transport Components (vcrxprt.gif).
    - Sharp VCR Transport with Major Parts Labeled (vcrshrp.gif).
    - VCR with Idler Tire (idler.gif).
    - Some Locations for VCR Mechnical Problems (vcrmprbs.gif).
    - VHS Cassette - Inside Top View (vhscasin.gif).
    - VHS Cassette Showing Start and End Sensor Locations (vhssens1.gif).
    - VCR Reel Rotation Sensor (vcrrsens.gif).
    - Typical 6 Head Upper Cylinder (head6.gif).

    - Panasonic VCR Switching Power Supply (vcrps.pdf).

- Go to Sam's VCR FAQ.

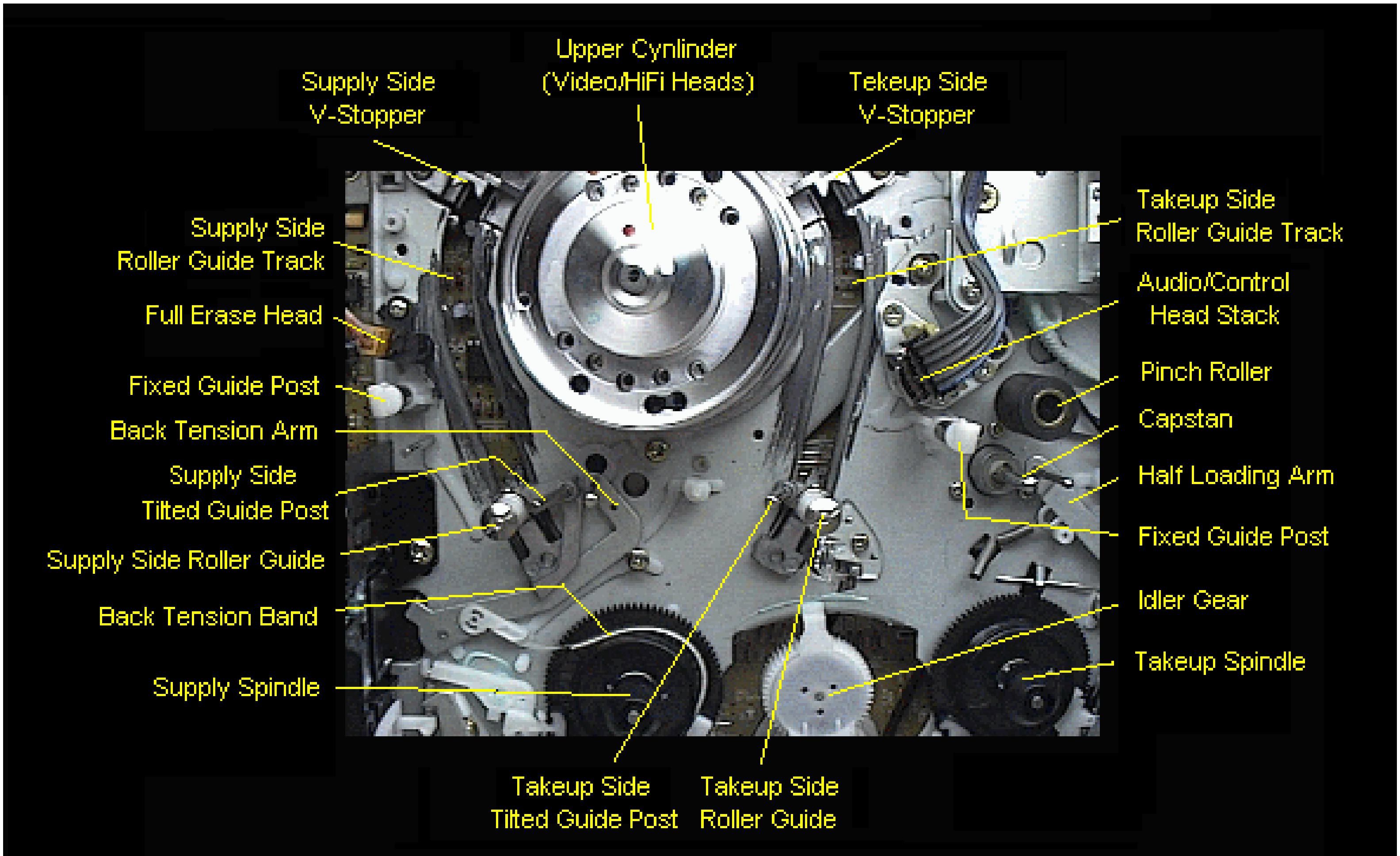


Helical Scan Video Head Assembly

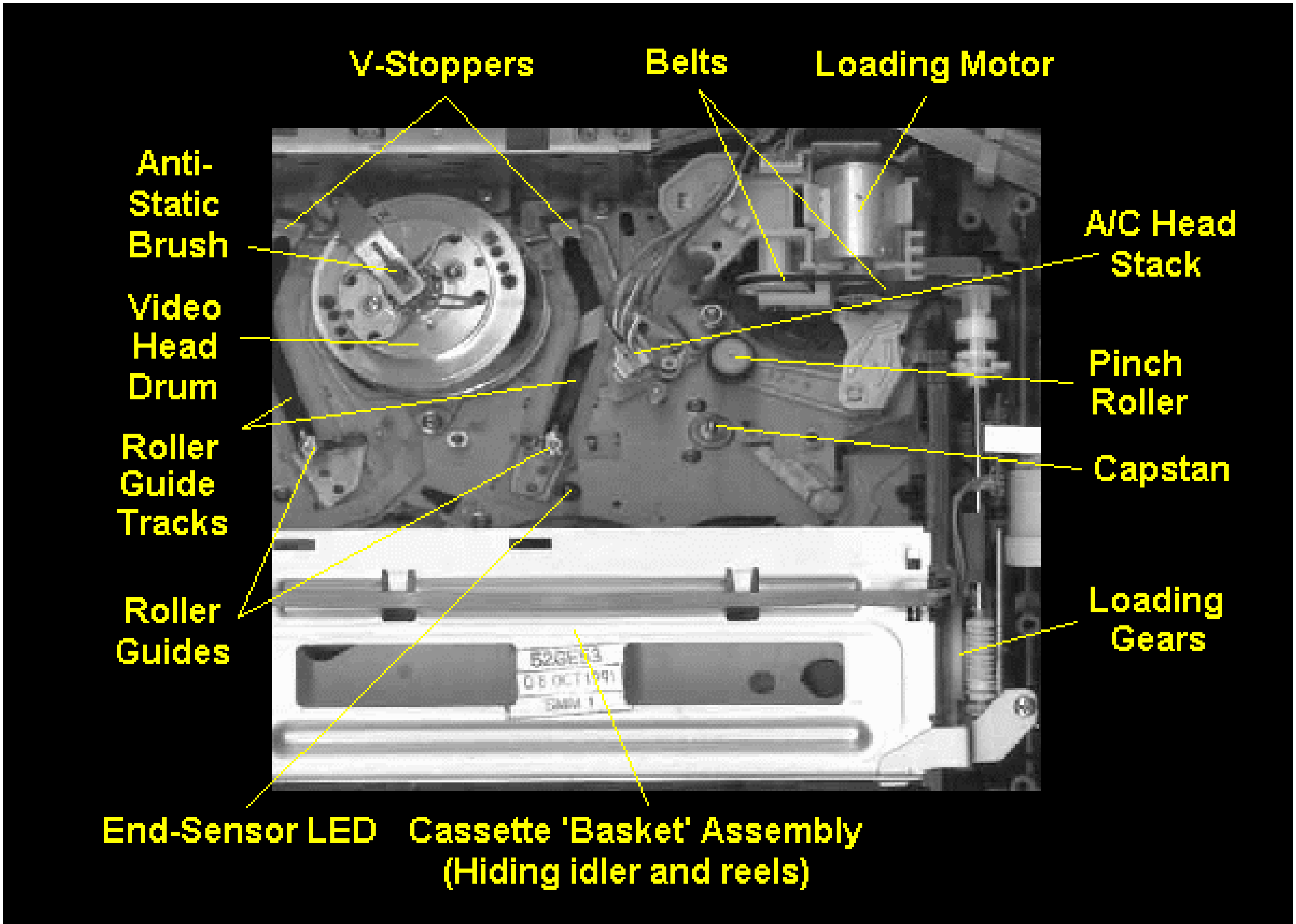


VHS Tape Format - View from Oxide Side of Tape (Not to Scale)

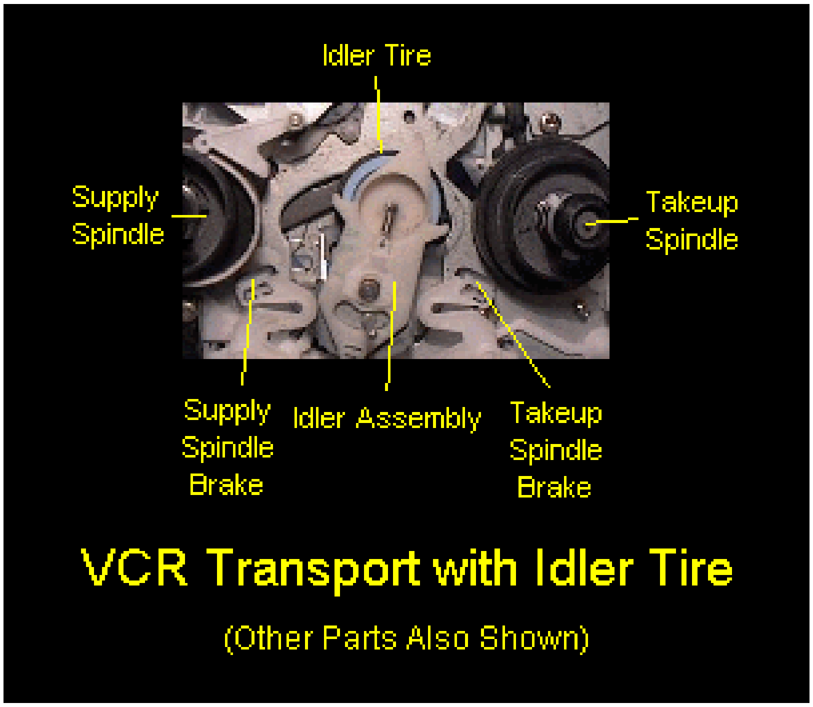
VHS Video Head Pair Azimuth Angles
(Not to Scale)



Typical VHS VCR Tape Transport Components

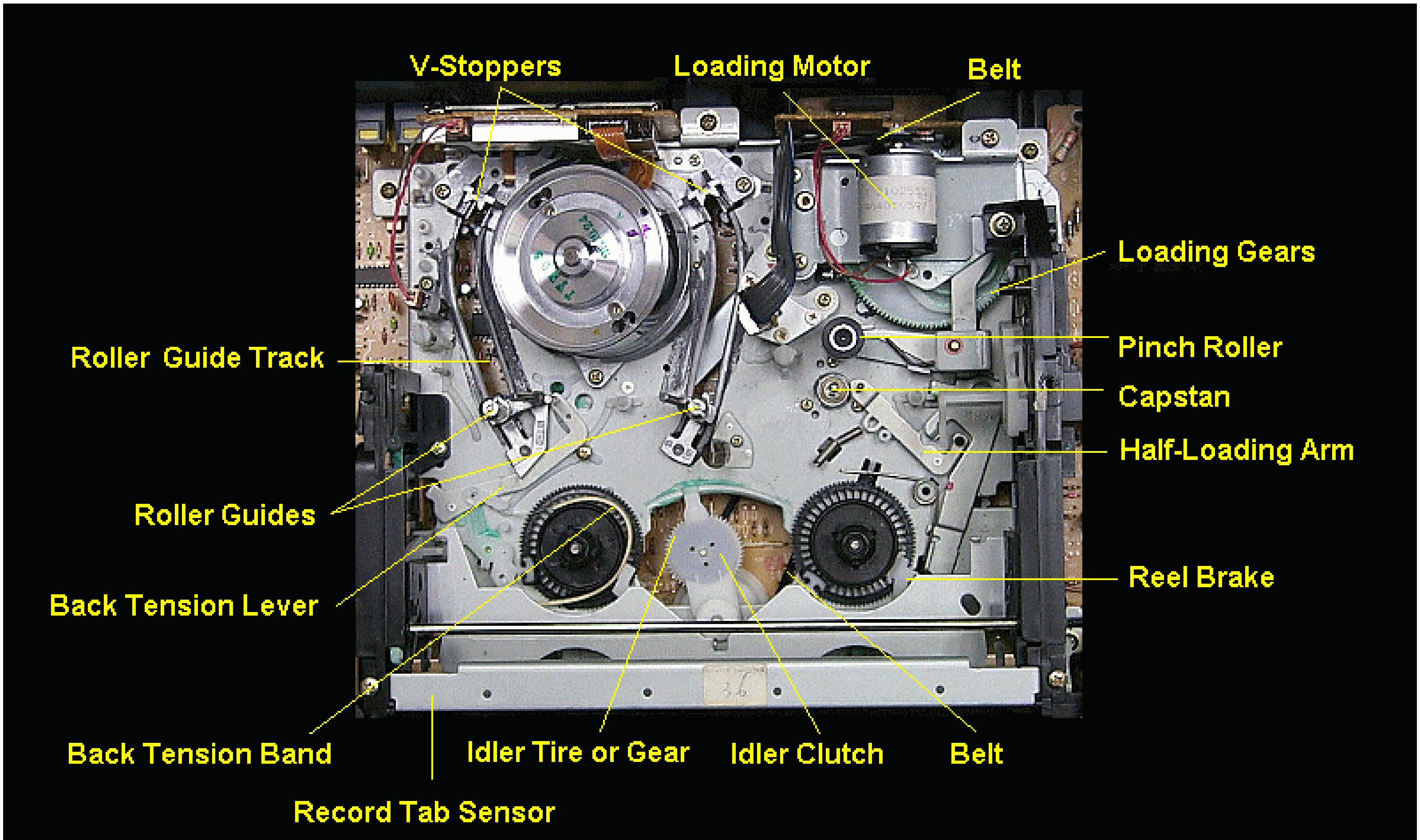


Sharp VCR Transport with Major Parts Labeled

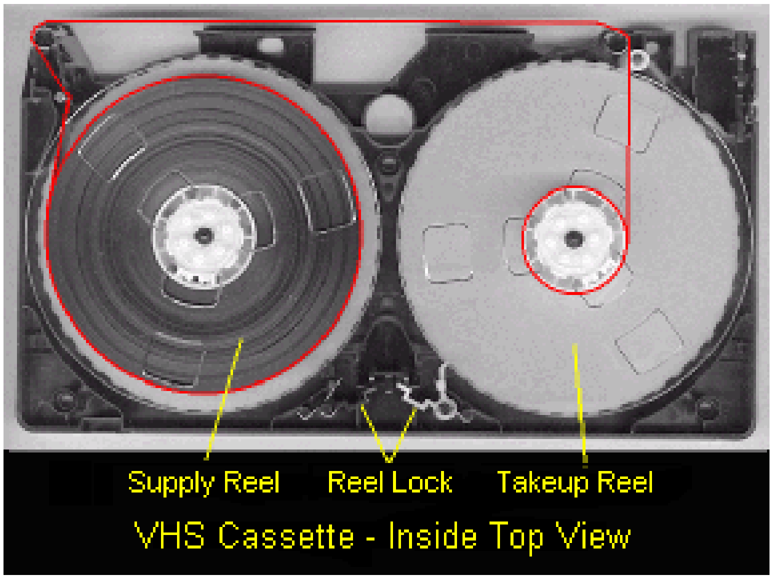


VCR Transport with Idler Tire

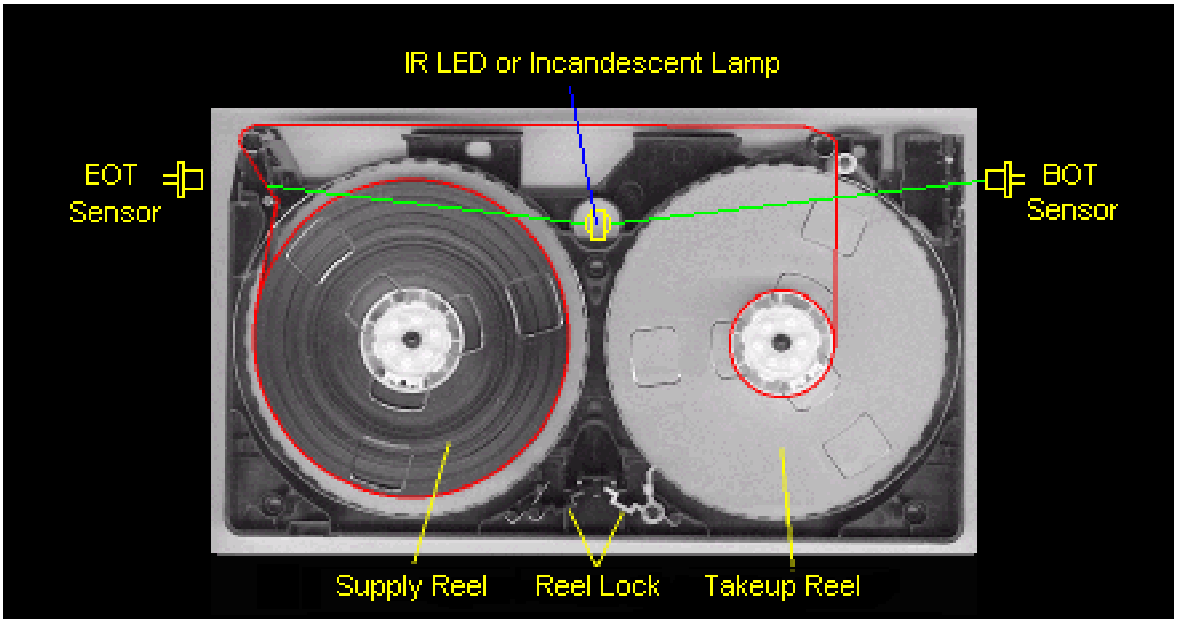
(Other Parts Also Shown)



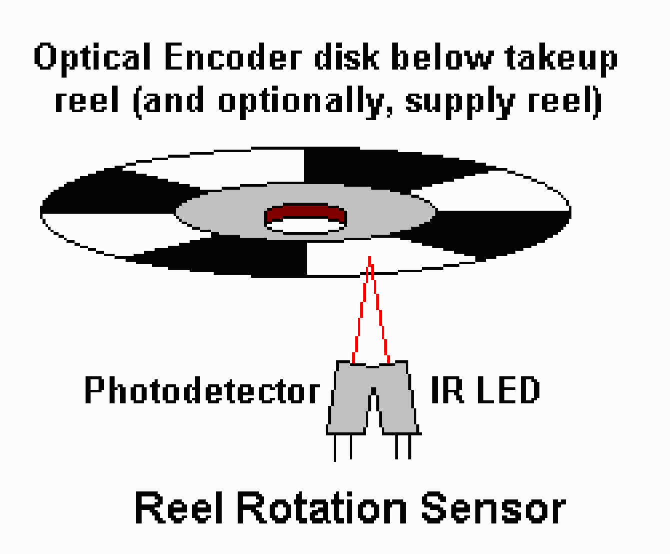
Some Locations for Play and Record Mechanical Problems

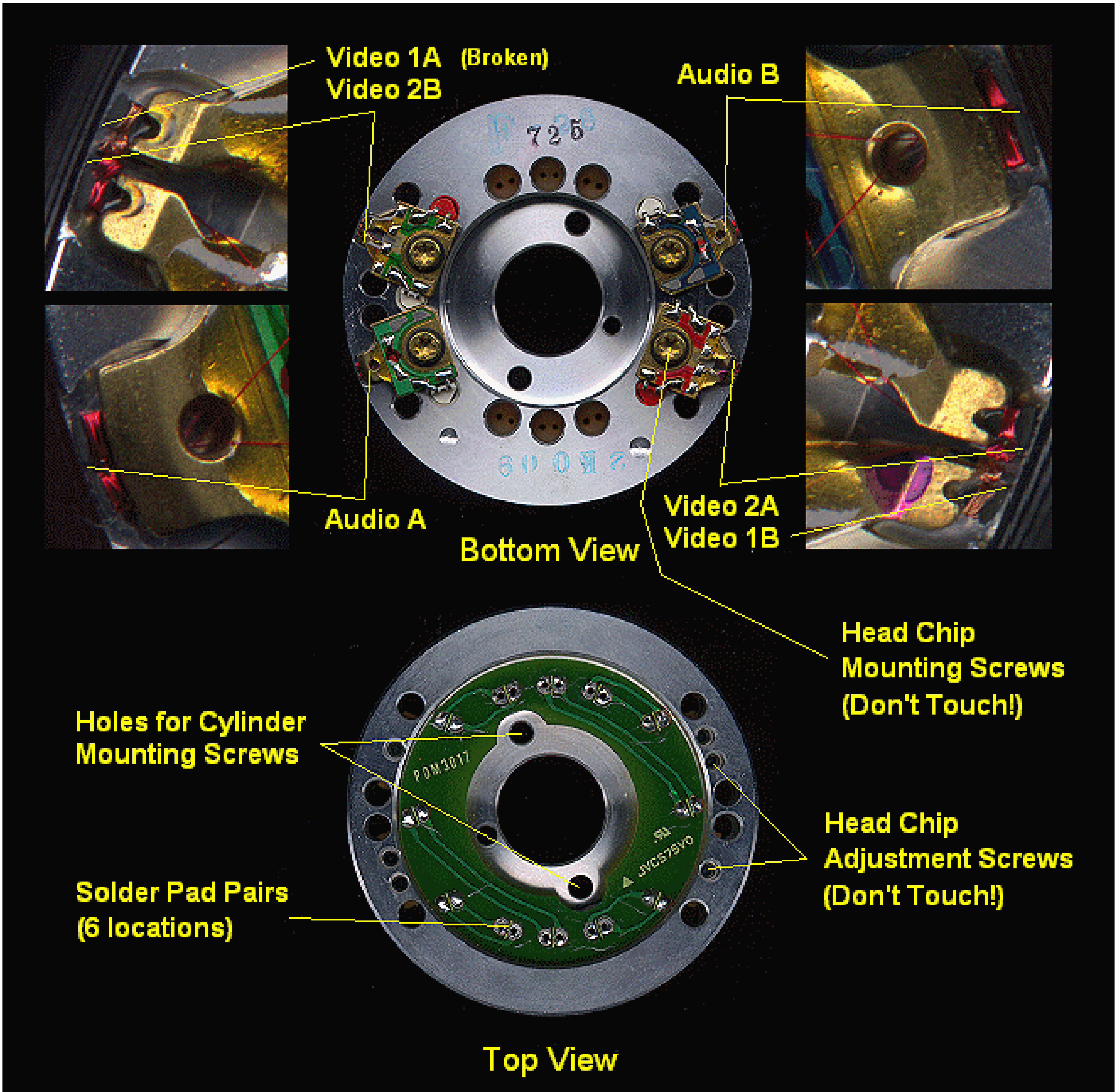


VHS Cassette - Inside Top View



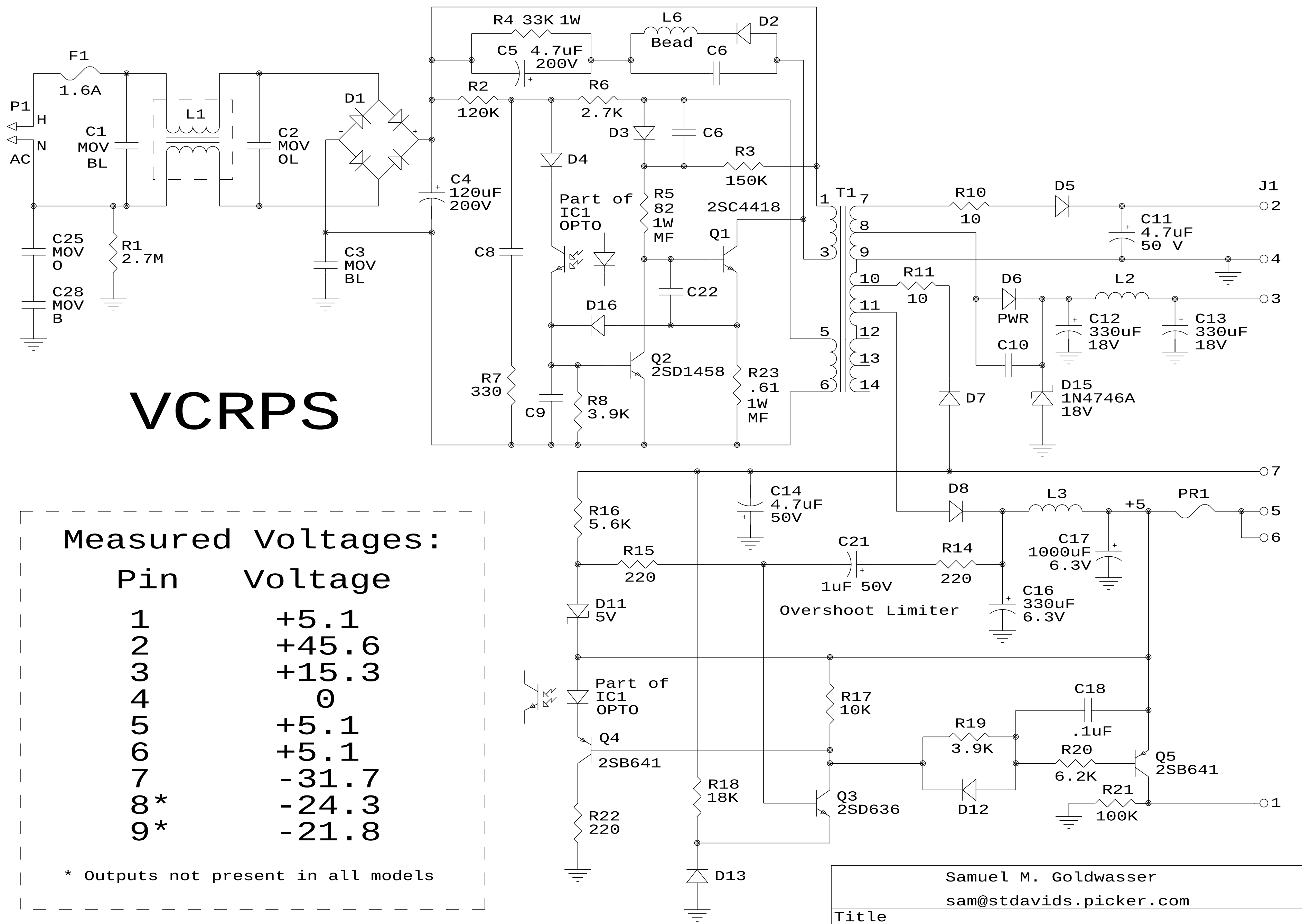
VHS Tape Cassette with Top Removed Showing Optical Path for BOT and EOT Sensors


Optical Encoder disk below takeup reel (and optionally, supply reel)
Photodetector
IR LED
Reel Rotation Sensor



Typical 6 Head Upper Cylinder

VCRPS



Measured Voltages:

Pin	Voltage
1	+5.1
2	+45.6
3	+15.3
4	0
5	+5.1
6	+5.1
7	-31.7
8*	-24.3
9*	-21.8

* Outputs not present in all models

Samuel M. Goldwasser
sam@stdavids.picker.com

Title	Panasonic VCR Power Supply	
Size A	Document Number VCRPS-SCH	REV 1.2
Date: April 6, 1998	Sheet 1 of 1	

VCR First Aid - What to Do in An Emergency

Version 1.35a

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

SAFETY:

If all you are doing will be working on a video cassette, then common sense use of small screwdrivers and sticky tape will be all that is needed. :)

However, if the cover of the VCR needs to be removed, there will be a few additional precautions though most of these disappear if the VCR is unplugged from the electric outlet (or in the case of a camcorder, the battery pack is removed.

Once you remove the cover(s) of a VCR (ignoring the warnings about no user serviceable parts, etc.), there are some risks to you and your VCR. You also, of course, void the warranty (at least in principle). Therefore, if the unit is still under warranty, having it serviced professionally may be your wisest option.

Since nearly everything described below can and should be done with the plug pulled from the outlet, there is little danger to you electrically as long as you stay away from the power supply (usually where the cord connects) where some large capacitors may retain a charge for as much as few minutes.

There are, however, various sharp sheet metal brackets which will be out to attach you if you reach into the bowels of the VCR. Just be aware of this hazard as you poke and prod (but only where directed!).

To avoid damage to the VCR, don't turn anything you don't understand fully and stay away from the video drum (the roughly 2.5 inch diameter cylinder mounted on an angle (this is normal, don't use Vise Grips in an attempt to straighten it out!!!). The reason is that the parts of the VCR that scans the tape - the video heads - are very fragile being little chips of ferrite - a brittle ceramic material.

DISCLAIMER

Once a VCR becomes hungry or a long neglected tape turns to a pile of what looks more like adhesive tape, there is no guarantee that the situation can be resolved with damaged to either the VCR or partial or total loss of irreplacible family memories. For tapes you consider to be really valuable (or just those Tom and Jerry cartoons you treasure!), consider a professional video recovery service. They won't be cheap but will probably have a better chance of success than you will if you've never seen the inside of a VCR or cassette before.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Introduction

This document is intended to address those problems with your VCR that just cannot wait. For detailed troubleshooting and repair procedures, refer to "Notes on the Troubleshooting and Repair of Video Cassette Recorders" which is also available at this site. Most of the information in this article is a subset of what in in that document.

VCR behaving strangely

Try unplugging it for a couple of minutes. Sometimes, a power surge will put the internal microcomputer into a confused state and just resetting it is all that is needed.

Ejecting a cassette from an uncooperative VCR

It is a common experience - the rental movie is due back at the video store **now** but no matter how you press the EJECT button, yell, scream, hold your breath, or jump up and down, the cassette refuses to be appear.

This section only deals with getting the cassette out without damaging either your (or the video store's) valuable recording or VCR.

Under no circumstances should you force anything - both your tape and your VCR will be history! If the rental tape really needs to be go back and you are unable or unwilling to risk going into your VCR, explain the situation to the video store - they would rather you get it out in such a way that it is not damaged just as much as you do.

First, see if the VCR just got into a confused state - pull the plug and patiently wait a minute or two. This will seem like an eternity but may reset the microcontroller and all will be well. These things happen.

If this is not successful, you will need to open up the VCR (unplug it first!) and attempt to cycle the mechanisms by hand. Probably, both the top and bottom covers will need to be removed. This will require a medium size philips screwdriver. There are usually 2 to 4 screws on top and 2 to 10 screws on the bottom. Don't be tempted to turn anything you see in there just yet!

CAUTION: Do not plug the VCR into the AC outlet while in the middle of this treament as there is no telling what it will do. The end result might be more of a mess than what you had originally! The VCR might in its infinite wisdom decide to complete the eject cycle but catch the tape on some guidepost or crinkle it in some other creative manner.

The following procedures assume that there are no broken parts, foreign objects, or other damage which might prevent manual cycling of the tape loading and cassette loading mechanism. (Inspect for toys and rocks.) Also note that some VCR designs use solenoids to engage various operations. This will complicate your task (to put it mildly) as locating and activating the proper ones at the appropriate time is, well, a treat.

Please refer to the photo: Typical VHS VCR Tape Transport Components for parts identification. (Photo courtesy of: Brian Siler (bsiler@PROMUS.com).) This VCR is shown in the fully unloaded position. The roller guides are in their retracted position. The cassette itself and cassette mechanism (called the basket or carriage) have been removed. Assuming that your cassette is in and down in the loaded position, its front-end would be just covering the roller guides, backtension arm, and capstan.

Depending on what the VCR was doing or attempting to do when it got confused, you may need to do both (1) and (2) or just (2). (For Panasonic and clone VCRs, see the section: Removing the cassette from Panasonic and clone VCRs.

1. Tape unloading: The first step is to determine if the tape has been unloaded from the video head drum back into the cassette. If the tape is fully retracted into the cassette - there is no tape showing, then go on to step (2). If not, you will need to figure out which shaft or pulley to turn to

unload the tape. Trace the linkage or gears that move the roller guide assemblies back to their motor - it may be the main capstan motor or a separate small motor used only for this purpose. (The roller guide assemblies include a white (usually) ceramic roller on a vertical post along side a funny looking tilted guidepost. They slide on tracks on either side of the video head drum and position the tape wrapped around the video drum.). Rotate this in the direction which moves the roller guides back towards the cassette.

It will take many revolutions - be persistent. If you feel any significant resistance or the roller guides move out toward the drum, turn the other way. The tape is fully unloaded when the roller guides are all the way into the cassette and the tape is straight across the cassette's stationary guideposts.

If turning the shaft is impossible, you can disconnect the wire leads going to the motor from the circuit board and apply 6 to 12 VDC from a battery, power supply, or wall adapter directly to the motor. It is essential to disconnect the motor completely to prevent damage to the circuitry in other parts of the VCR. Take care - reverse the connections if it seems to spin in the wrong direction and don't let it force anything. Motion should be smooth.

If a single motor performs both the tape loading and cassette loading functions, stop turning as soon as you see the cassette start to rise and read the next section before proceeding.

If you are not fully successful or if there is still a tape loop outside the cassette even once you have been turning for what seems to be an eternity, you can still try to eject the cassette but will need to be extra careful not to crinkle the tape as the cassette door closes with the tape sticking out. Before proceeding on in this case, try to find a way to turn one of the reels to pull that tape back in as this will make your task a lot easier. There may be an idler that swings between the two reels and this may be accessible from the bottom (the cassette will block it on top).

Sometimes, if for some reason the tape in the cassette is a bit loose when you go to insert it into the VCR, the tape may jump over a guide post or the pinch roller as the cassette is lowered into position. This tape will then get caught when the VCR goes to eject the cassette - it may come half way out and get hang up on the tape loop. The VCR then tries in vain to complete the eject sequence but gives up after a few seconds. It then either just shuts down or pulls the cassette back into position on the transport. If this happens, the tape is almost certainly damaged enough to be unusable and cutting the tape may be the easiest option. If you want to save what is on the tape, see the section: Recovering damaged or broken tapes.

2. Cassette unloading. Once the tape is fully retracted into the cassette, the cassette can be ejected safely. If a tape loop is still sticking out of the cassette - and you care about the recording - you will need to be especially careful not to crinkle the tape as the cassette door closes. It is usually not possible to get the cassette fully out without its door closing, so the best you can do is to make sure when this happens, the tape is flat across the gap. With care, it should survive.

   On a top loader, there is usually a solenoid specifically for EJECT or a simple mechanical pushbutton. Once the appropriate lever is pressed, the cassette should pop up - hold the basket with one hand as you do this to prevent any exposed tape loop from being crinkled.

On a front loader, locate the cassette loading motor and begin turning it in the appropriate direction - this will be fairly obvious assuming there are no broken gear teeth or other broken parts and that something isn't totally jammed. If this is the main capstan motor, then just continue turning as in (1). Eventually the cassette should raise up and out.

As above, applying external low voltage power (6 to 12 VDC) to the motor *after* disconnecting it is an alternative if you cannot gain access to its shaft to turn it by hand.

If you have a tape loop, be extra careful not to catch it on any guideposts or obstructions as you remove the cassette. Then, wind it back into the cassette by turning one of the reels (you may have to depress the release button on the bottom of the cassette with a pencil - this is the small hole in the center near the label side.)

And in some cases, just turning the VCR upside-down and gently easing the cassette out will work. But as noted, don't force anything.

Assuming the tape is not torn and not badly crinkled, it should be fine. If it is severely damaged, refer to the section: Recovering damaged or broken tapes.

Removing the cassette from Panasonic and clone VCRs

About now (1998), a variety of VCRs manufactured by Matsushita (these include Panasonic and several other brands) in the late 1980s and early 1990s are dying (or at least going into a coma) due to capacitors drying up in their power supplies. Thus, it is very common to attempt to turn on one of these VCRs and find it totally unresponsive. (These ARE easily repairable - see the companion VCR repair guide, "Notes on the Troubleshooting and Repair of Video Cassette Recorders" for more info. Among the panasonic models are those beginning with PV28 and PV48.

To determine if your VCR was made by Matsushita, search for its FCC number at: List of FCC ID numbers. One way to identify this mechanism is to remove the top cover (power off!): A large circuit board covers nearly everything but the area of the cassette and a white plastic circular knob like thing (great description, huh?) is visible poking though near the right hand side just beyond the cassette (DON'T touch or turn it!).

You will need to remove the bottom cover.

On this design where a single motor operates everything, there is a little tab next to the main gear (underneath near the capstan motor). Gently pressing this tab sideways (away from the gear) allows the mechanism to cycle through the various tape and cassette loading and unloading operations.

With the tab in the engaged position, turning the main motor or the big flywheel counterclockwise unloads the tape from the video heads, retracts the roller guides, and winds the tape back into the cassette, and then ejects the cassette itself. The tab will have to be engaged several times to accomplish all these tasks. DON'T force anything as it will move easily unless there is something binding or you reach the end of its travel. Take care that a loop of tape doesn't get caught behind a guide post or pinch roller. With care, the cassette will pop out as though nothing were wrong :-).

Manually winding a loop of tape back into the cassette

When you extract a tape from an uncooperative VCR, there is likely to be a loop of tape dangling in mid-air. Where the tape tape hasn't been seriously crinkled, mashed, torn, or otherwise damaged, it may be possible to get it back into the cassette with low risk of further problems.

WARNING: If the loop of tape is badly crinkled, mashed, at all torn, or damaged in any other way such that it could catch the spinning video heads, throw it away. If you must save the material, see the section: Recovering damaged or broken tapes.

There is a hole in the bottom of the cassette about 1/4" in diameter in the middle approximately 1 inch from the label side (front). Depress this with a suitable tool (a pencil will usually suffice), and the reels will be free to turn. Carefully wind the tape back into the cassette. That's it!

Video turns to snow while watching a movie

The most likely cause especially with old or rental tapes is that some oxide came off of the tape and clogged the spinning video heads. The oxide on old tapes tends to flake off and rental tapes are subject to abuse in VCRs of questionable pedigree. They may be creased or crinkled. Sometimes more serious damage results but in most cases, a good cleaning of the video heads (and other parts of the transport while you are at it - see the VCR FAQ additional info), possibly by hand, will restore your VCR to perfect health.

CAUTION: Read the following in its entirely to avoid an expensive lesson. Improper cleaning can ruin your expensive video heads. The head chips are very fragile and just rubbing them in the wrong direction (NEVER use an up-and-down motion) can break them completely off.

Manual cleaning using the proper head cleaning sticks is best but requires that you gain access to the interior of your VCR - i.e., take off the cover.

If you do not want to do this, you can try a wet type head cleaning tape. I do not recommend the dry type as they are much more abrasive and may cause premature wear of your video heads especially if used regularly. When using the wet type cleaning tapes, follow the directions and - very important - wait sufficient time for everything to dry out

CAUTION: If you do not wait long enough, the conseqauences can be unfortunate (and impressive) - wads of tape wrapped around the drum and caught in places where no tape should tread. Damage to the heads can also result. Needle to say, that tape will be ruined.

To clean by hand, you will need what are called 'head cleaning sticks'. These are covered by chamois and are safest. DO NOT USE QTIPS (COTTON SWABS). These can catch on the ferrite cores and damage them or leave fibers stuck in the heads. QTips can be used for cleaning the other parts like the rollers and audio/control head but not the video heads.

To use the cleaning stick, moisten it with head cleaner or alcohol. Pure isopropyl is best, however, the 91% medicinal stuff is ok as long as you dry everything pretty quickly. Don't flood it as it will take a long time to dry and you run the risk of any water in the alcohol sitting on surfaces and resulting in rust (very unlikely, but don't take the chance).

WARNING: Do not use any strong solvents like acetone (nail polish remover), paint thinner, fuming sulphuric acid, etc. Some of these may eat at the adhesives or plastic components of your VCR.

Gently hold the flat portion of the chamois against the upper cylinder where it is joined to the lower (non-rotating) cylinder. Rotate the upper cylinder be hand so that the heads brush up against the moist chamois.

WARNING: DO NOT MOVE THE HEAD CLEANING STICK UP-AND-DOWN - you will break the fragile ferrite of the heads - $$$$. Side-to-side is ok as long as you are gentle.

Depending on how dirty your heads are, a couple of passes may be enough. Let everything dry out for at least 1/2 hour. This process can be repeated. However, one pass will usually do it.

In addition, inspect and clean the drum itself staying safely away from the video head chips. The five fine grooves in the drum help control the air bearing that the tape rides on and helps to stabilize tape motion. These should be clear of dirt and tape oxide (DO NOT use anything sharp or hard - the moistened head cleaning sticks will work).

WARNING: Don't be tempted to try to clean the heads when they are spinning while playing a tape. Professionals may have their favorite technique but just stick to the recommendations above until you have cleaned your 1000th VCR!

Recovering damaged or broken tapes

So you just pulled your favorite tape from the VCR and there are two tape ends dangling from it. Or, perhaps, your VCR has just munched on that tape and a section is now seriously crinkled. (If it's only slightly crinkled, see the section: Uncrinkling a crinkled tape.) Maybe you haven't been following the recommendations on preventive maintenance; maybe your VCR was just hungry. In any case, what to do? The recording is, of course, irreplaceable.

If it is only slightly crinkled, the tape may be salvageable (though it will never likely play without some dropouts). How serious is 'serious'? Hard to say but ironing may help. See the section: Uncrinkling a crinkled tape.

However, if it is broken - even partially, or stretched and scrunched, I recommend you throw it away (and make sure no one else can pull it out of the trash and ruin *their* VCR!).. An imperfect splice or seriously crinkled section of tape can shatter your video heads - the most expensive single part in a VCR. If it is something you really treasure, than what I would do is to follow the procedure below.

Note: If you have never seen the inside of a video cassette, try the following on a couple you really don't care about first so that if you screw up, there is no great loss. Too bad AOL doesn't send out Internet software on video cassettes, huh?

CAUTION: The video tape itself is really really thin and easily crinkled. Be very gentle when handling it and avoid touching the oxide (dull side) if at all possible.

1. Locate a garbage cassette and disassemble it. Throw away the tape but save everything else including the reels. See the section: Disassembling a VHS cassette.

2. Construct two cassettes from the combined collection of parts you now have. Cut out any sections of tape that got mangled.

    - Cassette 1 has the first section of tape (before the break) and uses one empty reel from the garbage cassette for the supply reel. Rewind this to the beginning.

    - Cassette 2 has the second section of tape (after the break) and uses the other empty reel from the garbage cassette for the takeup reel.

    Use the little plastic plugs that came from the garbage tape reels or some adhesive tape to connect the tape to the reels.

3. If the break is at one end, you can just reconnect the bulk of the tape to the reel and dispose of the original leader. Just don't rewind or fast forward all the way to the end as the automatic end sensor will not work (for the particular end that has been repaired). What will happen is that instead of the sensor stopping REW or FF (as appropriate), the tape will run to the end and the VCR will then shut down when it discovers that the tape isn't moving. This can put additional stress on mechanical parts and/or rip the tape from the reel. Serious damage to the VCR isn't really that likely.

4. Copy to a good cassette.

5. Dispose of the original(s) or clearly mark 'DO NOT USE' with a detailed explanation.'

    Filip (I'll buy a vowel) Gieszczykiewicz (filipg@repairfaq.org) is a little more definitive about this: "I find the destruction of it more fulfilling :-) ... put it in a paper bag and smash the life out of it with a big, heavy hammer - or a small ball hammer for an even higher satistfaction ratio :-) "

The idea is to never have a splice in a VHS cassette. (Even a seriously crinkled tape such as might result from a tape eating incident can damage the heads.) It is possible to splice safely but as noted, it can be quite costly if you don't get it quite right.

Uncrinkling a crinkled tape

WARNING: Discarding a seriously crinkled tape is really the safest option from the point of view of the health of your VCR. However, if you really must view it, there are some relatively low risk options. The following only applies if there is absolutely NO evidence of even partial breakage or puncture of the tape's backing (it's OK if some of the oxide has flaked off):

Just winding the damaged section back into the cassette and then FFing or REWing as appropriate to put several layers of tape on top of it may help. Leave it like that for a few days and then carefully return to the crinkled section to see how it is doing. WARNING: Do all this on a VCR that DOESN'T have an instant response transport so that there is no chance of the video heads contacting the damaged part of the tape. You may have to do this a few times.

Passing the damaged section (backing side) around a blunt edge (like a table top) back and forth a few times may help as well.

(From: Paul K. Sagi (paul_sagi@astro.com.my).)

I had a go at a seriously crinkled VHS tape that my mom was wanting to show her class at temple. I put the crinkled section between pieces of the kind of paper that is sold for some kind of cooking use, can't remember what it is called. I then ironed it (heat only, no steam) and it worked OK except a couple of seconds dropout."

(From: Steven Van Assche (steven.vanassche@bluebottle.com).)

CAUTION: Use with care!!

I use the following: Get your iron, the one used for T-shirts, not your soldering iron! ;-)

What I do:

1. Let the iron warm up.

2. Release the reel latch by pushing something in the hole on the bottom, disengage and lift the lid, and then pull the tape gently out of the cassette. Make sure the *backside of the tape is lying upwards*.

3. Now go in one pass from left to right over the crinkled part with the iron. You can repeat this, if needed. Due to the heat, most crinkles will go away.

Now, to play it safe, copy it to another tape. and mark the old one as damaged.

The most important factor here is heat: Too hot and you will burn the tape instantly while too cold and nothing will happen. It is best to start from cold to warm, and slowly increase the heat until you see an improvement...

Disassembling a VHS cassette

These instructions should enable you to get inside a cassette for the purpose of reattaching a leader that pulled off of one of the reels or to enable you to transfer its contents or a portion thereof to another shell or vice-versa.

1. Peel off the label on the side or carefully slice down its center line with a knife or razor blade. This is necessary to allow the cassette halves to be separated.

2. Place the cassette upside-down and remove the five (5) phillips head screws and set aside.

3. While holding the cassette together, place it label side up on a clean surface.

4. Gently remove the top (along with the hinged door) to reveal the interior.

At this point, you should see something that looks like VHS Cassette - Inside Top View.

When you reassemble the cassette, take care to avoid crunching the tape under the hinged door - depress the unlock button on the side and lift it clear if needed.

Restoring old gummed up tapes

Where you have some really old tape that won't play or leaves excessive residue on the heads and elsewhere, it may be worth considering the info in the Curing Sticky Tape Problems by Baking Page. I have not tried this so can't guarantee that it will work and could make the problem worse. For really precious tapes, consider a professional video tape recovery service.

What about accidentally erased tapes?

Unfortunately, there isn't much hope if your prized wedding cassette got recorded over with the Simpsons. In fact, in a normal VCR, recording over a tape erases the original material twice: once using the stationary erase head and a second time by the rotating video heads. Even the combined might and technology of the FBI, CIA, NSA along with MI5 and the KGB would probably not succeed. Sorry.

- Back to VCR First Aid Table of Contents.

-- end V1.35a --

Sam's Schematic Collection

Various Schematics and Diagrams

Version 1.91b

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

- Sam's Schematic Collection Components - HTML, Diagrams, and Photographs.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Many of the circuits have been reverse engineered - traced from various schematics or actual hardware. There may be errors in transcription, interpretation, analysis, or voltage or current values listed. They are provided solely as the basis for your own designs and are not guaranteed to be 'plans' that will work for your needs without some tweaking.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Introduction

Scope of This Document

This is a collection of various useful and interesting schematics. Some of these are also referenced by or included in other documents at this site. Some are my own designs while many have been reverse engineered from commercial equipment. Many are the sorts of circuits you won't find in any textbook or in any other readily available on-line or print media. Some are just cute. :)

Safety Considerations

Some of these circuits operate at extremely lethal voltage and current levels. The energy storage capacitors in even the smallest disposable camera flash operating from a 1.5 V AA battery can be deadly under the wrong conditions. Line powered devices - including little ones - may have an added danger of high power at high voltage AND are often non-isolated (no power transformer). Do not attempt to troubleshoot, repair, or modify such equipment without understanding and following ALL of the relevant safety guidelines for high voltage and/or line connected electrical and electronic systems.

Related Information

Before thinking about experimenting with anything using or producing high voltages or connected to the AC line - even opening up a disposable camera that may have been laying around gathering dust (the capacitor can still be charged - outch!), see the document: Safety Guidelines for High Voltage and/or Line Powered Equipment. Something that looks innocent can really ruin your entire day!

Perhaps the larges collection of all sorts of on-line schematics and links in the explored universe can be found Tomi Engdahl's Lights and Electronics Page.

There are many other documents at the Sci.Electronics.Repair (S.E.R) FAQWeb site or one of its mirror sites which may be of use in the design, testing, and repair of electronic equipment. The Main Table of Contents (ToC) provides links to a variety of information on troubleshooting and repair of many types of equipment, general electronics, an assortment of schematics, over 1,000 technology links, and much more. Most of these documents are nicely formatted, indexed, and cross-referenced. (Silicon Sam's Technology Resource, which may be present at this site and others, usually contains slightly more recent versions of many of these same documents but most of those under the S.E.R FAQ Main ToC are easier to use and the actual content differences are likely to be minor.)

- Laser power supplies and other laser related schematics will be found in the document: Sam's Laser FAQ: Safety, Diode Lasers, Helium Neon Lasers, Drive, Info, Links, Parts.

- Additional electronic flash and other strobe related schematics will be found in the document: Notes on the Troubleshooting and Repair of Electronic Flash Units and Strobe Lights and Design Guidelines, Useful Circuits, and Schematics.

- Information on isolation transformers (essential for safety) and variable transformers (Variacs), series light bulb adapter, and other Incredibly Handy Widgets(tm) for your test bench will be found in the document: Troubleshooting and Repair of Consumer Electronic Equipment and possibly in the specific document for each type of equipment.

- General nifty gadget and other pack rat stuff can be found in the document: Salvaging Interesting Gadgets, Components, and Subsystems which identifies useful components which may be removed from common consumer electronics and appliances as well as unconventional uses for their subsystems, modules, or replacement parts.

See the Home and Mirror Site Locations for other possibilities which may be faster from where you live.

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High Voltage Power Supplies

Simple High Voltage Generator

This basic circuit is capable of supplying up to 30 kilovolts or more from a low voltage DC source using a flyback (LOPT) transformer salvaged from a TV or computer monitor. Typical output with a 12 VDC 2 A power supply or battery will be around 12,000 V. Current at full voltage is typically around 1 to 2 mA. Higher currents are available but the output voltage will drop. At 2 kV, more than 10 mA may be possible depending on your particular flyback transformer.

- Go to: Simple High Voltage Generator - Low Voltage DC In, up to 30 kV Out

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Adjustable High Voltage Power Supply

This circuit uses a pair of 555 timers to provide variable frequency variable pulse width drive to an inverter using a flyback transformer salvaged from a black and white or color TV or computer monitor. At very low repetition rates, it will produce individual sparks. At high rates with a low uF value high voltage capacitor, the output will essentially be HV DC with a specific value dependent on input voltage, pulse rate and width, and load. None of the component values is critical. The particular transistor used for Q2 seemed to be zappier better than a common horizontal output type but they work as well.

The input voltage can range from about 5 to 24 V. Using a flyback from a MAC Plus computer which had its bad primary winding excised, an output of more than 20 kV was possible (though risky since the flyback is probably not rated for more than about 12 kV) from a 24 VDC, 2 A power supply. By adjusting the drive frequency and duty cycle, a wide range of output voltages and currents may be obtained depending on your load.

With the addition of a high voltage filter capacitor (0.08 uF, 12 kV), this becomes a nice little helium neon laser power supply which operates on 8 to 15 VDC depending on required tube current and ballast resistor. See the document: Sam's Laser FAQ.

The transistor types are not critical. Those were selected basically because I had them in my junk box. A TV or monitor horizontal output transistor (HOT) should be satisfactory for the chopper but will require good strong drive. The lower voltage, high current transistor I used (2SD797) has both a higher current and higher Hfe rating than typical HOTs. Even a 2N3055 will probably survive and not be too bad in the performance department.

The drive transformer is from a B/W computer monitor (actually a video display terminal) and has a turns ratio of 4:1 wound on a 5/16" square by 3/8" long nylon bobbin on a gapped ferrite double E core. The primary has 80 turns and the secondary has 20 turns, both of #30 wire. Make sure you get the polarity correct: The base of the switching transistor should be driven when the driver turns on. You should be able to wind a transformer similar to this in about 10 minutes if a similar size (doesn't need to be exact) core is available.

Where the flyback includes an internal rectifier and/or you are attempting to obtain the maximum output voltage of a specific polarity, the direction of drive matters as the largest pulse amplitude is generated when the switching transistor turns off. Since flyback transformers are not marked, you will have to try both possible connections to the drive coil. Use the one that produces the higher output voltage for a given set of input conditions (drive and pulse rate/width).

Many variations on this basic circuit are certainly possible. The dual 555 circuit can be reduced to a single 555 with some loss in flexibility (unless you use the cute non-standard modification that allow independent adjustment of the high and low times - left as an exercise for the student).

One nice thing about running it at 24 VDC or less (as opposed to line voltage) is that it is much more difficult to let the smoke out of th circuit! The 5 A power supply I was using shut down on several occasions due to overcurrent but the only time I blew the chopper transistor was by accidentally shorting the base to collector.

- Get the schematic for HVGEN32 in PDF format: HVGEN32-SCH.

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Evertron Model 3210 Gas Tube Power Supply

(Thanks to Jeff Zurkow (jeff@atrox.com) for reverse engineering this device and drawing the schematic.)

Evertron Model 3210 Gas Tube Power Supply is the schematic of an inverter type unit for driving a neon sign. It has a pair of power MOSFETs driving a flyback style high voltage transformer, with a whole bunch of open-wound primaries and a potted secondary.

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Ricoh 3E06-1 High Voltage Power Supply

This is the high voltage power supply for a Ricoh laser printer or copier as shown in Photo of Ricoh Model 3E06-1 High Voltage Power Supply. It has two *negative* outputs of -5.3 kVDC at 0.3 mA max (output C) and -5.7 kVDC at 0.4 mA max (output T). I assume these stand for something like "Corona" and "Transfer" based on their functions. The two sections are independent with the only components in common being the power connector and a filter capacitor. Each section is based on a TL494 PWM controller IC. This is the same one used in many/most PC power supplies. A Web search will quickly locate a datasheet. Separate enable inputs permit each voltage to be turned on individually. All the low voltage circuitry is exposed with the high voltage circuitry being inside a module filled with red goop. I have not yet ungooped it so the circuitry inside the potting is essentially guessed at this point. The two sections are on separate schematic pages which are virtually identical except for part numbers and a few part values:

- Get the schematic for RI-3E1 in PDF format: ri3e1sch.pdf and ri3e2sch.pdf.

The adjustments on each section are for the current limit, not output voltage as might be expected. The output voltage for each section is set by fixed resistors (one of which is inside the potted HV module).

- Output C (5.3 kV) is approximately Vref*R101/(R8||(R12+R13)).
- Output T (5.7 kV) is approximately Vref*R121/(R28||(R32+R33)).

It would be a simple matter to replace R12 or R32 to vary the C or T output voltages within a modest range (like 4 to 6 kV). But going too high is asking for smoke. :) If pots are used, make sure their maximum value will limit the output voltage to something reasonable.

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Jacobs Ladders

The climbing arcs of old bad sci-fi movies are always a popular item. Just make sure you understand the safety implications before constructing one of these. See the document: Safety Guidelines for High Voltage and/or Line Powered Equipment.

- Go to: Jacob's Ladder (Climbing Arc) Construction

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Assorted High Voltage Circuits

Assorted High Voltage Circuits Introduction

These are assorted circuits which produce pulses or continuous high voltage for various purposes around the house. There is also an ultrasonic cleaner (sort of high voltage) here because it didn't seem to belong anywhere else. :-)

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Range, Oven, and Furnace Electronic Ignition

Many modern gas stoves, ovens, furnaces, and other similar appliances use an electronic ignition rather than a continuously burning pilot flame to ignite the fuel. These are actually simple high voltage pulse generators.

- Where starting is manual (there is a 'start' position on the control(s), a set of switch contacts on the control(s) provides power to the ignition module.
  - A problem of no spark with only one control indicates that the fault is with it or its wiring.
  - A problem with continuous sparking even with all the controls off or in their normal positions indicates a short - either due to a defective switch in one of the controls or contamination bypassing the switch contacts.
- Where starting is automatic, an electronic sensor, thermocouple, or bimetal switch provides power to the ignition module as needed.

The Harper-Wyman Model 6520 Kool Lite(tm) module is typical of those found in Jenne-Aire and similar cook-tops. Input is 115 VAC, 4 mA, 50/60 Hz AC. C1 and D1 form a half wave doubler resulting in 60 Hz pulses with a peak of about 300 V and at point A and charges C2 to about 300 V through D2. R2, C3, and DL1 form a relaxation oscillator triggering SCR1 to dump the charge built up on C2 into T1 with a repetition rate of about 2 Hz.

```
           C1                A       D1                      T1 o
    H o----||----------------+-------|>|-------+-------+       +-----o HVP+
         .1 uF     D2 1N4007 |     1N4007      |       |  o ::(
         250 V   +----|>|----+                 |       +--+ ::(
                 |           |                 |          )::(
                 +---/\/\----+                 |       #20 )::( 1:35
                 |  R1 1M    |             C2 _|_         )::(
                 |        R2 /           1 uF ---       +--+ ::(
                 |       18M \    DL1   400 V  |     __|__  ::(
                 |           /    NE-2         |     _\_/_     +-----o HVP-
                 |           |    +--+         |     / |
                 |           +----|oo|----+---------'  | SCR1
                 |       C3  |    +--+    |    |       | S316A
                 |  .047 uF _|_        R3 /    |       | 400 V
                 |    250 V ---       180 \    |       | 1 A
                 |           |            /    |       |
         R4 2.7K |           |            |    |       |
    N o---/\/\---+-----------+------------+----+-------+
```


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Bug Zapper 1

You know the type - a purplish light with an occasional (or constant) Zap! Zap! Zap! If you listen real closely, you may be able to hear the screams of the unfortunate insects as well :-).

The high-tech versions consist of a high voltage low current power supply and fluorescent (usually) lamp selected to attract undesirable flying creatures. (Boring low-tech devices may just use a fan to direct the insects to a tray of water from which they are too stupid to be able to excape!)

However, these devices are not selective and will obliterate friendly and useful bugs as well as unwanted pests.

Here is a typical circuit:

```
         S1        R1         C1            C2            C1-C4: .5 uF, 400 V
  H o----o/ o--+--/\/\--------||---+--------||---------+  D1-D5: 1N4007
               |  25K       D1    |   D2        D3    |   D4
               |         +---|>|---+---|>|---+---|>|---+---|>|---+
              +-+       |        C3        |        C4          |
 AC Line      |o| FL1    +---+----||----+----+---+----)|----+----+--o +
              +-+ Lamp    |   |    R3    |        |    R4    |       500 to
               |         |   +---/\/\---+        +---/\/\---+        600 V
```

```
               |    R2     |        10M                   10M              to grid
  N o----------+--/\/\---+------------------------------------------o -
                   25K
```

This is just a line powered voltage quadrupler. R1 and R2 provide current limiting when the strike occurs (and should someone come in contact with the grid). The lamp, FL1, includes the fluorescent bulb, ballast, and starter (if required). Devices designed for jumbo size bugs (or small rodents) may use slightly larger capacitors!

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Bug Zapper 2

This is your basic brute force approach!

(From: Andrew Bowers (falcon_@geocities.com).)

This is from my friend's bug zapper:

```
                        +----------------------+--o A
        H o-------+ ||(                        |
                   )||(                        |
         115VAC    )||(    Approx. 300V to     |
                   )||(    Fluorescent Tube    |
        N o-------+ ||(                        |
                    || +-----o F1    F2 o-----+
                    ||(
                    ||(
                    ||(
                    ||(
                    ||(
                    ||(
                    ||(
                    |  +-------------------------o B
        G o---------+
```

F1 and F2 connect to the ends of the purple fluorescent tube. A and B supply 5600VAC to the grid. We know this because it was one of the features of the zapper - said it right on the box in a big yellow sunburst: "5,600 Volts!!!". :)

This is your ultimate simple bug zapper -- no power switch, although the metal plate that the transformer and other parts are mounted on is grounded.

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Electronic Air Cleaner HV Generator

At least I assume this cute little circuit board is for an electronic air cleaner or something similar (dust precipitator, positive/negative ion generator, etc.)! I received the unit (no markings) by mistake in the mail. However, I did check to make sure it wasn't a bomb before applying power. :-)

This module produces both positive and negative outputs when connected to 115 VAC, 60 Hz line voltage. Each is about 5 kV at up to around 5 uA. It is probably similar to the high voltage power supply in the AirEase(tm) Personal Space Ionization Air Cleaner from Ion Systems, Inc., a small table top unit. (Unfortunately, the HV module in the AirEase was totally potted so I could not determine anything about its internal circuitry.)

```
                   D1                                           T1  o
  H o--------------|>|----+---+-------------------+               +-----o A
                 1N4007   |   |        Sidac     __|__ SCR1     ::(
                          |   |   R3  D2 100 V   _\_/_ T106B2   ::(
  AC                  C1  |   +--/\/\---|>|      / |   200 V    ::(
 Line      Power  .15 uF _|_     1.5K   |<|--+--'  |  4 A    o  ::( 350 ohms
          IL1 LED   250V ---               _|_     |  +-------+ ::(
        +--|<|---+        |              C2 ---    |  |        )::(
        |   R1   |   R2   |        .0047 uF  |     |  | .1 ohm )::(
  N o---+--/\/\--+--/\/\--+                  +-----+--+        )::(
           470      3.9K  |                                 +--+    +--+--o B
           1 W      2 W   |                                 |    R4    |
                          +---------------------------------+---/\/\---+
                                                               2.2M
```

The AC input is rectified by D1 and as it builds up past the threshold of the sidac (D2, 100 V), SCR1 is triggered dumping a small energy storage capacitor (C1) through the primary of the HV transformer, T1. This generates a HV pulse in the secondary. In about .5 ms, the current drops low enough such that the SCR turns off. As long as the instantaneous input voltage remains above about 100 V, this sequence of events repeats producing a burst of 5 or 6 discharges per cycle of the 60 Hz AC input separated by approximately 13 ms of dead time.

The LED (IL1) is a power-on indicator. :-)

The transformer was totally potted so I could not easily determine anything about its construction other than its winding resistances and turns ratio (about 1:100).

```
                                            A o
                                     C3       |
                              +------||-------+
          R5     R6      D3   |   D4     D5   |  D6     R7       R8
  HV- o--/\/\---/\/\--+--|>|--+--|>|--+--|>|--+--|>|---/\/\--+--/\/\--o HV+
         10M    10M   |      C4       |                220K  |  10M
                      +------||-------+                      |
       D3-D6: 10 kV, 5 mA            _|_                    _|_
       C3,C4: 200 pF, 10 kV          --- C5                 --- C6
       C5,C6: 200 pF, 5 kV            |                      |
                                 B o--+----------------------+
```

The secondary side consists of a voltage tripler for the negative output (HV-) and a simple rectifier for the positive output (HV+). This asymmetry is due to the nature of the unidirectional drive to the transformer primary.

From my measurements, this circuit produces a total of around 10 kV between HV+ and HV-, at up to 5 uA. The output voltages are roughly equal plus and minus when referenced to point B.

I assume the module would also operate on DC (say, 110 to 150 V) with the discharges repeating continuously at about 2 kHz. Output current capability would be about 5 times greater but at the same maximum (no load) voltage. (However, with DC, if the SCR ever got stuck in an 'on' state, it would be stuck there since there would be no AC zero crossings to force it off. This wouldn't be good!)

The secondary side circuitry can be easily modified or redesigned to provide a single positive or negative output or for higher or lower total voltage. Simply removing R4 will isolate it from the input and earth ground (assuming T1's insulation is adequate).

Where there is no high voltage from such a device, check the following:

- Make sure power is actually getting to the high voltage portion of the unit. Test the wall socket and/or AC adapter or other power supply for proper voltage with a multimeter.

- Excessive dirt/dust/muck/moisture or physical damage or a misplaced paper clip may be shorting it out or resulting in arcing or corona (a strong aroma of ozone would be an indication of this). With such a small available current (only uA) it doesn't take much for contamination to be a problem. Thoroughly clean and dry the unit and check for shorts (with a multimeter between the HV electrodes and case) and then test it again. Your problems may be gone!

- If this doesn't help and the unit is not fully potted (in which case, replacement is the only option), check for shorted or open components, especially the power semiconductors.

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Auto Air Purifier HV Generator

Well, maybe :-). This thing is about the size of a hot-dog and plugs into the cigarette lighter socket. It produces a bit of ozone and who knows what else. Whether there is any effect on air quality (beneficial or otherwise) or any other effects is questionable but it does contain a nice little high voltage circuit.

```
                                                                 DL1 +-+ |
                                                 o  T1 +-------+-----|o|
+12 o---+--------+----------+---------------------+ ::(        |     +-+ |
        |        |          |                D 30T )::(        | DL2 +-+
        |        |        -_|_ 4.7uF           #30 )::(        +-----|o| |
        |        |         ---  50V         +------+ ::( 3000T  |     +-+
        |      _|_ C2    + |              |        ::( #44    | DL3 +-+ |
        |      --- 470pF   +--------------|------+ ::(        +-----|o|
        |        |          |              | F 30T )::(        |     +-+ |
      +_|_ C1    |          |       D1      |   #36 )::(        | DL4 +-+
       --- 33uF  +----------|---+---|<|----|------+ ::(        +-----|o| |
      - |  16V   |          |   | 1N4002   |     o     +--+         +-+
        |        /          /   |        |/ C         o |              |
        |     R1 \       R2 \   +--------|Q1  TIP41       +--------------+
        |     1K /     4.7K /            |\ E             |            Grid
```

```
           |        \          \              |              |
           |        |          |              |              |
   GND o---+--------+----------+--------------+--------------+
```

T1 is constructed on a 1/4" diameter ferrite core. The D (Drive) and F (Feedback) windings are wound bifilar style (interleaved) directly on the core. The O (Output) winding is wound on a nylon sleeve which slips over the core and is split into 10 sections with an equal number of turns (100 each) with insulation in between them.

DL1 to DL4 look like neon light bulbs with a single electrode. They glow like neon light bulbs when the circuit is powered and seem to capacitively couple the HV pulses to the grounded grid in such a way to generate ozone. I don't know if they are filled with special gas or are just weird neon light bulbs.

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Ultrasonic Cleaner

Ultrasonic cleaning is a means of removing dirt and surface contamination from intricate and/or delicate parts using powerful high frequency sound waves in a liquid (water/detergent/solvent) bath.

An ultrasonic cleaner contains a power oscillator driving a large piezoelectric transducer under the cleaning tank. Depending on capacity, these can be quite massive.

A typical circuit is shown below. This is from a Branson Model 41-4000 which is typical of a small consumer grade unit. The H and N are Hot and Neutral of the 115 VAC line. WARNING: Line connected input. Use isolation transformer for safety when troubleshooting.

```
            R1        D1
  H o------/\/\-------|>|----------+
          1, 1/2 W  EDA456         |
                C1         D2      |
           +----||----+----|>|-----+
           |  .1 uF   |  EDA456    |  2
           |  200 V   |      +-----+---+ T1      +---+------->>------+
           |    R2    |     _|_ C2      )::  o 4 |   |               |
           +---/\/\---+     --- .8 uF D ):: +----+   |               |
           |   22K          _|_ 200 V   )::(         +               |
           |   1 W           -      1 o )::(          )::           _|_
           +-----------------+---------+ ::( O        ):: L1        _x_ PT1
           |           R3    |        7  ::(          )::            |
           |      +---/\/\---+   +-----+ ::( 5       +               |
          C \|    | 10K, 1 W     |    F ):: +---+    |               |
      Q1 NPN |--+-+--------------+  6 o )::     |    |               |
          E /|  |  D3     R4       +---+        +----+------->>------+
           |    +--|<|---/\/\--+  _|_
           |           47, 1 W |  ---       Input: 115 VAC, 50/60 Hz
           |                   |   |        Output: 460 VAC, pulsed 80 kHz
  N o------+-------------------+---+
```

The power transistor (Q1) and its associated components form an self excited driver for the piezo-transducer (PT1). I do not have specs on Q1 but based on the circuit, it probably has a Vceo rating of at least 500 V and power rating of at least 50 W.

Two windings on the transformer (T1, which is wound on a toroidal ferrite core) provide drive (D) and feedback (F) respectively. L1 along with the inherent capacitance of PT1 tunes the output circuit for maximum amplitude.

The output of this (and similar units) are bursts of high frequency (10s to 100s of kHz) acoustic waves at a 60 Hz repetition rate. The characteristic sound these ultrasonic cleaners make during operation is due to the effects of the bursts occuring at 60 Hz since you cannot actually hear the ultrasonic frequencies they use.

The frequency of the ultrasound is approximately 80 kHz for this unit with a maximum amplitude of about 460 VAC RMS (1,300 V p-p) for a 115 VAC input.

WARNING: Do not run the device with an empty tank since it expects to have a proper load. Do not touch the bottom of the tank and avoid putting your paws into the cleaning solution while the power is on. I don't know what, if any, long term effects there may be but it isn't worth taking chances. The effects definitely feel strange. At high enough power levels, it could indeed pulverize bones as described below. Whether that could happen with the typical small ultrasonic cleaner, I don't know and am not about to find out!

> (From: BIll Perry (perry.williamr@tacamo.navy.mil).)
>
> "While stationed on board the now-decommissioned submarine USS Hawkbill (SSN-666), I pondered this as well. One of my senior shipmates related a story of a sailor who had done that very act on his previous submarine. The guy put his feet it the cleaner while it was powered on. He remarked that it felt very good and relaxing. After a few minutes, he pulled his feet out, and as soon as he stood up and applied his full bodily weight on his feet, all the bones in his feet had shattered. He got permanent disability from it. Apparently, it had rattled his bones apart. Wow!"

Where the device doesn't oscillate (it appears as dead as a door-nail), first check for obvious failures such as bad connections and cracked, scorched, or obliterated parts.

To get inside probably requires removing the bottom cover (after pulling the plug and disposing of the cleaning solution!).

CAUTION: Confirm that all large capacitors are discharged before touching anything inside!

The semiconductors (Q1, D1, D2, D3) can be tested for shorts with a multimeter (see the document: Basic Testing of Semiconductor Devices.

The transformer (T1) or inductor (L1) could have internal short circuits preventing proper operation and/or blowing other parts due to excessive load but this isn't kind of failure likely as you might think. However, where all the other parts test good but the cleaning action appears weak without any overheating, a L1 could be defective (open or other bad connections) detuning the output circuit.

Where the transistor and/or fuse has blown, look for a visible burn mark on the transducer and/or test it (after disconnecting) with a multimeter. If there is a mark or your test shows anything less than infinite resistance, there may have been punch-through of the dielectric between the two plates. I don't know whether this could be caused by running the unit with nothing in the tank but it might be possible. If the damage is localized, you may be able to isolate the area of the hole by removing the metal electrode layer surrounding it to provide an insulating region 1/4 inch in diameter. This will change the resonant frequency of the output circuit a small amount but hopefully not enough to matter. You have nothing to lose since replacing the transducer is likely not worth it (and perhaps not even possible since it is probably solidly bonded to the bottom of the tank).

When testing, use a series light bulb to prevent the power transistor from blowing should there be a short circuit somewhere (see the document: Troubleshooting and Repair of Consumer Electronic Equipment) AND do not run the unit with and empty tank.

Also see the info on ultraonic humidifiers in the document: Troubleshooting and Repair of Small Household Appliances.

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Simple Linear Power Supplies

Simple Linear Power Supplies Introduction

This is a (currently somewhat meager) collection of basic power supply circuits that will hopefully grow as time passes.

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Converting an AC Output Wall Adapter to DC

Where a modest source of DC is required for an appliance or other device, it may be possible to add a rectifier and filter capacitor (and possibly a regulator as well) to a wall adapter with an AC output. While many wall adapter output DC, some - modems and some phone answering machines, for example - are just transformers and output low voltage AC.

This is also the simplest and safest way to construct a small DC power supply as you do not need to deal with the 110 VAC at all.

To convert such an adapter to DC requires the use of:

- Bridge rectifier - turns AC into pulsating DC.
- Filter capacitor - smooths the output reducing its ripple.
- Regulator - produces a nearly constant output voltage.

Depending on your needs, you may find a suitable wall adapter in your junk box (maybe from that 2400 baud modem that was all the rage a couple of years ago!).

The basic circuit is shown below:

```
            Bridge Rectifier   Filter Capacitor

    AC o-----+----|>|-------+---------+-----o DC (+)
            ~|              |+        |
   In from   +----|<|----+  |       +_|_   Out to powered device
   AC wall               |  |      C ___   or voltage regulator
```

```
Adapter   +----|>|----|--+       -  |
          |           |             |
 AC o-----+----|<|----+------------+-----o DC (-)
         ~                -
```

Considerations:

- An AC input of Vin VRMS will result in a peak output of approximately 1.4 Vin - 1.4 V. The first factor of 1.4 results from the fact that the peak value of a sinusoid (the power line waveform) is 1.414 (sqrt(2)) times the RMS value. The second factor of 1.4 is due to the two diodes that are in series as part of the bridge rectifier. The fact that they are both about 1.4 is a total coincidence.

  Therefore, you will need to find an AC wall adapter that produces an output voltage which will result in something close to what you need. However, this may be a bit more difficult than it sounds since the nameplate rating of many wall adapters is not an accurate indication of what they actually produce especially when lightly loaded. Measuring the output is best.

- Select the filter capacitor to be at least 10,000 uF per 1000 mA of output current with a voltage rating of at least 2 x Vin. This rule of thumb will result in a ripple of less than 1 V p-p which will be acceptable for many devices or where a voltage regulator is used (but may be inadequate for some audio devices resulting in some 120 Hz hum. Use a larger or additional capacitor or a regulator in such a case.

- Suitable components can be purchased at any electronics distributor as well as Radio Shack. The bridge rectifier comes as a single unit or you can put one together from 1N400x diodes (the x can be anything from 1 to 7 for these low voltage applications). Observe the polarity for the filter capacitor!

The following examples illustrate some of the possibilities.

- Example 1: A typical modem power pack is rated at 12 VAC but actually produces around 14 VAC at modest load (say half the nameplate current rating). This will result in about 17 to 18 VDC at the output of the rectifier and filter capacitor.

- Example 2: A cordless VAC battery charger adapter might produce 6 VAC. This would result in 6 to 7 VDC at the output of the rectifier and filter capacitor.

Adding an IC regulator to either of these would permit an output of up to a fraction to 2.5 V (depending on type) less than the filtered DC voltage.

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Adding an IC Regulator to a Wall Adapter or Battery

For many applications, it is desirable to have a well regulated source of DC power. This may be the case when running equipment from batteries as well as from a wall adapter that outputs a DC voltage or the enhanced adapter described in the section: Converting an AC output wall adapter to DC.

The following is a very basic introduction to the construction of a circuit with appropriate modifications will work for outputs in the range of about 1.25 to 35 V and currents up 1 A. This can also be used as the basis for a small general purpose power supply for use with electronics experiments.

What you want is an IC called an 'adjustable voltage regulator'. The LM317 is one example - Radio Shack should have it along with a schematic. The LM317 looks like a power transistor but is a complete regulator on a chip.

Here is a sample circuit:

```
                    I +-------+ O
    Vin (+) o-----+---| LM317 |---+--------------+-----o Vout (+)
                  |   +-------+   |              |
                  |       | A     /              |
                  |       |       \ R1 = 240     |
                  |       |       /              |           ___
                 _|_ C1   |       |            +_|_ C2      |_0_|  LM317
                 --- .01  +-------+             --- 1 uF    |   |  1 - Adjust
                  |  uF   |                    - |          |___|  2 - Output
                  |       \                      |           |||   3 - Input
                  |       / R2                   |           123
                  |       \                      |
                  |       |                      |
    Vin(-) o------+-------+----------------------+-----o Vout (-)
```

Note: Not all voltage regulator ICs use this pinout. If you are not using an LM317, double check its pinout - as well as all the other specifications. For a single output not referenced to a common, it doesn't matter whether a positive voltage regulator (as shown) or negative voltage regulator is used. However, were multiple power supplies like this are needed WITH a common point, negative voltage regulator ICs must be used for the negative ones.

Here are pinouts for the most common types:

```
  78xx (Fixed Pos)   79xx (Fixed Neg)    LM317 (Adj Pos)     LM337 (Adj Neg)

   ___                 ___                 ___                 ___
  |_O_|               |_O_|               |_O_|               |_O_|
  |   | 1 = Input     |   | 1 = Common    |   | 1 = Adjust    |   | 1 = Adjust
  |___| 2 = Common    |___| 2 = Input     |___| 2 = Output    |___| 2 = Input
   |||  3 = Output     |||  3 = Output     |||  3 = Input      |||  3 = Output
   123                 123                 123                 123
```

Note: Various manufacturers may label the pins differently than shown just to be confusing. For example, 1,3,2 instead of 1,2,3. However, the location of each pin will be the same so double check with the diagram.

For the LM317:

1. R2 = (192 x Vout) - 240, where R2 in ohms, Vout is in volts and must be at between 1.2 V and 35 V.

2. Vin should be at least 2.5V greater than Vout. Select a wall adapter with a voltage at least 2.5 V greater than your regulated output at full load.

   However, note that a typical adapter's voltage may vary quite a bit depending on manufacturer and load. You will have to select one that isn't too much greater than what you really want since this will add unnecessary wasted power in the device and additional heat dissipation.

3. Maximum output current is 1 A. Your adapter must be capable of supplying the maximum current safely and without its voltage drooping below the requirement in (2) above.

4. Additional filter capacitance (across C1) on the adapter's output may help (or be required) to reduce its ripple and thus the swing of its input. This may allow you to use an adapter with a lower output voltage and reduce the power dissipation in the regulator as well.

   Using 10,000 uF per *amp* of output current will result in less than 1 V p-p ripple on the input to the regulator. As long as the input is always greater than your desired output voltage plus 2.5 V, the regulator will totally remove this ripple resulting in a constant DC output independent of line voltage and load current fluctuations. (For you purists, the regulator isn't quite perfect but is good enough for most applications.)

   Make sure you select a capacitor with a voltage rating at least 25% greater than the adapter's *unloaded* peak output voltage and observe the polarity!

   Note: wall adapters designed as battery chargers may not have any filter capacitors so this will definitely be needed with this type. Quick check: If the voltage on the adapter's output drops to zero as soon as it is pulled from the wall - even with no load - it does not have a filter capacitor.

5. The tab of the LM317 is connected to the center pin - keep this in mind because the chip will have to be on a heat sink if it will be dissipating more than a watt or so. P = (Vout - Vin) * Iout.

6. There are other considerations - check the datasheet for the LM317 particularly if you are running near the limits of 35 V and/or 1 A.

7. For a negative output power supply, use the corresponding negative voltage regulator and note that their pinout is NOT the same as for the positive variety. See above!

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Dual Output Power Supply Using Centertapped Transformer

Where a centertapped secondary is available, a power supply outputting both positive and negative regulated or unregulated voltages can be constructed basically like a pair of the circuits above. The following would work for a +/- 15 VDC regulated unit to power analog circuitry like op-amps:

```
       28VCT,1A
   H o--+ T1
         )||       D1                   V+  In +------+ Out
         )|| +--+--|>|-----+--------------+----| 7815 |---------+----o +15 VDC
         )||(  ~|  D2      |         C1 +_|_   +------+    C3 +_|_
         )||(   +--|<|--+  |    5,000uF  ---   Com |     10uF  ---
         )||(  L1       |  |        25V - |        |       25V - |
 110 VAC )|| +----------------------------+--------+------------+--+-o Analog
         )||(  L2  D3   |  |         C2 +_|_       |       C4 +_|_ V   Common
```

```
        )||(   +--|>|--|--+    5,000uF  ---   Com |     10uF  ---
        )||(  ~|  D4   |          25V - |    +------+   25V - |
        )|| +--+--|<|--+-----------------+----| 7915 |---------+---o -15 VDC
        )||                            V-  In +------+ Out
  N o--+    D1-D4: 1N4007 or 2 A bridge
```

Note: Pinouts for 78 and 79 series parts are NOT the same!

For an unregulated supply, take the outputs from V+ and V-.

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Dual Output Power Supply Using Non-Centertapped Transformer

Without a centertap, it is still possible to provide both polarities of output voltage but a half wave configuration must be used. This is similar to the wiring of a voltage doubler but we are using the common point as ground:

Here is a circuit for a +/- 12 VDC supply:

```
       12V,1A
  H o--+ T1
        )||      D1           V+  In +------+ Out
        )|| +--+--|>|------------+----| 7812 |---------+----o +12 VDC
        )||(   |           C1 +_|_   +------+    C3 +_|_
 110 VAC )||(   |      10,000uF  ---   Com |     10uF  ---
        )||(   |           25V - |        |      25V - |
        )|| +--|----------------+--------+------------+--+-o Analog
        )||    |           C2 +_|_        |       C4 +_|_ V   Common
  N o--+       |      10,000uF  ---   Com |     10uF  ---
               |  D2       25V - |    +------+   25V - |
               +--|<|------------+----| 7912 |---------+---o -12 VDC
                               V-  In +------+ Out
```

For an unregulated supply, take the outputs from V+ and V-.

Since only half-wave rectification is used, the main filter caps, C1 and C2, should be at least twice the uF value compared to full wave or bridge circuits to obtain the same ripple.

Another disadvantage of this configuration is that if the currents drawn from the outputs aren't equal, net DC flows through the transformer secondary (with a voltage doubler having no output connection to the common point, this isn't possible). Core saturation may result if operating near the transformer's maximum current ratings.

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Higher Current Operation

By adding a PNP power transistor like a 2N2955 to either a fixed or adjustable regulator, maximum current can be easily increased. The circuit below will permit a very simple 3 to 5 A, 5 V power supply to be constructed assuming the power transformer/rectifier can supply this current. Q1 MUST be mounted on a large heat sink since it is dissipating power equal almost the entire output current times the difference between input and output voltage! Also, keep in mind that the filter capacitor(s) on the supply providing Vin must also be sized accordingly to keep ripple to a manageable level.

```
                 E     C
           +-----. Q1  .-------------+
           |     _\___/_             |
           |       B|                |
           |   R1   |   I +------+ O |
    Vin (+) o---+--/\/\--+-+---| 7805 |---+-+-----o Vout (+)
               5      |   +------+     |              ___
                      |       | C      |             |_O_|  7805
                     _|_ C1   |       +_|_ C2        |   |  1 - Input
                     --- .01  |        --- 1 uF      |___|  2 - Common
                      |  uF   |       - |             |||   3 - Output
                      |       |         |             123
    Vin(-) o--------------+-------+--------+-----o Vout (-)
```

The way this works is that once the current exceeds about Vbe(Q1)/5 A, Q1 turns on and bypasses current around the 7805.

For a negative supply based on a 79xx regulator, use an NPN transistor like a 2N3055 and reverse the capacitor polarities. Don't forget that the pinout for the 79xx and other negative voltage regulators is NOT the same as for the positive variety. See the section: Adding an IC Regulator to a Wall Adapter or Battery.

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Adjustable High Current Regulated Power Supply

This adds a gain stage to improve regulation compared to the circuit in the section: Higher Current Operation and is shown using an adjustable regulator though a fixed regulator could also be used. This is similar to the circuit in the Texas Instruments LM317 datasheet. Although not specified, I expect this is good for up to 5 A or more depending on the actual voltage difference between input and output and the size of the heat sink used for the power transistor, Q2.

```
+------------------.C   E.-------+
|               Q2 _\___/_       |
|            2N3055    |         |
|                      |    R5   |
+---------.E   C.------+---/\/\---+
|      Q1 _\___/_          500   |
|  2N2905     |                  |
|             / R4               |
|             \ 5K               |
|             /                  |
```

```
            |      R3    | I +-------+ O      | 1N4002
Vin (+) o---+-+---/\/\---+---| LM317 |---+----+--+------+-------+---o Vout (+)
              |    22      +-------+   |       |      |       |
              |                  | A     /      _|_     |       |
              |                  |       \ R1   /_\ D1  |       |
              |                  |       / 120   |      |       |
             _|_ C1              |       |       |    +_|_ C2   /
             --- 10uF            +-------+---+---+     --- 47uF \ RL*
              |                  |           |        - |       /
              |                  \ R2       +_|_ C3     |       |
              |               +->/ 5K        --- 10uF   |       |
              |               |  \         - |          |       |
              |               |  |           |          |       |
Vin(-) o------+---------------+--+-----------+----------+-------+---o Vout (-)
```

* For proper regulation, RL must be low enough in value to guarantee at least a 30 mA current at the selected output voltage. It can be a separate resistor or part of the actual load.

For even higher current operation, multiple power transistors (Q2) can be wired in parallel as a pass-bank with small (e.g., .1 ohm) emitter resistors to balance the load. In this case, Q1 may need to be a slightly bigger transistor and R4 reduced in value to provide adequate base drive. Details will depend on your particular needs.

As with the other circuits, a negative power supply can be constructed by using the appropriate regulator IC, swapping NPN or PNP transistors, and reversing all the polarities of the capacitors and diode.

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1.5 V Alkaline Cell Eliminator

I constructed this to provide a means of testing and experimenting with electronic flash circuits and (modifications to these circuits) that run on single Alkaline cells as their appetite for these is quite huge. See the section: Up to 350 VDC Inverter from 1.5 V Alkaline Cell.

```
                                         IC1
               D1                   I +--------+ O
            +--|>|--+-----+--------+--| LT1084 |--+------+-----o +1.5 VDC
       T1   |       |     |        |  +--------+  |      |
H o--+      |  D2   |     |        |      | A     / R1   |          IC1
      )|| +-+--|<|--|-+   |        |      |       \ 220  |        LT1084CP
      )||(          | |   |        |      |       /      |          ___
  115 )||( 4        | | +_|_ C1  +_|_ C2  |       |    +_|_ C3     |_O_|
  VAC )||( VAC      | |  --- 10K  --- 10K +-------+     --- 470uF  |   | 1 - A
      )||(     D3   | | - |  uF  - |  uF  |            - |  6.3V   |___| 2 - O
      )|| +-+--|>|--+ |   |  10V   |  10V \ R2           |          |||  3 - I
N o--+      |         |   |        |      / 62           |          123
            |         |   |        |      \              |       Front View
            |  D4     |   |        |      |              |
            +--|<|----+---+--------+------+--------------+-----o Return
```

The power transformer (T1) that I used was actually rewound from one that was rated at 12 V, 1 A. This was a high quality transformer, so removing 2/3rds of the secondary was quite a pain. Actually, the purpose was an experiment to see if it could be done non-destructively. Conclusions: Just barely. :-) Obviously, a transformer actually designed to produce about 4 or 5 V at 3 A could also be used.

D1 to D4 can be individual diodes or a bridge rated for at least 3 A.

The regulator (IC1) is an LT1084CP which is similar to an LM317 but is a low dropout type rated at 5 A max. I had a pile of these left over from a certain multi-million dollar project that had been cancelled due to upper management foot in a** disease..... An external pass transistor may be needed to use an LM317 because of the peak current requirement.

Despite the transformer only being rated for 1 A, with IC1 on a modest heatsink, the supply seems perfectly happy putting out 3 A at 1.5 V for an extended period. I don't know that I would run it all day at this high current but for my purposes, it seems fine.

It turns out that the typical electronic flash circuit from a disposable camera like the Kodak MAX (see Schematic and Photo), actually draws more than 3 A at the start of its recharge cycle. So, the voltage does dip a bit but this doesn't affect much of anything. Recharge time with the power supply is at least as rapid as with a fresh Alkaline cell. The voltage from an Alkaline cell also dips a bit under these conditions.

Obviously, the circuit could be easily modified to put out 2.4 VDC (for a pair of NiCd cells), 3 VDC (for two Alkalines), or whatever else you might need.

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Full Wave Voltage Doubler

A problem with most voltage doubler circuits is that the positive and negative outputs operate on alternate half-cycles so ripple is at the power line frequency rather than at twice the power line frequency. The transformer is also not utilized efficiently since only half of the secondary winding is passing current at any given time.

Here is a cute circuit that gets around both these problems. The original article is at: George Hrischenko's Genuine Full Wave Voltage Doubler Page.

```
   +-----------------+
||(                  |      +
||(        +---|>|---+-+---)|-----+---|>|---+
||(        |   D1      |   C1     |    D5    |
||(        |           |   D3     |          |
||(        |           +---|>|--+ |          |
||(   +----+                    | |          +---+
||(  _|_   |           +---|>|--|-+          | +_|_
||( ////   |           |   D4   |            |  --- C3
||(        |   D2      |   C2   |     D6     |  _|_
||(        +---|>|-+---+---)|---+-----|>|---+ ////
||(                |         +
   +---------------+
```

The output voltage is approximately 2.8 times the RMS rating of the transformer secondary (primary not shown). Ripple is at 2X the power line frequency.

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Boost Supply for PC

Boost Supply to Produce Clean Regulated +12 VDC shows an approach for getting a higher voltage than +12 VDC from an unmodified PC power supply. In this specific case, a source of +12 VDC for an audio or instrumentation PCI card was needed to be derived from the normally noisy +12 VDC output of a standard PC power supply. Any filtering would reduce the voltage below an acceptable level. The 555 implements an oscillator that runs at somewhere around 50 kHz which drives the MOSFET chopper and stepdown transformer to generate a few VDC which is added to the original 12 VDC from the PC. This is then regulated down using the 7812. By only generating a few V boost (just enough for the dropout requirements of the linear regulator) rather than the full output voltage, the components can be smaller since less power is involved.

Obviously, other voltages than +12 VDC can be produced in this manner - the example was a coincidence.

This could also be done with fewer components using modern SMPS ICs designed DC-DC converter applications but I don't have any suggestions off-hand.

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Switching Power Supplies

Panasonic VCR Switching Power Supply (PV48XX and Clones)

This circuit was reverse engineered from the switching power supply from a Panasonic VCR. It is typical of the small switchers used in the Panasonic PV28XX, PV48XX, and many other models, their Magnavox clones, as well as other Matsushita manufactured VCRs. Many VCRs of other brands use similar designs.

Errors in transcription are possible. Some models use additional outputs each fed from a single rectifier diode and filter capacitor (not shown). Some part numbers and the connector pinout may not be the same for your particular VCR.

A totally dead supply with a blown fuse usually means a shorted switchmode power transistor, Q1. Check all other components before applying power after replacement as other parts may be bad as well.

The most common problems resulting in low or incorrect outputs are dried up or leaky electrolytic capacitors - C4, C16, C17, C21.

See the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies for more info.

- Get the schematic for VCRPS in PDF format: VCRPS-SCH.

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Power Supply for Small SVGA Color Monitor

This is the complete schematic for the switchmode power supply (SMPS) from a small (probably 14 or 15 inch) "I guarantee you never heard of the brand name" SVGA color monitor.

The AC line input and degauss components are at the upper left, the SMPS chopper, its controller, and feedback opto-isolator are in the lower left/middle, and the secondaries - some with additional regulation components - occupy the entire right side of this diagram. Even for relatively basic application such as this, the circuitry is quite complex. There are more than a half dozen separate outputs regulated in at least 3 different ways!

The variable voltage B+ regulator is in the upper right corner. This provides an voltage to power the horizontal deflection which is determined by the video input. To maintain the same picture width, the required voltage to the horizontal output transistor/flyback needs to be roughly proportional to horizontal scan rate.

* Get MONPS-SCH: mon1ps.gif

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Inverter Circuits

Inverter Introduction

Most of these circuits were reversed engineered from commercial products. The good news is that this means they probably all work somewhat reliably. The bad news is that a custom wound transformer (you can build in most cases) will be needed and there may be errors in the number of turns and wire sizes listed since these were all determined without totally dismembering the unit in question.

However, the circuit described in the section: Super Simple Inverter" only requires off-the-shelf components but has a pitiful efficiency. But construction is, well, super simple :-).

And, it should be easy to make modifications to the flash units from pocket or disposable cameras as described in the section: Up to 350 VDC Inverter from 1.5 V Alkaline Cell since these are quite readily available for free if you know where to ask!

For more information on fluorescent and xenon lamps, see the documents: Fluorescent Lamps, Ballasts, and Fixtures and Notes on the Troubleshooting and Repair of Electronic Flash Units and Strobe Lights and Design Guidelines, Useful Circuits, and Schematics, respectively.

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Super Simple Inverter

This circuit can be used to power a small strobe or fluorescent lamp. It will generate over 400 VDC from a 12 VDC, 2.5 A power supply or an auto or marine battery. While size, weight, and efficiency are nothing to write home about - in fact, they are quite pitiful - all components are readily available (even from Radio Shack) and construction is very straightforward. No custom coils or transformers are required. If wired correctly, it will work.

Output depends on input voltage. Adjust for your application. With the component values given, it will generate over 400 V from a 12 V supply and charge a 200 uF capacitor to 300 V in under 5 seconds.

For your less intense applications, a fluorescent lamp can be powered directly from the secondary (without any other components). This works reasonably well with a F13-T5 or F15-T12 bulb (but don't expect super brightness). Q1 does get quite hot so use a good heat sink.

```
                     C1 1 uF                   D2 1N4948   R2
                 +------||------+        T1    1.2kV PRV  1K 1W
                 |              |           +-----|>|-----/\/\---+------o +
                 | R1 4.7K, 1W  |   red  ||( blk                 |
                 +-----/\/\-----+------+ ||(                     |
                 |                  yel )||(                   +_|_ C2
  + o----------------------------------+ ||(                    --- 300 uF
                 |                  red )||(                   - |  450 V
                 |      +--------------+ ||(                     |
                 |  Q1  |                ||( blk                 |
 6 to 12         |    |/ C                  +--------------------+------o -
 VDC, 2A         +----|    2N3055    Stancor P-6134
             D1 _|_   |\ E           117 V Primary (blk-blk)
         1N4007 /_\     |            6.3 VCT Secondary (red-yel-red)
                 |      |
  - o------------+------+
```

Notes on Super Simple Inverter

1. Construction can take any convenient form - perf board, minibox, etc. Make sure the output connections are well insulated.
2. C1 must be nonpolarized type - not an electrolytic.
3. D1 provides a return path for the base drive and prevents significant reverse voltage on the B-E junction. Any 1 A or greater silicon diode should be fine.
4. C2 is shown as typical energy storage capacitor for strobe applications. Remove D2 and C2 for use with a fluorescent lamps.
5. D2 should be a high speed (fast recovery) rectifier. However, for testing, a 1N4007 should work well enough. R2 limits surge current through D2.
6. The polarity of the input with respect to the output leads is important. Select for maximum voltage by interchanging the black output wires.
7. Mount Q1 (2N3055) on a heat sink if continuous operation is desired. It will get warm. Other NPN power transistors with Vceo > 80 V, Ic > 2 A, and Hfe > 15 should work. For a PNP type, reverse the the polarities of the

power supply and D1, and interchange one set of leads (where a diode is used for DC output).

8. Some experimentation with component values may improve performance for your application.

9. When testing, use a variable power supply so you get a feel for how much output voltage is produced for each input voltage. Component values are not critical but behavior under varying input/output voltage and load conditions will be affected by R1 and C1 (and the gain of your particular transistor).

10. WARNING: Output is high voltage and dangerous even without large energy storage capacitor. With one, it can be lethal. Take appropriate precautions.

11.
```
        |                         |           |
     ---+--- are connected;    ---|--- and ------- are NOT connected.
        |                         |           |
```

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AmerTac Fluorescent Lamp Inverter

(From: (Dennis Hawkins (n4mwd@amsat.org).)

The AmerTac Fluorescent Lamp Ballast is from a portable 12 V light made in China for American Tack & Hardware Co sold in Home Depot stores. It burned out after about 30 minutes of continuous use. (OK, maybe you shouldn't consider duplicating this exactly! --- Sam) So I decided to take it apart and see what was in there.

What it had was a very small circuit board (about 1/2" x 2"). Both the transformer and the transistor were melted beyond recognition. The transformer was apparently custom made out of two 'E' cores taped together. I have another identical unit, so I could read the transistor part number: 2SD882. It is rated 80 V, 5 A, 40 W, typical Hfe of 30, in a TO127 package.

Unlike many of the others, this circuit powers both both filaments in the tube but is otherwise very similar.

I have another identical unit which hasn't been fried so I put a UV bulb in there and fired it up. It is clear that only one end has a glowing filament. It is the end connected to pins 5 & 6 of the transformer. The filament attached to pins 1 and 2 appears to only work as a resistor. The circuit will not operate without the bulb so I wasn't able to get reliable readings.

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Archer Mini Flashlight Fluorescent Lamp Inverter

The circuit below was reverse engineered from the Archer model number 61-3724 mini fluorescent/incandescent flashlight combo (no longer in the Radio Shack catalog). The entire inverter fits in a space of 1-1/8" x 1" x 3/4". It is powered by 3 C size Alkaline cells and drives a F4-T5 tube.

This design can easily be modified for many other uses at lower or higher power.

```
                                    o  T1
  + o----+----------+----------------+     o
         |          |                 ):: +--------------+-+
         |          \           D 28T )::(               | |
         |       R1 /             #26 )::(              +|-|+
         |      560 \      +---------+ ::(              | - |
         |          /      |           ::( O 315T       |   | FL1
         |          |      |        o  ::( #32          |   | F4-T5
         |          +------|---------+ ::(              | - |
         |          |      |          )::(              +|-|+
       +_|_ C1      |      |    F 28T )::(               | |
        --- 47 uF   |      |      #32 ):: +--------------+-+
       - |  16 V    |      |     +---+
         |          |      |  Q1 |           O = Output
         |          |     C \|   |           D = Drive
         |      C2 _|_       |---+           F = Feedback
         | .022 uF ---    E /|   |
         |          |      |    _|_ C3
         |          |      |    --- .022 uF
         |          |      |     |
   o-----+----------+------+-----+
```

Notes on Archer mini flashlight fluorescent lamp inverter:

1. T1 is an E-core ferrite transformer. The core is 5/8" x 3/4" x 3/16" overall. The outer legs of the core are 1/8" thick. The central leg is 3/16" square. The square nylon bobbin has a diameter of 5/16". There is a .020" gap (spacer) in between the two halves of the E-core.

   The 315T O (Output) is wound first followed by the 28T D (Drive) and 28T F (Feedback) windings. There should be a strip of mylar insulating tape between each of the windings.

   The number of turns were estimated without disassembly as follows:

   - The wire sizes were determined by matching the diameters of the visible ends of the wire for each winding to magnet wire of known AWG.

   - The number of turns in the Output winding was determined based on its measured resistance, core diameter, and the wire gauge tables.

   - A 50 kHz .1 V p-p signal was then injected into the Feedback winding. The amplitudes of the resulting outputs from the Drive and Output windings were then measured. From these, the ratios of the number of turns were calculated.

2. The transistor was totally unmarked. A general purpose NPN medium power transistor like a 2N3053 or ECG24 should work. For PNP types, reverse the polarities of the power supply and C1.

   Since it is very low power, no heat sink is used in the Archer flashlight. However, for other applications, one may be needed.

3. Some experimentation with component values may improve performance for your application.

4. When testing, use a variable power supply so you get a feel for how much output voltage is produced for each input voltage. Component values are not critical but behavior under varying input/output voltage and load conditions will be affected by C2 and C3, the number of turns on each of the windings of T1, and the gain of your particular transistor.

5. WARNING: Output is high voltage and dangerous. Take appropriate precautions.

6.
```
   |                         |           |
---+--- are connected;    ---|--- and ------- are NOT connected.
   |                         |           |
```

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Energizer Mini Flashlight Fluorescent Lamp Inverter

The circuit below was reverse engineered from the Energizer model number unknown (worn off) mini fluorescent/incandescent flashlight combo. The entire inverter fits in a space of 1-1/8" x 1-1/8" x 3/4". It is powered by 4 AA size Alkaline cells and drives a F4-T5 tube.

This design is very similar to the Archer model (see the section: [Archer Mini Flashlight Fluorescent Lamp Inverter](#), but eases starting requirements by actually heating one of the filaments of the T5 lamp. Thus, a lower voltage transformer can be used.

```
                                              o  T1  o
+ o----+----------+--------+-------------------+    +----------------+
       |          |   C4 _|_                   ):( H 16T #32       |
       |          \  1000 ---             D 32T ):: +--------------+ |
       |       R1 /    pF  |                #26 )::(               | |
       |      360 \        +-------------------+ ::(              +|-|+
       |          /        |                     ::(              | - |
       |          |        |                  o  ::( O 160T       |   | FL1
       |          +--------|-------------------+ ::( #32          |   | F4-T5
       |          |        |                    )::(              | - |
     +_|_ C1      |        |              F 16T )::(              +|-|+
      --- 47 uF   |        |                #26 )::(               | |
     - |  16 V    |        |  Q1           +---+    +--------------+-+
       |          |        |  MPX9610      |
       |          |       C \|        R2   |       O = Output
       |      C2 _|_         |---+---/\/\---       D = Drive
       | .047 uF ---      E /|   |    22           F = Feedback
       |          |        |    _|_ C3             H - Heater (filament)
       |          |        |    --- .01 uF
       |          |        |     |
 o-----+----------+--------+-----+
```

Notes on Energizer Mini Flashlight Fluorescent Lamp Inverter

1. T1 is an E-core ferrite transformer. The core is 1/2" x 5/8" x 3/16" overall. The outer legs of the core are 3/32"

thick. The central leg is 3/16" square. The square nylon bobbin has a diameter of 5/16". There is a .010" (estimate) gap (spacer) in between the two halves of the E-core.

The 160T O (Output) is wound first followed by the 16T H (Heater), 32T D (Drive), and 16 T F (Feedback) windings. There should be a strip of mylar insulating tape between each of the windings.

The number of turns were estimated after unsoldering the transformer from the circuit board as follows:

- The wire sizes were determined by matching the diameters of the visible ends of the wire for each winding to magnet wire of known AWG.
- The number of turns in the Output winding was determined based on its measured resistance, core diameter, and the wire gauge tables.
- A 100 kHz .1 V p-p signal was then injected into the Drive winding. The amplitudes and phases relationship of the resulting outputs from the Feedback, Heater, and Output windings were then measured. From these, the ratios of the number of turns and winding start/end were determined.

2. The transistor was an MPX9610. I was not able to locate specs for this part number but a transistor like a 2N3053 or ECG24 should work. For PNP types, reverse the polarities of the power supply and C1.

   Since it is very low power, no heat sink is used in the Energizer flashlight. However, for other applications, one may be needed.

3. Some experimentation with component values may improve performance for your application.

4. When testing, use a variable power supply so you get a feel for how much output voltage is produced for each input voltage. Component values are not critical but behavior under varying input/output voltage and load conditions will be affected by C2 and C3, the number of turns on each of the windings of T1, and the gain of your particular transistor.

5. WARNING: Output is high voltage and dangerous. Take appropriate precautions.

6.
```
        |                          |           |
     ---+--- are connected;    ---|--- and ------- are NOT connected.
        |                          |           |
```

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Pocket Fluorescent Blacklight Inverter GH-RV-B1

(Schematic from: Axel Kanne (axel.k@swipnet.se).)

This was reverse engineered from a toy pocket blacklight, made in China. It has been tested with tubes up to 6 W.

```
 4.5 to 12V (4)                                T1(2)
  + o---+-------------------+--------------+    +-----+-+
        |                   |   R2          )::(      | |
```

```
       |                     +--/\/\--+    W1 )::(     +|-|+
       |                        470   |       )::(     | - |
     +_|_ C1                    +-----|------+ ::( W3  |   | FL1
      --- 47uF                |/ C   _|_ C3    ::(     |   | (3)
       |  16V    +---+------| Q1   --- .015  ::(     | - |
       |         |   |   (1)|\ E    |  uF    ::(     +|-|+
       |    C2 _|_  |        |     +------+ ::(      | |
       |  .01uF ---  |   R1   |     |    W2 ):: +--+--+-+
       |         |   +--/\/\--|-----|------+       |
       |         |      20    |     |              |
   - o---+---------+------------+-----+--------------+
```

Notes on Pocket Fluorescent Blacklight Inverter GH-RV-B1

1. The original transistor is marked 8050 C0ZC. A 2N3055 works better than the original, the tube starts faster and the transistor runs much cooler.

2. T1 is a ferrite E-core transformer measuring 17mm x 15mm x 15mm. The core seems to be 5 mm thick. The turns ratio has not been determined. Winding W1 is made of ~0.2 mm wire, the resistance is below 1 ohm. The data for winding W2 is the same as winding W1. Winding W3 is made of ~0.5 mm wire and its resistance is 5 ohms.

3. The original tube is an F4T5BLB blacklight tube, but the inverter has been tested with an ordinary F4T5 tube as well as a Philips 6W tube. The 6W tube causes the original transistor to run quite hot, so using a 2N3055 or similar power NPN is recommended.

4. 4.5V seems to be the absolute minimal voltage required to start an F4T5 tube. 5V will start the 6W tube when a 2N3055 transistor is used. Voltage can probably be cranked up above 12V, but that was the highest I tried (Didn't want to test when the tube blows).

5. CAUTION: The inverter can give a nice(?) shock when run with the original transistor on 5V. With a 2N3055 and higher supply voltage, it can be nasty. Avoid touching the tube terminals. The bottom of the PCB can also give quite suprise, as I discovered :-(.

6.
```
       |                          |           |
    ---+--- are connected;    ---|--- and ------- are NOT connected.
       |                          |           |
```

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Automotive Light Stick Inverter

(Circuit and description From: Manuel Kasper (mk@mediaklemm.com).)

Here's another schematic from a little light stick intended for use in a car at 12 V. It uses an F8T5 bulb and is quite similar to the Archer inverter (A HREF="#schamf">Archer Mini Flashlight Fluorescent Lamp Inverter) which, BTW, I've built successfully. :) Here's the ASCII schematic (I'm no ASCII wizard, so I took one out of your schematic collection and made the appropriate modifications). Or see the Automotive Light Stick Inverter in .gif format.

```
                                         o      o
+12 V o----+--------+---------------------+    +------------+-+
           |        |                      )||(             | |
           |        \             28 turns )||(            +|-|+
           |   5.1K /                  #28 )||(            | - |
           |        \    +----------------+ ||(            |   |
           |        /    |                  ||( 280 turns  |   | F8T5
           |        |    |               o  ||( #38        |   |
           |        +----|----------------+ ||(            |   |
   47 uF +_|_       |    |                 )||(            | - |
    25V   ---       |    |        28 turns )||(            +|-|+
           |        |   C \| Q1        #28 )||(             | |
           |        |      |------+---+---+    +---+--------+-+
           |       _|_  E /|      |   |            |
           | 10 nF ---   |        \  _|_           |
           |        |    |    10K /  --- 40 nF     |
           |        |    |        \   |            |
           |        |    |        |   |            |
     o-----+--------+----+--------+---+------------+
```

Notes on Automotive Light Stick Inverter

1. The transformer was an E-core ferrite, most likely E20. The primary and feedback windings were wound side-by-side first, followed by a strip of insulating tape, then the secondary. I'm absolutely positive that it was #38, however the primaries may also have been #26. There were tiny spacers on both outer legs, consisting of two layers of the same yellow insulating tape that was used to hold both halves of the core together. Total not thicker than .004". I could not remove the core without destroying it, so I don't know if there was a gap or spacer on the central leg. Stupid as I am, I forgot to measure the inductance of the secondary before disassembling, so no calculations about the AL value of the core can be made. :(

2. Q1 was in a TO-220 case (not heatsinked) and marked "D313 F5H4", so I suppose it was a 2SD313. If so, from what I know it would have an Ic of 2 A, a Vceo of 50 V and an hFE of 40..320. It ran very cool in the circuit. Power consumption from 12 V was about 250 mA - the tube was lit fairly bright, but of course not at full power. On the label it states "Power: 12 Volt DC at 5 Amps", but I don't think the latter is correct. ;)

3. It has got a long cable with a nice set of plugs - a pair of alligator clips as well as a cigarette lighter plug. It's made in China, cost the equivalent of $8 and could not be disassembled without cutting thick black rubber apart.

Comments on Automotive Light Stick Inverter

I just experimented with rebuilding it a bit. It works fine with a home-made transformer using an E 25 core (25 mm core width, or 0.79"). I tried both an un-gapped (AL = 1750 nH) and a 0.4"-gapped (on central leg; AL = 151 nH) version. Concerning efficiency, the result was more or less the same, but due to the higher switching frequency with the gap, there was no buzzing sound from the transformer. It worked even with 32 primary and 350 secondary turns, secondary wound first with the output and feedback winding not side-by-side but one over another. It's also great as an inverter for use with a G4-T5 to erase EPROMs, as I discovered.

Transistors with low gain don't seem to work well - BD237 and 2N5191 were reasonably good. It's easy to have it operate at more power - just decreasing the 5.1 k resistor and adding a small heatsink works great.

The filter capacitor gets pretty warm; needs to be low ESR or it will probably overheat, especially at higher power levels.

In the original inverter, there was a connection between the secondary and ground. Strange - it doesn't seem to make any sense because nothing changes if you remove it. But they have got their reasons, I suppose.

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Low Power Fluorescent Lamp Inverter 1

The circuit below was reverse engineered from a model number FL-12 'Made in Hong Kong' battery (8 AA cells) or 12 V wall adapter powered portable fluorescent lamp. The bulb is an F8-T5.

This design can easily be modified for many other uses at lower or higher power. Note that its topology is similar to that of the circuit described in the section: Super Simple Inverter.

```
                            C2 .01 uF
                         +------||------+        T1   3
                         |              |           +------------+-+
                         |   R1 1.5K    |    4 o ::(             | |
                         +-----/\/\-----+------+ ::(            +|-|+
                         |               18T F )::(             | - |
                         |                   1 )::(             |   | FL1
      + o-----+----------|---------------------+ ::( O 350 T    |   | F8-T5
              |          |                     )::(             |   |
              |          |               25T D )::(             |   |
              |       R2 /                   2 )::(             | - |
              |       68 \      +-------+------+ ::(            +|-|+
    6 to 12  _|_ C1      /  Q1  |       |        ::( 5           | |
      VDC    ---  100 uF |      |       |           +---+--------+-+
              |   16 V   |    |/ C      |               |
              |          +----|    5609 +---------------+
              |      C3 _|_   |\ E NPN                     O = Output
              | .027 uF ---     |                          D = Drive
              |          |      |                          F = Feedback
    - o-------+----------+------+
```

Notes on Low Power Fluorescent Lamp Inverter 1

1. T1 is an E-core ferrite transformer. The core is 5/8" x 3/4" x 3/16" overall. The outer legs of the core are 3/32" thick. The central leg is 3/16" square. The square nylon bobbin has a diameter of 5/16". There is no visible spacer between the cores but I did not disassemble to confirm.

   The 350T O (Output) is wound first followed by the 25T D (Drive) and 18T F (Feedback) windings. There should be a strip of mylar insulating tape between each of the windings.

   The number of turns were estimated without disassembly as follows:

   - The resistances of each of the windings was measured to determine the arrangement of the transformer.

- The inverter was run at just enough input voltage for it to oscillate (so the load of the fluorescent tube would not affect the readings) and the voltages on all 3 windings were measured on an oscilloscope. From this, the ratios for the windings were determined.

- An estimate was made of the number of turns likely to be on the Drive winding based on other similar designs. The number of turns on the other windings were calculated based on the turns ratios. Wire size is probably #36 AWG.

2. The transistor was marked 5609 which I could not cross to anything. I would guess that a general purpose medium NPN power transistor like a 2N3053 or ECG24 should work. For a PNP type, reverse the polarities of the power supply and C1.

   Since it is very low power, no heat sink is used in this lamp. However, for other applications, one may be needed.

3. Some experimentation with component values may improve performance for your application.

4. When testing, use a variable power supply so you get a feel for how much output voltage is produced for each input voltage. Component values are not critical but behavior under varying input/output voltage and load conditions will be affected by C2, C3, R1, R2, the number of turns on each of the windings of T1, and the gain of your particular transistor.

5. WARNING: Output is high voltage and dangerous. Take appropriate precautions.

6.
```
       |                          |           |
    ---+--- are connected;    ---|--- and ------- are NOT connected.
       |                          |           |
```

Gary's EPROM Eraser

(From: Gary Perry (perry_gary@ascom.co.uk).) I used this circuit based on this design to build an EPROM eraser, using the 4 watt G4T5 germicidal tube.

The tube seems to like 75 VAC in order to 'fire it up'.

I used a 2N3053 transistor and a commonly available commercial 6 - 0 - 6 primary 240VAC 100mA secondary transformer. After 25 minutes constant usage, both transistor and transformer remained cool.

A variable PSU was connected, and the circuit worked first time. The required 75 VAC output was achieved with only 5 VDC input.

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Low Power Fluorescent Lamp Inverter 2

The circuit below is the type used in inexpensive fluorescent camping lanterns. In this particular model, an F6-T5 lamp was used. It will drive F4-T5 to F13-T5 tubes depending on input voltage. The power source can be a 4 to 9 V, 2 A power supply (depending on the size of your lamp) or a suitable battery pack. This design was reverse engineered from a random commercial unit of unknown manufacture using a lead-acid battery battery that expired long ago.

```
                                     o T1
+ o----+---------+-------------------+
       |         |                    )::  o      C2
       |     S1 |              D 20T )::  +-------||------+-+
       |   Start  |-              #26 )::(     .022 uF    | |
       |         |                    )::(      600 V    +|-|+
       |         |           +-------+ ::(               | - |
       |     R2 \           |         ::( O 250T        |   |
       |    270 /           |      o  ::( #32           |   | FL1
       |         \    +------|-------+ ::(               |   | T5 lamp
     +_|_ C1      |    |      | F/S 7T )::(               |   |
      --- 100 uF |    |      |    #32 )::  +--------+     | - |
     - |  16 V   +----|------|---+---+             |     +|-|+
       |              |      |   |                 |      | |
       |              |      |   +-----------------|------+-+
       |              |      +-----------+         |
       |     S2       |      |           |         |  O = Output
       | _|_ Off      |     |/ C        |         |  D = Drive
       +-- --+--------+----|    Q1     |         |  F/S = Feedback/starting
       |     |        |    |\ E 2SC1826 _|_ D2     |
       |     \       _|_      |          /_\ 1N4007 |
       |  R1 /    D1 /_\     |           |         |
       | 220 \ 1N4148 |      |           |         |
       |     |        |      |           |         |
 o-----+-----+--------+------+-----------+---------+
```

The approximate measured operating parameters are shown in the chart below. The two values of input current are for starting/running (starting is with the Start button, S1, depressed.

Lamp type ---> V(in)	F4-T5 I(in)	F6-T5 I(in)	F13-T5 I(in)
3 V	.9/.6 A	-	-
4 V	1.1/.7 A	1.1/.8 A	-
5 V	1.3/.8 A	1.2/.9 A	-
6 V	-	1.4/1.0 A	1.6/.95 A
7 V	-	-	1.7/1.0 A
8 V	-	-	1.8/1.2 A
9 V	-	-	2.1/1.3 A
10 V	-	-	2.2/1.4 A

Notes on Low Power Fluorescent Lamp Inverter 2

1. Construction can take any convenient form - perf board, minibox, etc. Make sure the output connections are well insulated.

2. T1 is assembled on a square nylon bobbin, 3/8" cubed. Wind the 250T O (Output) first, insulate with mylar tape, 20T D (Drive) next, and 7T F/S (Feedback/Starting) last. Observe directions of windings as indicated by the dots (o). The number of turns for the O winding was estimated based on measured winding resistance, wire size, and the dimensions of the bobbin.

The core is just a straight piece of ferrite 1/4" x 1/4" x 1-3/8" It is fully open - there is no gap.

3. Any general purpose NPN power transistor with Vceo > 80 V, Ic > 2 A, and Hfe > 15 should work. For a PNP type, reverse the polarities of the power supply, C1, D1, and D2.

   Use a good heat sink for continuous operation at higher power levels (6 V input or above). The type used (2SC1826) was a replacement after I fried the unidentified transistor originally installed (103-SV2P001).

4. Pushbutton switches are used to control operation. S1 (Start) provides initial base drive to the transistor via the Feedback/Starting winding of T1 until the tube arc is established. At that point, feedback is sustained via current flowing through the tube. S2 (Off) shorts the base of the transistor to ground to stop the oscillator.

   Like a regular manual start preheat fluorescent fixture, the start switch, must be depressed until the lamp comes on at full brightness indicating that the filaments are adequately heated.

5. Some experimentation with component values may improve performance for your application.

6. When testing, use a variable power supply so you get a feel for how much output voltage is produced for each input voltage. Component values are not critical but behavior under varying input/output voltage and load conditions will be affected by R1 and R2 (during starting in particular), the number of turns on each of the windings of T1, and the gain of your particular transistor.

7. WARNING: Output is high voltage and dangerous. Take appropriate precautions.

8.
```
       |                          |           |
    ---+--- are connected;     ---|--- and ------- are NOT connected.
       |                          |           |
```

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Medium Power Fluorescent Lamp Inverter

This circuit is capable of driving a variety of fluorescent lamps from a 4 to 12 V, 2 to 2.5 A DC power supply, rechargeable battery pack, or auto or marine battery. With appropriate modifications (if needed) it may be used for other applications like powering an electronic flash or HeNe laser tube. The transformer will need to be custom wound (by you) but this is not really difficult - just slightly time consuming for the 600 turn O (Output) winding if you don't have a coil winding machine.

I have used it with fluorescent tubes of many sizes: F6-T5, F13-T5, F15-T12, and F20-T12. The arc will be sustained with the filaments hot on an input as low as about 3.5 to 4 V (with a new tube) but during starting, an input voltage of about 5 or 6 V may be needed until the filaments are hot enough to sustain the arc at the lower voltage.

Two nearly identical circuits are shown.

- This design saves a couple of diodes but requires a centertapped feedback winding on the transformer. The input voltage must exceed about 4 V for oscillation to commence:

```
              +Vcc                           o T1
```

```
       o       Q1  +----------------+
       |           |                 )::
       +       B |/ C                )::
 L1 ::(   +------|    MJE3055T       )::             C1
24T ::(   |      |\ E         D 15T ):: +----------||---------+-+
#22 ::(   |        |            #26 )::(       .0039 uF       | |
       +  |       -_-                )::(         600 V      +|-|+
       |  |                          )::(                     | - |
       +--|-------------------------+ ::(                     |   |
       |  |                          )::(                     |   |
       |  |    Q2 _-_                )::(                     |   |
       |  |        |                 )::( O 600T              |   | FL1
       |  |    B |/ E         D 15T )::( #32                  |   |
       |  |  ----|    MJE3055T   #26 )::(                     |   |
       |  |  |   |\ C                )::(                     |   |
       |  |  |     |                 )::(                     |   |
       |  |  |     +----------------+ ::(                     | - |
       |  |  |                        ::(                     +|-|+
       |  |  |                      o ::(                      | |
       |  |  -----------------------+ :: +---------------------+-+
       |  |                    F 10T )::
       |  |                      #32 )::
       |  |               +---------+ ::    O = Output
       |  |               |    F 10T )::    D = Drive
       |  |               |      #32 )::    F = Feedback
       |  +-------------------------+
       |                  |
       |            R1    |    R2
       +----------/\/\/\--+--/\/\/\--+
                    220        22   _|_
                    1 W        2 W   -
```

- The following slightly modified design starts oscillating at a very low input voltage (under 2 V). This may be beneficial when driving small lamps. The circuit behaves quite similarly in all other respects.

```
     +Vcc                             o T1
       o          Q1 +----------------+
       |             |                 )::
       +           B |/ C              )::             C1
 L1 ::(   +---+----|    MJE3055T       ):: +----------||---------+-+
24T ::(   | __|__  |\ E         D 15T )::(       .0039 uF       | |
#22 ::(   | _/_\_   _|_            #26 )::(         600 V      +|-|+
       +  |  _|_     -                 )::(                     | - |
       |  |   -   D1 1N4148            )::(                     |   |
       +--|---------------------------+ ::(                     |   |
       |  |  _-_  D2 1N4148            )::(                     |   |
       |  | __|__   _-_                )::( O 600T              |   | FL1
       |  | _\_/_    |                 )::( #32                  |   |
       |  |   |  B |/ E         D 15T )::(                     |   |
       |  |  +----|    MJE3055T   #26 )::(                     |   |
       |  |   |    |\ C                )::(                     |   |
```

```
                 /  |   |      |                 )::(                     | - |
             R1  \  |   |  Q2  +----------------+ ::(                     +|-|+
             1K  /  |   |                         ::(                      | |
                 \  |   |                       o :: +---------------------+-+
                 |  |   +-----------------------+ ::
                 |  |                      F 10T )::    O = Output
                 |  |       R2 22, 2 W       #32 )::    D = Drive
                 +--+---------/\/\/\------------+       F = Feedback
```

The switching frequency is about 21 kHz and varies less than 5 percent over the range of input voltage for which the bulb remains lit (it is significantly higher with no load - about 140 kHz). An input voltage of about 4 V is needed to start oscillation (reducing R1 or increasing R2 would lower this at the expense of efficiency at higher voltages) but it will continue well below 3 V.

The measured input current at various input voltages for two lamp types are shown in the chart below. SV (Starting Voltage) is the minimum input voltage required to preheat the filaments before the lamp will turn on (current is lower until filaments are hot). FB (Full Brightness) is the point at which the lamp appears to be operating at the same intensity as if it were installed in a normal 115 VAC fixture.

Lamp type ---> V(in)	F13-T5 I(in)	F20-T12 I(in)
3 V	-	1.37 A
4 V	1.76 A	1.52 A (SV)
5 V	1.80 A (SV)	1.60 A
6 V	1.90 A	1.65 A
7 V	1.96 A (FB)	1.70 A
8 V	2.02 A	1.80 A
9 V	2.16 A	1.90 A
10 V	2.33 A	2.05 A
11 V	-	2.30 A (FB)
12 V	-	2.60 A

Notes on Medium Power Fluorescent Lamp Inverter

1. T1 is an E-core ferrite transformer. Once complete, the cores are installed on the bobbin with a 2 mm gap. Some experimentation with the core gap may be needed to optimize performance for a given lamp type and input voltage.

   Each E core is 1" x 1/2" x 1/4" overall. The outer legs of the core are 1/8" thick. The central leg is 1/4" square. The square nylon bobbin has a diameter of 5/16" and length of 3/8".

   The 600T O (Output) is wound first followed by the 15T D (Drive) and 10T F (Feedback) windings. For convenience, wind the D and F windings bifiler style (the two wires together). Determine the appropriate connections with an ohmmeter (or label the ends). The centertaps are brought out to terminals. Try to distribute the O winding uniformly across the entire bobbin area by winding it in multiple layers. This will assure that no wires with a significant voltage difference are adjacent. There should be a strip of insulating tape between the O and the other windings.

2. L1 isolates the power supply. It is 24 turns of #22 wire wound on a 1/4" ferrite core. The inverter works fine without L1 but seems to have a tad more strength at low voltage with it.

3. The transistors are MJE3055T (2N3055 in a TO220 package) types but are not critical. However, I expect that some faster switching transistors would run cooler. Any fast switching NPN power transistor with Vceo > 80 V, Ic > 3 A, and Hfe > 15 should work. For PNP types, reverse the polarity of the power supply.

   For operation above about 6 V, a pair of good heat sinks will be required. However, power dissipation in the transistors does not seem to increase as much as expected - the base drive is probably more optimal at higher input voltage.

4. Some experimentation with component values may improve performance for your application.

5. When testing, use a variable power supply so you get a feel for how much output voltage is produced for each input voltage. Component values are not critical but behavior under varying input/output voltage and load conditions will be affected by C1, the number of turns on each of the windings of T1, the gap of the core of T1, and the gain of your particular transistor. If the circuit does not start oscillating, interchange the F winding connections to Q1 and Q2.

6. WARNING: Output is high voltage and dangerous. Take appropriate precautions.

7.
```
       |                         |           |
    ---+--- are connected;    ---|--- and ------- are NOT connected.
       |                         |           |
```

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Lazar's Comments on F-Lamp Inverter Design

(From: Lazar Pancic (dextter@eunet.yu).)

I planned one week of camping with my friends this summer, so I wanted to make one fluorescent tube run on 12V and studied a lot of Internet places for the ideas. I made some of the circuits (some of them I found on your site) but the performance was not as I expected. Yes, they do run a 8W tube but the brightness is quite obviously lower than when the tube is run on mains supply. Then I started to study app-notes of many different electronic ballasts for fluoro-tubes and got the idea what was wrong. I send my conclusions to you with the hope that it could help others in selecting the good circuit with less trouble than I got :))

1. For the good performance it is important to drive fluorescent tube by pure AC voltage. It may look strange, but simple flyback transformer drives the tube on DC, not AC! Look at one of the flyback circuits: when the transistor is conducting the primary windings get more and more current which produces storage of magnetic energy in the core of the transformer. At the point when the core saturates the base drive for the transistor is being suddenly cut off (this "suddenly" depends on the core material properties), and the stored energy is being transferred by the secondary winding to the tube as a high voltage pulse. Since the orientation of primary and secondary windings and the battery (e.g. accumulator) is always the same this pulse also has the same polarity every time. That's why only one side of the tube gets darker after it is being run on such inverter for some period of time, and that is why the tube can't perform well for some reasonable period of time with the flyback topology of the driver.

2. Because there is one period within the flyback cycle when the transistor is only supplying the transformer with the magnetic energy and the tube doesn't get any portion of the energy during this period, the tube would probably turn off during this. That is not good at all. One of the biggest advantages of the electronic ballasts over older ballasts with the inductors (or transformers) is that the tube is run on high frequency so that it doesn't turn off at any time.

There is no flicker but one more important consequence is that the tube need not be started at the beginning of every single cycle! That's why the tube has 10% more light power when being run on electronic ballasts. Naturally, the good ballasts have no "dead-time" in their operation cycles.

3. For the long lifetime of the tube, many app-notes suggest sinusoidal form of the tube driving voltage, which is not the case with the flyback inverters. The tube voltage would be probably the very high voltage pulse at the very beginning of the tube supply period of the inverter cycle, and approx. 100V of continuous voltage at the rest of the cycle (all of these is during the period while the transistor is not conducting; while it does, the output voltage is 0 V).

4. Since only one transistor is performing the switching job, it's current is at least two times bigger than if there were two of them, for the same output power of the inverter. For example, if the inverter gets constant current of 1 Amp from the power supply, the transistor's peak current would probably be greater then 2 Amps!

   So, it seams that far better topology for fluorescent tube inverters is symmetrical push-pull inverter, such the one described in "Medium Power Fluorescent Lamp Inverter". There is only slightly higher cost for this (one power transistor more), but also fewer resistors and capacitors!

   The output voltage of this circuit is alternating (+/-) square wave. The tube gets constant power supply (it lights during positive as well as during negative half-cycle, which means AC), and it doesn't turn off at all.

5. It is good to preheat the electrodes of the tube before it is being started. There are some of the flybacks that does so, but during this period of operation the peaks of output voltage are even higher. Unfortunately, Medium Power... doesn't preheat the tube. This could be done by adding one high voltage capacitor in parallel with the tube. It's capacitance should be few times lower than the one in series with the tube... (read on :) Notice that the oscillating frequency of the inverter is around 7 times higher with no load (e.g., when the tube is not started yet). At this very high frequency this small capacitor's impedance is low enough so that considerable preheating current could flow through the filaments. Every simple compact fluorescent tube electronic ballast has one of these, the value of which is 2n2/1000V. I suggest using one of them or any with the similar properties.

   One additional good feature of this capacitor is that it heats the filaments of the electrodes even during normal operation of the tube but in much lower rate (about 5% of the preheating current). It may look as a fault but it doesn't. The lamp life would be longer if the filaments are hotter.

6. High speed switching transistors could be the good choice but only if special "hard" ferrite core materials are used. These materials have very sharp hysteresis curve which means that they saturate fast and provide fast and clean switching pulse for the transistors. If normal core is used, fast switching transistors may not be of any benefit. Nevertheless, standard cores for ferrite transformers tend to be made of the "hard" materials (and these materials get better and cheaper) so it could be interesting for enthusiasts to experiment.

7. If you use emitter resistor as I do, it is quite likely that no cooler would be needed for the transistors! It's resistance depends on the power of the tube that is being run and could be calculated with this rule-of-thumb:

   ```
   Re = 1.2V/I(Amps)
   ```

8. Small capacitors in parallel with the base resistors help in starting the oscillations. Their value is not critical (0.33 to 2.2 nF).

9. Finally, there is another way of providing the base drive pulses to the transistors without separate "base-drive" windings. I experimented for some time with this topology and find it satisfactory. Any transistor type would probably need different values for resistors, bud not much different than one I suggested. However - is obviously

much easier to experiment with resistors than with number of base-drive turns :)

With a 12 VDC power supply, this resistor produces around 10% of power loss but if the compactness of the device is important, it is acceptable. Without it the transistors would dissipate almost the same amount of heat as resistor dissipates when is present, so I suggest using it anyway. The inverter runs much more stablely with it and the transistors are much less stressed, which ensures long and reliable operation of the inverter.

Lazar's Improved Medium Power F-Lamp Inverter

Here is the drawing of the inverter I use to power the 18W tube on 12 VDC:

```
+Vcc                              o T1
  o          Q1  +--+-------------+
  |              |  |              )::
  |          B |/ C |              )::
  |  +---------|    |              )::       C1
  |  |         |\ E |       D1 22T ):: +-----||-------+
  |  |           |  |          #26 )::(o   4.7 nF     |
  |  |           +--|-----+        )::(    1200V      |
  |  |       4k7    |     |        )::(               |
  |  +----+-/\/\/-+-|--+  |        )::(               |
  |  |    |       | |  |  |        )::(               | +---------+
  |  |    +--||---+ |  |  |        )::(               | |         |
  |  |       1nF    |  |  |        )::(              +|-|+        |
  |  |              |  |  |        )::(              |   |        |
  +--|--------------|------------+ ::(               |   |        |
  |  |        4k7   |  |  |      o)::(               |   |        |
  |  |  +----/\/\/--+  |  |        )::(              |   |        |
  |  |  |           |  |  |        )::(              |   |        |
  |  |  +-----||----+  |  |        )::( O 500T       |   |    2n2 _|_
  |  |  |     1nF      |  | D2 22T )::(   #32        |   | 1200V ___
  |  |  |              |  |    #26 )::(              |   |        |
  |  |  |    Q2  +-----+  |        )::(              |   |        |
  |  |  |        |     |  |        )::(              |   |        |
  |  |  |    B |/ C    |  |        )::(              |   |        |
  |  |  +------|       |  |        )::(              |   |        |
  |  |  |      |\ E    |  |        )::(  Fluoro-tube |   |        |
  |  |  |        |     |  |        )::(      18W     |   |        |
  |  |  |        |     +--|-------+ ::(              | - |        |
  |  |  |        |        |         ::(             +|-|+        |
  |  |  |   1k   |        |         ::(              | |          |
  |  |  +-/\/\/--+        |           +--------------+ +---------+
  |  |           |        |
  |  +----/\/\/--+        |
+_|_        1k   |        |    Re       Q1,Q2: BD243C
 ---             +--------+--/\/\/\---+
- | 100uF/16V                1 Ohm    |
  |                           2W      |
  +-----------------------------------+
                                     _|_
                                      _
```

All resistors are rated to 1/4 W except Re, which is 2 to 4 W.

My lamp has survived abt 20 hours being run on this circuit. I will send you an update if I notice something else useful or interesting.

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Compact Fluorescent Lamp Electronic Ballast 1

This unit is from a Techna-Bright EDXR-38-16 compact fluorescent lamp used as a (mediocre) replacement for the ubiquitous 150 W outdoor floodlight. It's a 3 U-section tube inside a light weight glass floodlight reflector. With a rated electrical input of only 16 W, I doubt it's even as bright as a 60 W incandescent lamp. The inverter is remarkably simple and must be dirt cheap to manufacture. It uses a pair of 400 V, 4 A bipolar transistors in a self-oscillating configuration which appears to have its output in resonance with a LC network in series with the lamp. The only magnetic components are an inductor for RFI suppression, an inductor in series with the lamp, and a driver transformer for the transistor bases (3 sets of 2 or 3 turns on a ferrite core). An RC and diac circuit provides a kick start to get it going. Protection of sorts (one time) consists of a fusable 0.47 ohm resistor in the AC line input.

- Get the schematic for CFLAMP1 in PDF format: CFLAMP1-SCH.

The same basic circuit could be used on 220 to 240 VAC, 50 Hz but the voltage ratings of the filter capacitor and possibly the transistors would need to increase, and probably some other changes would be needed.

However, note that these ballasts do not seem to be very tolerant of any sort of fault in the lamp circuit itself and may fail instantly if there is a short, open, intermittent connection, or wrong type or size lamp. Thus care should be taken if attempting to use the ballast to power anything other than the original lamp. Double check that all wiring is correct and secure before applying power.

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Compact Fluorescent Lamp Electronic Ballast 2

This unit is from a General Electric 26 W helical compact fluorescent lamp which is a fairly decent replacement for a 100 W incandescent lamp, but having just over 1/4 the energy consumption. The model number on the CFL is: FLE26HT3/2/SW. However, even what appear to be identical GE CFLs may have slightly different part numbers. The lamp, ballast (bottom view inset), and base are shown in Major Parts of General Electric Helical Compact Fluorescent Lamp.

This inverter uses a pair of N and P channel 250 V, 2 to 2.5 A, MOSFETs in a self oscillating configuration with a transformer (actually labeled L3 on the schematic) boosting the half-bridge output voltage. (L3 may actually have at least one of its windings wired with Litz multistrand insulated wire based on the appearance of the wire ends at its terminals.) Gate drive feedback is via a series L-C circuit. A Positive Temperature Coefficient thermistor provides current to power the tube filaments and then increases to a high resistance while the lamp is running. This is easier on the filaments during starting but uses a bit extra power than might be possible with some sort of active switching circuit to disable them. Protection is provided by a real 1.5 A mini glass fuse wired directly to the center of the CFL screw base.

- Get the schematic for CFLAMP2 in PDF format: CFLAMP2-SCH.

The same basic circuit could be used on 220 to 240 VAC, 50 Hz but the voltage ratings of the filter capacitor and MOSFETs would need to increase, the L3 turns-ratio would decrease, and probably some other changes would be needed.

However, note that these ballasts do not seem to be very tolerant of any sort of fault in the lamp circuit itself and may fail instantly if there is a short, open, intermittent connection, or wrong type or size lamp. Thus care should be taken if attempting to use the ballast to power anything other than the original lamp. Double check that all wiring is correct and secure before applying power.

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Basic 200 W Power Inverter

This circuit was reverse engineered from a Tripp-Lite "Power-Verter" Model PV200 DC to AC Inverter - typical of those used for camping or boating applications where the only source of power is an auto or marine battery. This particular model is rated 200 W continuous. The output is a 60 Hz squarewave and there is no regulation or precise frequency control. (Unlike the other circuits in this collection, it is NOT a high frequency inverter.)

Modifications for higher or lower output voltage are easily achieved. For example, a fast cycle strobe requiring 330 VDC, would only require using three times the number of turns on the Output winding and the addition of a bridge rectifier to charge the energy storage capacitor(s). Alternatively, the inverter could be used as-is with the addition of a voltage tripler. A tripler rather than doubler is needed because of the squarewave output. (The RMS and peak voltages are the same so you don't get the boost of 1.414 as you do with the sinusoidal waveform from the power company.)

Circuits similar to this will also be found inside UPSs (Uninterruptible Power Sources) so if all you want is a cheap low voltage DC to line voltage inverter, find a dead UPS - there's a good chance the battery is bad, not the electronics! (However, it may not be designed for 12 VDC input.)

```
                                                 3 o
     +12 VDC                +--------+--------------+
        o                   |        |               )||
        |                 |/ C     +_|_ C1           )||
        S F1 20 A  +------|    Q1   --- 10 uF  31T D )||  o 2
        |          |      |\ E     -_|_ 160 V    #13 )|| +----------o AC Hot
         \ S1      |       _|_       -               )||(
        |  Pwr     |        -                        )||(
        |          |                               4 )||(
        +------+---|--------------------------------+ ||(
        |      |   |       _-_                       )||(
        |      |   |        |                        )||( O 360T
        |      |   |      |/ E      _-_ C2     31T D )||( #20
        |      /   |  ----|    Q2  -_|_ 10 uF    #13 )||(
   C3 +_|_  R3 \   |  |   |\ C      --- 160 V        )||(
10 uF  --- 150 /   |  |     |      + |             5 )||(
 50 V - |  5 W \   |  |     +--------+--------------+ ||(
        |      |   |  |                               ||( 1
        |      |   |  +---------------------+         || +------o AC Neutral
        |      |   |                        |     6 o ||
```

```
+------+---|------------------+    +-------+ || T1
           |                  |     F 17T   )||
           |       R3 2.7 10 W |      #24 7 )|| O = Output
           |      +----/\/\----+------------+ || D = Drive
           |      |R2 2.7 10 W            10 o || F = Feedback
           |      +----/\/\-----------------+ ||
           |     _|_                F 17T   )|| (Pin numbers from
           |      -                   #24 8 )||  Triplite unit.)
           +--------------------------------+
```

Notes on Basic 200 W Power Inverter

1. Construction was all done point-to-point - there is no circuit board. Layout appears not to be critical.

2. T1 is a relatively large heavy laminated E-I core transformer. The E and I sheets alternate direction to assure a low reluctance magnetic circuit.

   The core dimensions are 3-3/4" x 3-1/8" x 1-1/8" overall. The outer legs of the core are 5/8" thick. The central leg is 1" wide. The square bobbin has a diameter of 1-3/8".

   The 360T O (Output) secondary is wound first as 4 or 5 insulated layers followed by the 31T D (Drive) and 17T F (Feedback) windings. There are insulating layers between each of the windings.

   The number of turns were estimated without disassembly as follows:

   - The wire sizes were determined by matching the diameters of the visible ends of the wire for each winding to magnet wire of known AWG and/or measuring with a micrometer where possible. (The Drive windings are actually wound using square cross-section magnet wire for maximum packing density. This was estimated to be equivalent to #13 AWG round wire.)

   - The number of turns in the Output winding was determined based on its measured resistance, core diameter, and the wire gauge tables.

   - The inverter was run and the amplitudes of the signals on each winding were measured. From these ratios, the number of turns were calculated.

3. The transistor were marked 69-206. ECG29 is a close match - high power amplifier switch - 80 V, 50 A, 300 W, Hfe 20 min. 2SD797 is another readily available power transistor that should work. For PNP types, reverse the polarities of the power supply, C1, C2, and C3.

   The transistors are mounted on heat sinks which form the sides of the case.

4. C3 and R3 are required for starting. Since there is no source of current for the bases of the transistors other than the Feedback windings, this provides a starting pulse to Q2 when the unit is switched on. Ramping the input voltage slowly rather than using the power switch would likely result in the inverter behaving like an inanimate object.

5. Measured frequency of operation was about 56 Hz. This is likely affected by nearly everything - input voltage, capacitance, core saturation, phase of the moon, etc. Therefore, don't expect to drive a clock mechanism from this thing with any accuracy!

6. Some experimentation with component values may improve performance for your application.

7. When testing, use a variable power supply so you get a feel for how much output voltage is produced for each input voltage. Component values are not critical but behavior under varying input/output voltage and load conditions will be affected by C2 and C3, the number of turns on each of the windings of T1, and the gain of your particular transistors. However, See note (3) about starting.

8. WARNING: Output is high voltage and dangerous - even more so if you increase its output for true HV applications. Over 200 W is available continuously. Take appropriate precautions.

9.
```
        |                          |           |
     ---+--- are connected;    ---|--- and ------- are NOT connected.
        |                          |           |
```

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Up to 350 VDC Inverter from 1.5 V Alkaline Cell

Using the basic circuit of the electronic flash unit from a disposable pocket camera, it is possible to generate any voltage from a few V to 350 V or more from a 1.5 V AA Alkaline battery. (Similar modifications could be made to other pocket camera or external flash unit circuits.)

The specific circuit described below is derived from the inverter used in a Kodak "MAX" disposable camera electronic flash. The beauty of this approach is that the remains of these cameras are often available for the asking at 1 hour photo developing outfits since they are usually thrown away after extracting the film (though apparently some are recycled, this is probably the exception rather than the rule).

The original Kodak MAX Flash Unit Schematic and Photo of Kodak MAX Flash Unit show what you get for nothing. All newer Kodak disposable cameras including the "Funsaver Sure Flash" and APS (Advanced Photo System) "ADVANTIX" appear to use a similar if not identical circuit but I haven't disassembled one of those as yet.

This is certainly useful intact for strobe and high voltage projects but for the purposes of this discussion, all we need are T1 (which we may modify), Q1, R1, perhaps S1 or an equivalent, C1, and D1.

By rewinding the inverter transformer, any output voltage up to about 350 VDC can be obtained from a 1.5 V Alkaline cell. More than 350 V is probably possible but just thinking about winding the needed secondary makes me tired!

The Mini Power Supply Based on Modified Kodak MAX Inverter shows the simplified circuit. The original circuit board can be used and is very convenient though a more compact unit can be constructed if you use a bit of perf board or your on PCB. Note that for higher voltages, Q2 in the original MAX schematic may be needed. For low voltage operation, performance is much better without it. I don't know what the break-even point is so you may want to leave a spot for Q2 just in case.

The main difficulty is in disassembling T1 in a nondestructive way. It seems that the ferrite core is held together by an adhesive which is very tough and resistant to any solvent that won't destroy the plastic bobbin and wire insulation as well. Therefore, you may need to sacrifice two of these - one so that just the ferrite core can be salvaged by soaking the transformer in some nasty solvent (maybe lacquer thinner will work) to dissolve the adhesive.

For the 6 turn primary, the number of turns required on the secondary is approximately:

```
N = 6 * (Vout + 1.2) / 1.2
```

assuming a small load on the output.

So for: 4 VDC, N = 26; for 50 VDC, and for N = 256 300 VDC, N = 1506.

The original circuit topped out at about 350 VDC with N = 1750.

It may be possible to use multiple output windings to provide more than one output voltage but as will be shown below, all output power must be drawn on the forward stroke of the converter since the flyback pulse of the reverse stroke is needed to drive the voltage on C1 and the base of Q1 negative.

I have done the modifications for the 4 VDC version by removing the original 1,750 turn secondary (I had to do this anyway so I could confirm the number of turns for the circuit description) and replacing it with a 26 turn winding of #32 wire. Unfortunately, I also had to Epoxy the half dozen pieces of the ferrite core back together after somewhat destructive disassembly but I don't think there are any significant gaps left in the core :-((I confirmed that the transformer still worked by installing another set of undamaged original windings and checking that it still charged and fired the flash properly).

With no load, the output reaches about 5 V in a fraction of a second.

With a 100 ohm load, the output drops to a bit over 4 V.

Following a post to sci.electronics.design suggesting this circuit as a simple way of obtaining a dual op-amp supply from a single Alkaline cell (dual part as yet to be tested), we have the following discussion on the theory of operation of this circuit:

(From: Tony Williams (tonyw@ledelec.demon.co.uk).)

> "That sounds about right, rough sums:
>
> Q1 bottoming-V is going to vary from about 0.1V to about 0.3V on the forward stroke, from no-load to full-load.
>
> D1 + Q1Vbe fwd-drop is going to similarly vary from about (0.7 + 0.35)V to (0.7 + 0.6)V.
>
> V/C2(NLoad) = (1.5 - 0.1)26/6 - 1.05 = 5.02V.
> V/C2(Fload) = (1.5 - 0.3)26/6 - 1.3 = 3.9V.
>
> 4 V across 100 ohms is about 160 mW, not bad really.
>
> Well, I still haven't seen what recharges C1 negatively. Some scope waveforms for C1 and D1 would be nice (hint, hint). :)"

After noting that I was impressed that both our numbers work as well as they do, Tony replied:

> "Don't be, it was a pure fluke. The V-drops were only guesstimated and things like primary IR-drop were not even included."

Well, IR-drop should be negligible - 4 inches of #26 wire is only about .013 ohms :-).

Some additional info (after I took the hint) finally appears to have solved the mystery:

I checked the waveform across B-E of Q1. It is around .6 V for most of the cycle with strong -6 V going spikes! So, where are they coming from????

Possible sources include:

- Transformer (T1) Interwinding capacitance.
- Circuit board capacitance.
- Diode (D1) junction capacitance.
- Diode (D1) reverse conduction.

I thought that maybe the relatively long recovery time of the standard-looking (though unknown markings) diode (D1) is providing enough reverse current to turn off the transistor. I tested this by subbing both a fast recovery and high efficiency rectifier - no difference. OK, well maybe just a bit better performance :-). Perhaps it still is the reverse current spike as the transistor switches off that drives the base hard to -6 V.

Now, here is the kicker (no pun....):

Monitoring the waveform ACROSS D1 - do you want to guess what it looks like?

We have a greater than 110 V, 200 ns spikes occurring when Q1 switches off! Geez! 110 V from a 26 turn winding and a 1.5 V battery! It wouldn't take much capacitance or reverse recovery leakage through D1 to drive the base and C1 negative by 6 V. Looking at the equivalent circuit:

```
                        X pF         470 pF
>110 V pulse o-------||-----+------||------+
  ~200 ns                   |             _|_
                            o              -
                       ~6 V pulse
```

X of about 26 pF would result in an appropriate divider ratio. However, this sounds high for the layout and 26 turns. Then again, stranger things have happened :-). But, a combination of the reverse recovery conduction and higher capacitance at low voltage as the diode reverses could probably do it.

Tony replies to this new information:

> "You will recall that I was puzzled about energy transfer on the fwd stroke only. That transformer is going to get stored energy on every fwd stroke, and yet there appears to be no means of dissipating that energy..... There is even no protection for the collector of the transistor. In fact, I would suspect that that is part of the design, in that they did not want the energy clamped by the primary, they needed it as a high voltage reverse dissipation in the secondary.
>
> Think varactor-action. For D1 being spiked from fwd conduction to 110 V negative I would suspect that a 26pF-equivalent for D1 is quite reasonable. Bearing in mind that we have an inherent reverse-Vbe clamp I would not even be surprised if D1 could also be allowed to avalanche."

I just wonder how this design came about. The vast majority of these simple flash inverter circuits use the traditional blocking oscillator topology with a separate winding or portion of a winding for the base drive/feedback. (At this point I have taken a look at over a dozen different types.) This Kodak circuit appears to be unique in letting the high voltage (originally) winding serve double duty. It probably does save 5 cents in the manufacturing cost of the transformer by not having to have a separate winding. :-).

And, Tony's reply:

> "I worked for a chap once (one Jevon Crossthwaite, about 70 now if still alive) who could take a circuit and absolutely *squeeze* the last ounce of performance out of it. This is typical of what he would get up to. I did learn a lot from him, but only partially, because my inbuilt design nature is still yer brick outhouse.
>
> If there are any BOFs around; I think Jevon Crossthwaite, in his early days, worked for Sylvania and for George Philbrick (before and after Teledyne entered the scene), both in the States."

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Strobe Circuits

Strobe Circuits Introduction

Don't forget, there are many more electronic flash and strobe circuits in: Notes on the Troubleshooting and Repair of Electronic Flash Units and Strobe Lights and Design Guidelines, Useful Circuits, and Schematics.

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Variable Intensity Variable Frequency Stroboscope

This circuit (referenced in the document: Notes on the Troubleshooting and Repair of Electronic Flash Units and Strobe Lights and Design Guidelines, Useful Circuits, and Schematics is designed to provide a variety of options in terms of repetition rate, flash intensity, and various repeat and triggering modes.

The design includes:

- Line operated voltage doubler power supply.
- Power transformer operated low voltage logic supply.
- Variable frequency repeat mode controlled by 555 timer.
- Optoisolated external trigger input.
- Selectable flash intensities of .2, 2, and 20 W-s.
- Autorepeat speeds from .05 to 100 Hz.

Note that the flashlamp will NOT operate at all intensities for these entire ranges due to recharge and power dissipation limitations.

Parts of this circuit have been built and tested but the entire unit is not complete. Maybe someday.... :-)

- Get the schematic for STROBEX in PDF format: STROBEX-SCH.

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Kevin's Strobe Schematics

(The following two sections are from: Kevin Horton (khorton@tech.iupui.edu).)

High power inverter and trigger circuits

I'm building a super strobe bar! It has 8 strobe tubes under computer control. (Actually a PIC processor, but hey, computer is a computer.) I have all the stuff done except the control section, and I only have 2 of the 8 strobe units done due to the fact that I haven't found any more cheap cameras at the thrift store! (One Saturday morning's worth of garage sales and flea markets would remedy that! --- sam).

It runs on 12 V, at up to 6 A, and can fire the tubes at a rate of about 8-10 times per second. The storage cap is a 210 uf, 330 V model; it gets to about 250 V to 300 V before firing; depending on how long it has had to charge. Because of this high speed, the tubes get shall we say, a little warm. (Well, maybe a lot warm --- sam). I have it set up at the moment driving two alternating 5 W-s tubes. I'm pumping them quite a bit too hard, as the electrodes start to glow after oh, about 5 seconds or so of continuous use. I know, a high class problem, indeed! My final assembly will have 8 tubes spaced about 8 inches apart on a 2x4, with a Plexiglass U-shaped enclosure with a nice 12 V fan blowing air through one end of the channel to cool the inverter and the tubes. Stay tuned.

Inverter - High power 12 V to 300 V inverter for high repeat rate medium power strobes. Schematic in GIF format: inverter.gif

Trigger - Opto-isolated logic level trigger for general strobe applications. Schematic in GIF format: trigger.gif

Teeny Tiny Inverter Design

I have developed a cool little transformer circuit that seems to be very efficient. I built this inverter as tiny as I could make it. It runs off of 3V, and charges up a little 1 uf 250V cap all the way up in about 30 seconds; drawing about 5 to 8 mA in the process. The numbers by the windings tell the number of turns. The primary and feedback windings are #28, while the secondary is #46. Yes, #46! I could hardly tell what gauge it was, as it was almost too small to measure with my micrometer! It may be #44 or #45, but at these sizes, who knows? I used a trigger transformer for the wire. I used all the wire on it, to be exact; it all **JUST** fit on the little bobbin. The primary went on the core first, then the secondary, and finally the feedback winding. This order is very important. I used a ferrite bobbin and corresponding ferrite 'ring' that fit on it. The whole shebang was less than 1 cm in diameter, and about 3-5 mm high! I gave it a coat of wax to seal things up, and made the inverter circuit with surface-mount parts, which I then waxed onto the top. There are two wires in, and two wires out. It's enough to run a neon fairly brightly at 1.2 V, with a 3 ma current draw.

Schematic in GIF format: teeny.gif

```
    Vcc >---+--------------+ T1
            |            6T )::
            \           #28 )::  +-------o HV output
         R1 /               )::(
        47K \          +---+ ::(
```

```
            /  2N4401  |     ::(
            |         |/ C    ::( 450T
            |      +--|   Q1  ::( #46
            |      |  |\ E    ::(
            |      |    |     ::(
            +--+  +--------+ ::(
            |  |        |17T )::(
        C1 _|_ |        |#28 ):: +-------o HV return
   .001 uF --- |        |    )::
            |  +-----------+
            |          |
   Gnd >----+----------+
```

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Ultra-Compact 350 V Capacitor Charger

These two circuits are based on the inverters from disposable camera flash units. While not having quite the fewest components, they have an advantage in that a simpler inverter transformer like the one in the Kodak MAX Flash with a single primary and single secondary winding can be used. (Some of the other flash inverters require either a separate feedback winding or an additional tap for the feedback.) Even so, the total space for either of these circuits excluding the battery, power switch, and energy storage capacitor may be less than 0.1 cubic inch! And the cost may be $0.00.

The schematics are shown in Ultra-Compact 350 V Capacitor Charger. The only differences between the circuits are whether the HV output is positive or negative with respect to the input and whether one side of the battery and HV are in common. Otherwise, they should behave in a similar manner. (The Kodak MAX is negative output type 1). The versions using 2SD879 or 2SD965 (NPN) transistors for Q1 have both been tested and appear to work about equally well, charging a 120 uF 350 V photoflash capacitor (C2) to 350 V in about 10 seconds. (The 10 uF C2 shown is just an arbitrary example.). This was at least as fast as the original flash using the same transformer. The actual transformer used for these tests is from a newer flash and is somewhat smaller in size than the one found in the original MAX. It may be a more modern version of the MAX since the design and PCB layout look very similar but I don't know for sure. (See: Photo of Disposable Camera Flash Unit. Please contact me via the Sci.Electronics.Repair FAQ Email Links Page if you know for sure from which model camera this originated.) Using the larger transformer should result in a faster charging speed. The value of C1 isn't critical - almost anything will work though values between about 200 pF and 10 nF seem to be best. The versions using PNP transistors should work just as well as long as a transistor with similar gain to the NPN types are used. (The 2SB1050 or ECG12 might work but I have not confirmed this. The 2SA1585S and 2SB1395S, which were the actual transistors found in two versions of the flash from which the transformer I used were taken, oscillated but would have taken a few *minutes* to charge a 120 uF capacitor to a useful voltage. I assume their gain was too low. It's also possible that low gain samples of the 2SD879 or 2SD965 would not work well in the negative output circuit but all the ones I tried were fine though there was some variation in charging rate probably due to variations in gain. In the original flash circuit, an additional transistor in a quasi-Darlington configuration where the collector of the first transistor goes to the supply instead of the collector of the second transistor boosts the gain. This, of course, could be added to be sure of reliable operation.) If S1 is a momentary switch, the inverter will charge to a voltage based on the uF of the energy storage capacitor (C2) where there is no longer enough of a feedback pulse to maintain oscillation. With a C2 of 120 uF, this is between 250 and 300 VDC. (In the original flash circuit, with the additional transistor, the inverter would run to well above 300 VDC at which point the voltage limiter circuit turned it off.) The circuit then shuts off and will not restart until S1 is pressed again. If S1 remains on continuously, the inverter will run continuously. At an input of 1.5 VDC, the output will then top off at 350 to 400 VDC. The inverter may be shut off by shorting the base of Q1 to COM (either directly or via a transistor). However, note that except for the Kodak MAX configuration, note that I've only tested the circuits with S1 on permanently. I do not know if all configurations will work with a momentary switch.

See Photo of Ultra-Compact 350 V Capacitor Charger for an example of the compact construction (shown sitting on a U.S. dime).

The simplest source of power for these circuits is a single AA Alkaline cell. An alternative is the 1.5 V Alkaline Cell Eliminator. The peak current draw is several AMPs - anything that even slightly limits current will dramatically reduce the charging speed. DO NOT attempt to run on much more than 1.5 V as bad things may happen.

If your circuit doesn't oscillate at all, reverse the connections to the primary or secondary of the transformer, but not both.

There appears to be a slight difference in charging speed depending on which end of the HV winding goes to the HV rectifier. This is likely due to the interwinding capacitance or some other parasitic. Try both (reversing the primary as well) and pick the one that performs best. I'd expect the better one to be where the end of the HV winding goes to the HV rectifier.

Other factors which affect charging rate are input circuit resistance (due to the high current) and stray capacitance. These circuits seemed to charge consistently more slowly (by about 10 to 20 percent) when tested on a solderless breadboard compared to the original flash unit or the construction shown in the photo, above.

WARNING: Almost any uF value cap charged to 350+ VDC will result in a shocking experience if touched and may be lethal under the wrong conditions. Take care as potential danger of this little tiny circuit running from a 1.5 V battery easily be underestimated!

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IR Detector/Tester Circuits

IR Detector/Tester Circuits Introduction

Two approaches are shown below.

- The first uses a bare photodiode as the sensor. It is simpler, lower power, and shouldn't care what, if any, modulation is used by the IR source.

- An IR detector module salvaged from a TV or VCR, or purchased from Radio Shack or elsewhere may be used instead of a photodiode. This will have a much greater dynamic range (response to both weak and powerful signals) than a simple photodiode. However, some of these assume a particular modulation frequency and will be blind to anything else. Power requirements may also be more restrictive - it may insist on regulated 12 V).

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IR Detector Circuit Using Bare Photodiode

This IR Detector may be used for testing of IR remote controls, CD player laser diodes, and other low level near IR emitters. It will not have the sensitivity or dynamic range of the approach described in the section: IR Detector Circuit Using IR Receiver Module but will respond to all sources of IR falling within the wavelength range of the photodiode used since there is not demodulation or coupling circuitry to get in the way.

IR radiation falling on the photodiode causes current to flow through R1 to the base of Q1 switching it and LED1 on.

Component values are not critical. Purchase photodiode sensitive to near IR - 750-900 um or salvage from optocoupler or photosensor. Dead computer mice, not the furry kind, usually contain IR sensitive photodiodes. For convenience, use a 9V battery for power. Even a weak one will work fine. Construct the circuit so that the LED does not illuminate the photodiode!

The detected signal may be monitored across the transistor with an oscilloscope.

```
 Vcc (+9 V) o-------+---------+
                    |         |
                    |         \
                    /         /  R3
                    \ R1      \  500
                    / 3.3K    /
                    \       __|__
                    |       _\_/_  LED1 Visible LED
                  __|__       |
       IR ---->  _/_\_ PD1    +--------o Scope monitor point
         Sensor     |         |              (low active)
       Photodiode   |     B |/ C
                    +-------|    Q1 2N3904
                    |       |\ E
                    \         |
                    / R2      +--------o Gnd
                    \ 27K     |
                    /         |
                    |         |
       Gnd o--------+---------+
                   _|_
                    -
```

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IR Detector Circuit Using IR Receiver Module

This one uses an entire IR receiver module as the IR sensor. Its sensitivity and dynamic range will be much better than the circuit described in the section: IR Detector Circuit Using Bare Photodiode since these modules have automatic gain control circuitry built in. However, some modules are tuned to a particular modulation frequency and/or are AC coupled and will not respond to all remotes or other pulsed or continuous IR sources.

The IR receiver module from a TV, VCR, or purchased from Radio Shack or elsewhere, drives the base of Q1 through R1. It may even be possible to eliminate the transistor circuit entirely and connect the LED directly to the module's output (in series with a current limiting resistor to Vcc or Gnd) but that depends on the drive capabilities of the module. You can use whatever Vcc is required for the IR receiver module for the LED circuit as well but may need to change the value of R2 to limit the current to the LED to less than its maximum rating.

The specific case where Vcc is +5 V is shown.

```
                                  R2
    Vcc (+5) o------+-----------/\/\--------+
                    |           220       __|__
                    |                     _\_/_  LED1 Visible LED
                    |                       |
                    |+                      +--------o Scope monitor point
               +----------+                 |              (low active)
              -|    IR    |out     R1     B |/ C
       IR ---> : Receiver |------/\/\-----|    Q1 2N3904
              -|  Module  |      10K      |\ E
               +----------+                 |
                    |-                      |
      Gnd o------+-----------------------+--------o Gnd
                  _|_
                   -
```

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Radio Frequency Circuits

Sam's 6146A RF Power Oscillator

This is a tunable RF generator based on a 6146A - a once popular "beam power tube", which I built about 30 years ago and recently resurrected in conjunction with my laser activities. It is a basic Hartley oscillator capable of at least 15 watts of RF output when powered from a 400 VDC, 100 mA power supply (of the same vintage and also recently resurrected). My most accurate power estimates are based on the "fluorescent lamp brightness test" and when driving a 15 W light bulb as a dummy load. :) The 15 W bulb runs best when attached to a 25 turn, 1 inch diameter air-core coil inserted into the main tuning coil (L2). Impress kids of all ages: Look, it lights with no wires!

However, depending on the tuning and loading cap settings, the oscillator may not start when the bulb is cold (due to its much lower filament resistance and thus too much load) and fully inserted into L2 - it must be partially withdrawn to start up. Much more than 15 W could likely be generated by powering the system from a higher voltage input (the 6146A's maximum ratings exceed 725 V and 250 mA).

With the components values used, its output frequency range is about 2.5 to 5 MHz which almost actually agrees with calculations (at least within a factor of 2. :)

I make no other claims about this circuit either in terms of efficiency or output purity - I know that it produces all sorts of harmonics which mess up local (at least) radio and TV reception depending on the setting of its tuning cap.

Schematic in GIF format: Sam's 6146A RF Power Oscillator.

A note about the power supply: This was probably one of my first electronics projects, back in the days when tubes were king (but in the process of being dethroned). It uses an old TV power transformer, 5U4 full wave rectifier, and a CRC filter with a dual section twist-lock electrolytic cap. It isn't good to put more than 500 V on a 450 V electrolytic cap: I was running the unit on a Variac capable of 140 VAC with the supply outputting 425 VDC or so. While adjusting the oscillator, the plate current went way down and without regulation, the output of the power supply drifted up to 500 or 550 V. While my back was turned, the cap started smoking profusely and all sorts of disgusting icky juice leaked out. Locating a replacement that would fit became a non-trivial exercise. :(

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Basic Light Dimmer Circuits

Light Dimmer Circuits Introduction

These are the type of common triac based light dimmers (e.g., replacements for standard wall switches) widely available at hardware stores and home centers.

CAUTION: However, note that a dimmer should not be wired to control an outlet since it would be possible to plug a device into the outlet which might be incompatible with the dimmer resulting in a safety or fire hazard.

While designed for incandescent or heating loads only, these will generally work to some extent with universal motors as well as fluorescent lamps down to about 30 to 50 percent brightness. Long term reliability is unknown for these non-supported applications.

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Simplest Dimmer Schematic

The first schematic is of a normal (2-way) inexpensive dimmer - in fact this contains just about the minimal number of components to work at all!

S1 is part of the control assembly which includes R1.

The rheostat, R1, varies the amount of resistance in the RC trigger circuit. The enables the firing angle of the triac to be adjusted throughout nearly the entire length of each half cycle of the power line AC waveform. When fired early in the cycle, the light is bright; when fired late in the cycle, the light is dimmed. Due to some unavoidable (at least for these cheap dimmers) interaction between the load and the line, there is some hysteresis with respect to the dimmest setting: It will be necessary to turn up the control a little beyond the point where it turns fully off to get the light to come back on again.

```
      Black o--------------------------------+--------+
                                             |        |
                                          |  |        |
                                      R1 \   |        |
                                   185 K /<--+        |
```

```
                                              \  v CW      |
                                              |         __|__ TH1
                                              |         _\/\_ Q2008LT
                                              +---|>|   / |   600 V
                                              |   |<|--'  |
                                          C1 _|_  Diac    |
                                       .1 uF --- (part of |
                       S1                     |    TH1)   |
          Black o------/ ---------------------+-----------+
```

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Types of 3-Way Dimmers

There are at least two varieties of inexpensive 3-way style dimmer switches which differ mainly in the switch configuration, not the dimmer circuitry. You will probably have no reliable way of telling them apart without testing or disassembly.

None of the simple 3-way dimmer controls permit totally independent dimming from multiple locations. With some, a dimmer can be installed at only one switch location. Fully electronic approaches (e.g., 'X10') using master programmers and addressable slave modules can be used to control the intensity of light fixtures or switch appliances on or off from anywhere in the house.

However, for one simple, if inelegant, approach to independent dimming, see the section: [Independent Dimming from Two Locations - Lludge #3251](#).

Simple 3-Way Dimmer Schematic 1

The schematic below is of one that is essentially a normal 3-way switch with the dimmer in series with the common wire. Only one of these should be installed in a 3-way circuit. The other switch should be a normal 3-way type. Otherwise, the setting of the dimmer at one location will always affect the behavior of the other one (only when the remote dimmer is at its highest setting - full on - will the local dimmer have a full range and vice-versa).

Note that the primary difference between this 3-way dimmer schematic and the normal dimmer schematic shown above is the addition of an SPDT switch - which is exactly what is in a regular 3-way wall switch. However, this dimmer also includes a choke (L1) and capacitor (C2) to suppress Radio Frequency Interference (RFI). Operation is otherwise identical to that of the simpler circuit.

This type of 3-way dimmer can be used at only one end of a multiple switch circuit. All the other switches should be conventional 3-way or 4-way types. Thus, control of brightness is possible only from one location.

```
   Red 1 o--------o
                    \
                 S1   o----+------------+-----------+
                           |            |           |
   Red 2 o--------o        |         R1 \  ^ CW     |
                           |      220 K /<-+        |
```

```
                           |            \  |        |
                           |            |  |        |
                           |            +--+        |
                           |            |           |
                           |         R2 /           |
                       C2 _|_      47 K \           |
                  .047 uF ---           /         __|__ TH1
                           |            |         _\/\_ SC141B
                           |            +---|>|   / |   200 V
                           |            |   |<|--'  |
                           |         C1 _|_  D1     |
                           |   .062 uF ---  Diac    |
                           |            |           |
                           |   ::::::   |           |
   Black o-----------------+---^^^^^^---+-----------+
                                 L1
                         40 T #18, 2 layers
                       1/4" x 1" ferrite core
```

Simple 3-Way Dimmer Schematic 2

The schematic below is of a 3-way dimmer with a slightly more complex switching arrangement such that when the local dimmer is set to full on or full off, it is bypassed. (If you ignore the intermediate dimming range of the control, it behaves just like a normal 3-way switch.) With this scheme, it is possible to have dimmers at both locations without the dimmer circuitry ever being in series and resulting in peculiar behavior.

Whether this is really useful or not is another story. The wiring would be as follows:

```
              Location 1             Location 2
             3-way Dimmer      A    3-way Dimmer     +---------+
                  /o----------------------o\         |  Lamp   |
    Hot o------o/    Silver 1     Silver 2   \o------|   or    |-----o Neutral
           Brass   o----------------------o   Brass  | Fixture |
                     Silver 2  B  Silver 1           +---------+
```

(If dimming interacts, interchange the A and B wires to the silver screws at one dimmer).

This one uses a toggle style potentiometer where the up and down positions operate the switches. Therefore, it has 3 states: Brass to Silver 1 (fully up), dim between Brass and Silver 1 (intermediate positions), and Brass to Silver 2 (fully down).

```
                        Br  /o---o            Br   o---o          Br/\/o---o
  3-way dimmer is up o---o/   S1   or down o---o\  S1    or Dim o---o  S1
                             o---o                \o---o               o---o
                              S2                   S2                   S2
```

However, it is still not possible to have totally independent control - local behavior differs based on the setting of the remote dimmer (details left as an exercise for the reader).

Like the previous circuit, this dimmer also includes a choke (L1) and capacitor (C3) to suppress Radio Frequency Interference (RFI). It is just a coincidence (or a matter of cost) that the 3-way dimmers have RFI filters and the 2-way type shown above does not.

```
  Silver 1 o---+----------------+--------------------+-----------+
               |                |                    |           |
               |                |                 R1 \  ^ Up     |
               |                |              150 K /<-+        |
               |                |                    \  |        |
               |                |                    |  |        |
               |                |          +---------+--+        |
               |                |          |         |           |
               |            C3 _|_         |      R2 /           |
               |               ---         |    22 K \           |
               |                |          |         /         __|__ TH1
               |                |      C2 _|_        |         _\/\_
               |                | .047 uF ---        +---|>|   / |   200 V
           Up \                 |          |         |   |<|--'  |
               |                |          |     C1 _|_   D1     |
               |                |          |.047 uF ---  Diac    |
               |                |   ::::   |         |           |
               |  Dim  o--------+---^^^^---+---------+-----------+
               |     /               L1
     Brass o---+---o               12T #18
                           1/4" x 1/2" ferrite core
                 Down  o
                       |
  Silver 2 o-----------+
```

Independent Dimming from Two Locations - Kludge #3251

Here is a scheme which will permit dimming with independent control from two locations. Each location will have a normal switch and a dimmer knob. The toggle essentially selects local or remote but like normal 3-way switches, the actual position depends on the corresponding setting of the other switch:

```
                 Location 1       Location 2
           +--------+  4-way SW    3-way SW
Hot o--+---| Dimmer |----o\ /o--------o\            +---------+
       |   +--------+      /           \o----------| Fixture |------o Neutral
       |              +--o/ \o--------o      Center +---------+ Shell
       |              |                      (brass)           (silver)
       |              |            +--------+
       |              +------------| Dimmer |--+
       |                           +--------+  |
       +---------------------------------------+
```

As usual, the brass screw on the fixture or outlet should be connected to the Hot side of the wiring and the silver screw to the Neutral side.

The dimmers can be any normal knob or slide type with an off position.

Note that as drawn, you need 4 wires between switch/dimmer locations. 4-way switches are basically interchange devices - the connections are either an X as shown or straight across. While not as common as 3-way switches, they are available in your favorite decorator colors.

If using Romex type cable in between the two locations, make sure to tape or paint the ends of the white wires black to indicate that they may be Hot as required by Code.

And, yes, such a scheme will meet Code if constructed using proper wiring techniques.

No, I will not extend this to more than 2 locations!

CAUTION: However, note that a dimmer should not be wired to control an outlet since it would be possible to plug a device into the outlet which might be incompatible with the dimmer resulting in a safety or fire hazard.

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Heating Appliance Schematics

Heating Appliance Introduction

This are only two circuits at present - both for toaster oven/broilers. :)

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Typical Toaster Oven/Broiler

Here is a schematic of a typical 'dumb'toaster oven/broiler - one without a P5-1000 chip if you can believe such a thing exists. :) Most of the complexity of these simple devices is actually in the sheet metal of the toast release mechanism! Like the more elaborate unit described in the section: Toastmaster Toaster Oven/Broiler with Electronic Controls, there is a knob for control of the oven/broiler functions and another for toast Light/Dark. A separate lever engages the toast function which terminates when the toast is done. You will note that other than that unit having an IC for toast timing, the basic circuits are almost the same.

Apparently, the only real difference between a "toaster oven" and a "toaster oven/broiler" is that the latter has a means of disabling the bottom heating element while in oven (non-timed) mode - and, of course, the price!

- The heating elements are either Calrod(tm) type or Nichrome wire coils, possibly enclosed in quartz tubes.

- A single knob selects OFF (full CCW, S1A open), oven temperature S1B opens at selected temperature), and BROIL (full CW, S1C open). Some models may have a separate both/top only switch.

- The Toast Timer can be a mechanical timer and/or a bimetal or other toast temperature sensor. Individual details will vary but when the toast is ready, they will both release the Toast Lever and open S2 as well as possibly signaling with a bell. The Light/Dark control may vary time or the temperature at which toast is considered 'done'.

This diagram is not based on any particular model.

```
                  +- - - - - - + - - - - - - - + All part of Oven Control
                  :            :               :
                 S1A      S1B _:_              :        R1           R2
  AC H o--+------/ -----------o o------+---+---:-----/\/\/\/\----/\/\/\/\---+
          |  Oven Power    Thermostat  |   |   :          Top Element       |
          |                            |   |   :                            |
          |        S2 ___ Toast On     |   |  S1C       R3           R4     |
          +------------o:o-------------+   +---/ ----/\/\/\/\----/\/\/\/\---+
                         :             |     Broil      Bottom Element      |
           +-------+     :          R5 /   Top Brown                        |
       +-->| Timer |--+ :  Toast   47K \   (Full CW)   R1-R4: 8-12 ohms     |
       |   +-------+   )|| Release     /                                    |
   Light/Dark          )|| Solenoid    |   +--+ IL1 Power                   |
   Temp. Sensor       +                +---|oo|---+ Indicator               |
                      |                NE2 +--+   |                         |
  AC N o--------------+---------------------------+-------------------------+
```

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Toastmaster Toaster Oven/Broiler with Electronic Controls

Well, for toast, at least! :)

Aside from the CMOS IC based toast timer, this is a fairly basic design:

- Toastmaster Toaster Oven/Broiler Schematic

The toast function and oven/broiler are controlled separately. A single Power/Temperature/Broil knob controls the oven/broiler. This is entirely electro-mechanical with a conventional bimetal thermostat. Toast darkness is based only on time using CD4541B timer chip to release a manually activated Toast lever. Older 'dumber' toasters often were more sophisticated in their operation using a combination of time and temperature. Not this one.

Its conventional counterpart would be identical except using a mechanical and/or toast temperature sensor in place of the IC timer. Despite what you might think, the most likely failures are NOT in the 'high-tech' electronics but the usual burnt out heating element(s), bad cord or plug, broken wires, and tired switches.

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Rechargeable Appliance Schematics

Rechargeable Appliance Schematics Introduction

Here are circuit diagrams from several inexpensive rechargeable flashlights. and an electric toothbrush. These all use very 'low-tech' chargers so battery life may not be as long as possible and energy is used at all times when plugged into an AC outlet. The electric toothbrush schematic is more interesting since it uses a high frequency inductive coupling rather than a direct connection.

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First Alert Series 50 Rechargeable Flashlight

This one is typical of combined all-in-one units using a lead-acid battery that extends a pair of prongs to directly plug into the wall socket for charging.

It is a really simple, basic charger. However, after first tracing out the circuit, I figured only the engineers at First Alert knew what all the diodes were for - or maybe not :-). But after some reflection and rearrangement of diodes, it all makes much more sense: C1 limits the current from the AC line to the bridge rectifier formed by D1 to D4. The diode string, D5 to D8 (in conjunction with D9) form a poor-man's zener to limit voltage across BT1 to just over 2 V.

The Series 50 uses a sealed lead-acid battery that looks like a multi-cell pack but probably is just a funny shaped single cell since its terminal voltage is only 2 V.

Another model from First Alert, the Series 15 uses a very similar charging circuit with a Gates Cyclon sealed lead-acid single cell battery, 2 V, 2.5 A-h, about the size of a normal Alkaline D-cell.

WARNING: Like many of these inexpensive rechargeable devices with built-in charging circuitry, there is NO line isolation. Therefore, all current carrying parts of the circuit must be insulated from the user - don't go opening up the case while it is plugged in!

```
                                             2V LB1  Light
                                           1.2A +--+ Bulb    S1
                                       +--------|/\|----------o/ o----+
            _ F1   R3         D3       |        +--+                  |
   AC o----- _----/\/\---+----|>|--+---|----------------------+       |
          Thermal  15    |    D2   |   |                 4A-h |       |
           Fuse          | +--|>|--+   |         BT1 - |+ 2V  |       |
                         | |  D4       +--------------||------|-------+
                         +----|<|--+   |               |      |       |
                           |  D1   |   |  D8   D7   D6   D5   |  D9   |
          +--------+-------+--|<|--+---+--|<|--|<|--|<|--|<|--+--|>|--+
          |        |                                                  |
          |        /                                                  |
         _|_ C1    \ R1                                               |
         --- 2.2uf / 100K                                             |
          |  250V  \                                                  |
          |        |               R2          L1  LED                |
   AC o---+--------+--------------/\/\-----------|<|------------------+
                                 39K 1W       Charging
```

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Black & Decker Spotlighter Type 2 Rechargeable Flashlight

This uses a 3 cell (3.6 V) NiCd pack (about 1 A-h). The charging circuit is about as simple as it gets!

```
                                                                 S1
         11.2 VRMS                                +---------------o/ o----+
  AC o-----+ T1       R1      LED1         D1     |  +| | | -             |
            )|| +----/\/\-----|>|---->>----|>|----+---||||||---+          |
            )||(      33    Charging     1N4002       | | |    |  KPR139  |
            )||(      2W                           BT1         |    LB1   |
            )||(                                   3.6V, 1 A-h |    +--+  |
            )|| +-------------------->>------------------------+----|/\|--+
  AC o-----+                                             Light Bulb +--+


        |<------- Charger ---------->|<---------- Flashlight ----------->|
```

I could not open the transformer without dynamite but I made measurements of open circuit voltage and short circuit current to determine the value of R1. I assume that R1 is actually at least in part the effective series resistance of the transformer itself.

Similar circuits are found in all sorts of inexpensive rechargeable devices. These have no brains so they trickle charge continuously. Aside from wasting energy, this may not be good for the longevity of some types of batteries (but that is another can of worms).

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Brand Unknown (Made in China) Rechargeable Flashlight

This is another flashlight that uses NiCd batteries. The charger is very simple - a series capacitor to limit current followed by a bridge rectifier.

There is an added wrinkle which provides a blinking light option in addition to the usual steady beam. This will also activate automatically should there be a power failure while the unit is charging if the switch is in the 'blink' position.

With Sa in the blink position, a simple transistor oscillator pulses the light with the blink rate of about 1 Hz determined by C2 and R5. Current through R6 keeps the light off if the unit is plugged into a live outlet. (Q1 and Q2 are equivalent to ECG159 and ECG123AP respectively.)

```
            R1          D1                 R3   LED1
    AC o---/\/\----+----|>|-------+---+---/\/\--|>|--+     D1-D5: 1N4002
```

```
             33    ~|     D2         |+  |   150         |
            1/2W    +----|<|----+  |   |       R4      |  D5
                         D3     |  |   +------/\/\----+--|>|--+
               C1   +----|>|----|--+   |    33, 1/2W          |   LB1 2.4V
             1.6uF ~|     D4     |      |   | |                |   +--+ .5A
     AC o--+---||---+----|<|----+--+---|--||||--------------+-+---|/\|----+
           |  250V  |              |-  | - | |+             |     +--+    |
           +--/\/\--+              |   |   BT1      + C2 -  |      R5     |
               R2                  |   |  2.4V    +---|(----|-----/\/\----+
              330K                 |   |          |  22uF   |     10K     |
                                   |   |    R6    |       |/ E            |
                                   |   +---/\/\---+-+-----| Q1            |
                                   |       15K      |     |\ C  +---------+
                                   |                /  C327 |   |         |
                                   |            R7 \   PNP |   |   1702N |
                                   |          100K /       |   |   NPN |/ C
                                   |                \       +---|-------| Q2
                                   |      On        |           |       |\ E
                                   |   S1 o---------|-----------+         |
                                   +----o->o Off    |                     |
                                          o---------+---------------------+
                                     Blink/Power Fail
```

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Electric Toothbrush with Inductively Coupled Charger

This was found in an Interplak Model PB-12 electric toothbrush but similar designs are used in other appliances that need to be as tightly sealed as possible.

A coil in the charging base (always plugged in and on) couples to a mating coil in the hand unit to form a step down transformer. The transistor, Q1, is used as an oscillator at about 60 kHz which results in much more efficient energy transfer via the air core coupling than if the system were run at 60 Hz. The amplitude of the oscillations varies with the full wave rectifier 120 Hz unfiltered DC power but the frequency is relatively constant.

```
      E1           CR2          R1                                E3
   AC o----+----+--|>|-----+---/\/\---+----+----------------+-------+  Coupling
           |   ~|  CR1     |+   1K    |    |                |        ) Coil
         +-+-+  +--|<|--+  |          |    / R2             |        ) 200T
     RU1 |MOV|     CR3  |  |      C1 _|_   \ 390K           |        ) #30
         +-+-+  +--|>|--|--+   .01uF ---   /          CR5   |     E4 ) 1-1/2"
        E2 |    |  CR4  |       250V  |    \ MPSA +---|<|---|----+--+
   AC o----+----+--|<|--+             |    |   44 |         |    |
               ~        |-     R3     |    | Q1 |/ C    C3 _|_  _|_ C2
                        +-----/\/\----+----+----|     .1uF ---  --- .0033uF
       CR1-CR4: 1N4005  |     15K               |\ E  250V  |    |  250V
                        |                R4       |         |    |
                        +---------------/\/\------+---------+----+
```

```
                                        1K
```

The battery charger is nothing more than a diode to rectifier the signal coupled from the charging base. Thus, the battery is on constant trickle charge as long as the hand unit is set in the base. The battery pack is a pair of AA NiCd cells, probably about 500 mA-h.

For the toothbrush, a 4 position switch selects between Off, Low, Medium, and High (S1B) and another set of contacts (S1A) also is activated by the same slide mechanism. The motor is a medium size permanent magnet type with carbon brushes.

```
                                       S1B
                              S1A  +--o->o
                 D1           _|_  |       R1,15,2W
             +---|>|---+------o o--+   L o---/\/\---+
    Coupling |         |                   R2,10,2W |
       Coil  +        _|_ BT1          M o---/\/\---+
       120T (          _  2.4V                      |
        #30 (         ___ .5A-h        H o----------+
     13/16"  +         _                            |
             |         |        +-------+           |
             +---------+--------| Motor |-----------+
                                +-------+
```

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Solar Powered Walk Light

This was found in a Malibu(tm) LZ1 Solar light set made by Intermatic. It uses a solar cell, approximately 4 square inches in area, to charge a pair of AA NiCd cells during the day which powers a superbright yellow LED at night. I estimate the actual light output to be 2 or 3 mW at around 595 nanometers wavelength (something like stoplight yellow). Actually, it is kind of cool in more ways than one! :) If only the cheap plastic enclosure was actually waterproof....

```
       +------+---|>|---+------------+----------+
       |      |   D1    |            |          |
       |      | 1N4004  |            /          |
       |      |         |            \ R3     __|__
      +| SC1  |       +_|_ BT1       / 2.2K   _\_/_ LED
    +--+--+   |         _  2xAA NiCd \          |
    |Solar|   |        ___ 550mA-hr  |        |/ C
    |Cell |   |       - _            +---+----| Q2 SS8050
    +--+--+   |         |    R2      |   |    |\ E (ECG216)
      -|      |         |   20K    |/ C  /      |
       |      +---------|---/\/\---| Q1  \ R1   |
       |                |   SS9013 |\ E  / 100K |
       |                | (ECG123A)  |   |      |
       +----------------+------------+---+------+
```

When there is enough voltage from the solar cell, Q1 is turned on and Q2 (the LED driver) is turned off. As far as I can tell, there is nothing to actually limit current to the LED except for the combination of battery, transistors, LED, and wiring resistance. Both transistors could probably be replaced with 2N3904s. So, if you were duplicating this thing, I'd recommend adding something to control the current to the LED or at least checking it first!

Actual failure of this complex device would most likely be due to worn out NiCd cells or corrosion to due exposure to the weather.

Operational problems like weak output or inadequate lighting time could be due to insufficient Sunlight (the thing is installed under a bush!) or extended cloudy conditions. Of course, these don't produce a huge amount of light in any case!

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Miscellaneous Circuits

Discrete Multivibrator

This is an astable multivibrator using discrete parts. Yes, I know, low tech but you can actually fondle all the internal points of interest that way :-).

The time constant of R1*C1 and R2*C2 determine the blink rate. (Try 50K, 10 uF to start for a visible blink rate).

You can also put an LED in series with one or both of the collector resistors (to blink alternately) and do away with any additional buffers.

Modify the values of these pair of Rs and Cs for operation at higher or lower frequencies. Some considerations:

- For very low Cs, stray capacitance and device frequency response will limit highest frequency.
- For very large Cs and/or very large Rs, leakage will limit lowest frequency.
- For very large Rs, gain of transistors may be inadquate.
- For very small Rs, transistors may melt down :-).

Note: C1 and C2 can be either non-polarized or polarized (electrolytic) types. If polarized (e.g., to obtain higher capacitance values for lower operating frequencies), install the capacitors in the direction shown.

```
                    Vcc
                     o
                     |
        +----+-------+--------+----+--------------+
        |    |                |    |              |
        |    |                |    |              /
        /    /                /    /              \ 220
```

```
     \ 1K \ R1             \ R2 \ 1K           /
     /    /                /    /              \
     \    \                \    \            __|__
     |    |                |    |            _\_/_ LED
     +--------------+      |    |              |
     |    |      +--|-----------+              |   Q1-Q3: 2N3904 or similar
     |    |      |  |      |    |     10K    |/ C         general purpose
     |    |      |  |      |    +----/\/\----| Q3         NPN transistor.
    C \|  |  C1  |  |  C2  |  |/ C           |\ E
    Q1 |--+--)|--+  +--|(--+--| Q2             |
    E /|    -  +      +  -    |\ E            _|_
    _|_                        _|_             -
     -                          -
```

Question for the student: What happens if one or both Cs are replaced by resistors?

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Simple Pushbutton Clock Circuit

```
        Vcc
         o
         |
         /
         \ 10K
         /
         \
         |           |\  74xx14
         +----+-----o|  >-----> To clock input (positive edge or pulse).
         |    |      |/
    2uF _|_    \
        ---   |
        _|_  _|_
         -    -
```

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Interesting Sequential Neon Flasher

This is a sort of brain teaser since it certainly isn't intuitively obvious how this circuit works (if it works at all). It may be instructive to start with the degenerate case of 2 resistors, 2 neon lamps, and a single capacitor. What happens with that configuration?

(From: Steve Roberts (osteven@akrobiz.com).)

```
 +200V o----+-----+-----+-----+-----+
            |     |     |     |     |
            /     /     /     /     /
            \ R1  \ R2  \ R3  \ R4  \ R5    R1-R5: 2.7M
            /     /     /     /     /
            \     \     \     \     \
            |     |     |     |     |
            +-o A +-o B +-o C +-o D +-o E
            |     |     |     |     |
            | IL1 | IL2 | IL3 | IL4 | IL5   IL1-IL5: NE2
           +-+   +-+   +-+   +-+   +-+
           |o|   |o|   |o|   |o|   |o|
           +-+   +-+   +-+   +-+   +-+
            |     |     |     |     |
   Gnd o----+-----+-----+-----+-----+
```

Connect a .22 uF, 200 V capacitor between each of the following pairs of points: A to C, A to D, B to D, B to E, C to E.

Neons will flash in sequence ABCDE if fed off DC. Momentarily removing the DC will cause them to flash EDCBA.

Hint (sort of): This system may NOT do what would be expected when simulated on a computer unless certain conditions are met. What are they?

From an ancient Radio Shack "Pbox" kit - the first kit I ever built!

(From: Tim Conrad (tim.conrad@usoc.org).)

The sequential flasher circuit is very old, going back to the 1950s at least. Operation follows classic neon light theory. As the voltage rises on the lamps, one will reach threshold first, and fire. That drops the voltage (via caps) on the two connected lamps, and to a lesser degree on the lamps those are connected to. The caps will charge through the resistors and one of the far lamps will finally reach threshold and fire. The process goes on from there.

If you really want a strange one, draw 5 points in a circle. Then draw lines between the points. You will have a star inside of a pentagon. Replace each line with a 0.1 uF cap. Replace each point with a neon lamp and resistor. Resistor goes to +v and lamp. Other side of lamp to ground. (polarity doesn't really matter, just needs DC). Similar to your circuit, except more caps.

Power it up and the bulbs will flash in some 5 step pattern, which will repeat until you interrupt power. Only one lamp on at a time.

There are a whole lot of neon lamp circuits like this one. It is possible to build logic elements and flip-flops from them. I suppose one could build a computer with enough parts, although I don't know of anyone who had the patience.

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Circuit to Allow AC Signal to Activate Small Relay

This allows a low voltage AC (or +DC for that matter) signal to drive a relay.

```
                           Vcc o--+---+
                                  |   |
                                 _|_   )||
                          1N4002 /_\   )|| Low current 12 VDC relay coil
                                  |    )||
                                  |   |
                                  +---+
                                      |
            1N4148          5K       |/ C
       AC o---|>|-----+----/\/\-----|     General purpose NPN transistor
                     +_|_            |\ E  like 2N3904
     (2-10 VRMS)      --- 10uF        |
                       |  15V         |
       AC +-----------+--------------+
```

Modify for your needs.

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1.5 V LED Circuits

Here are a pair of circuits that will light an LED when powered from a single 1.5 V alkaline cell. They should also operate on the 1.2 V output of a NiCd or NiMH cell as well as from a supercapacitor or ultracapacitor charged to 1 to 1.5 V.

Both circuits and the descriptions below have been contributed by: Andre De-guerin (mandoline@gtonline.net).

1.5 V LED Flasher

This circuit utilizes the voltage doubling principle to flash an LED from a 1.5 source like a single alkaline cell. In addition, it can be dark activated by gating pin 5 of U1 with an LDR (Light Dependent Resistor) and resistor. The current drain is less than 40 uA between flashes. The LED current is 50 mA peak so it's quite bright.

The original source for this circuit is from the ZSCT1555 Application Notes and a standard voltage doubler which was slightly modified so I could use a resistor instead of a diode. Not exactly new, but just a novel use of existing components as it isn't in any literature since the standard 555 timer works down to 3 V whereas this one works down to 0.9 V.

Using a 1 Farad supercapacitor charged to 1.5 V as the power source, the LED flashed for about eight hours. There was no change in oscillator frequency and the brightness stayed constant down to about 1.0 volts.

```
           R1 1M
         +--/\/\---+---+------------+---o Vcc (1.5 V)
         |         |   |            |
         |      +---------+       __|__
         |      |  4   8  |       _\_/_ LED1 9,600 mcd yellow LED
         +------|7        |    C3   |
```

```
     |      |   IC1   |   47uF  |
  R2 /  +---|6       3|----|(---+   IC1 is ZSCT1555
  1M \  |   |         |   +  -  |
     /  +---|2 5   1  |         / R3
     |  |   +---------+         \ 470
     +--+      |  _|_           /
    C1 _|_    _|_  -           _|_
0.33uF ---    --- C2            -
       _|_    _|_ 10nF
        =      -
```

Dark Activated 1.5 V LED Flasher

This circuit uses an ICL7660S to flash an LED from 1.5 V. A second LED in photodiode mode is used as the light sensor, inhibiting IC1 during daylight hours. Use a 9,600 mcd yellow LED for LED1, and a high efficiency red LED for LED2 to get maximum sensitivity. Replace LED2 with an infra-red (IR) LED to make a remote control sensor. The LED will go out when IR is detected

The original source of the this circuit was at: Circuitos Corporation under "LED Flasher" (along with many other interesting schematics). However, the original design used an ORP12 as the sensor instead of an LED. And it didn't work. Evidently, it was never tested.

```
      - |+ BT1,1.5V
    +--||--+----+----------+
    |   |  |   _|_ C2      |
    |      |   --- 22nF    |
  +----------+  |          |
  | 3      8 |  |   LED2    |
  |         7|--+---|>|----+
  |          |    Red LED  |
  |   IC1   6|--+          |  IC1: ICL7660
  |          |  |   LED1    |
  |         5|--+---|<|----+
  | 2      4 | 9,600 mcd yellow LED
  +----------+
    | +  - |
    +--|(--+
       C1
    47uF,6V
```

With only a minor modification (increase C2 to 0.1 uF) a similar flasher can be built with a MAX660. This provides a slightly higher output current and it will flash reliably with a larger time delay between flashes (like up to a minute with a 3.3 uF capacitor).

Additional Notes on Low Voltage Flashers

- I found that connecting pin 1 to ground made the circuit more stable.

- It will flash a blue or white LED if the circuit is run from a 3 V battery.

- To get maximum output from the LED, replace C1 with a 1,000 uF electrolytic and the circuit makes a good night-time flasher for model rocketry.

- If it's low current you are after, the circuit will work with an LED series resistor. You can also use a N channel JFET with gate wired to source in series with the LED in order to limit the flash current to between 1 and 3 mA. Also, use a tantalum bead capacitor for C1. It works well and allows the 7660 to run from up to 24 VDC down to 5 VDC. I set one up last night and it works well using a 4069 as the flasher and it draws 10 uA.

- I have tested this circuit and it runs from a 4 F supercapacitor for eight hours without the above modifications. A possible improvement would be to use a constant current source in series with a 1 F, 5.5 V supercapacitor in order to maximize the flash time.

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Brinkmann LED Light

This uses a single white LED to implement something that looks like a flashlight though it probably wouldn't win any awards for brightness. The challenge in such a circuit was to run a white LED with a 4+ V drop off a pair of AA batteries. This cute little circuit does it. In fact, it will run (at reduced brightness) at 1.5 V or less. See: Brinkmann LED Light.

The oscillator circuit runs at about 200 kHz producing a more or less squarewave voltage waveform across the LED with a peak of 4.5 to 5 V on fresh AA batteries. At reduced input voltage, the frequency is a bit lower and there is a longer low time as well as slightly reduced peak voltage.

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Variations on 555 Timer Circuits

Here some simple modifications to the basic 555 astable circuit. (Only the charge/discharge circuits are shown.)

Independently variable high and low time

```
 -----------+                             R1
        DIS |------------------------+---/\/\----o Vcc
            |         R2       D1    |
  555    TH |--+-----/\/\------|<|---+
            |  |      R3       D2    |
         TR |--+-+---/\/\------|>|---+
 -----------+   _|_
                --- C1
                _|_
                 -
```

R2 and/or R3 would typically be variable resistors. The time constant (R1+R2)*C1 controls the charge (high) time. The time constant (R1+R3)*C1 controls the discharge (low) time.

Fixed frequency, variable pulse width

```
         -----------+
                DIS |--------------+----------+
                    |        D1    |          |
           555   TH |--+-----|<|---+          |
                    |  |      R2       D2     v R3   R1
                 TR |--+-+---/\/\------|>|---/\/\---/\/\---o Vcc
         -----------+   _|_
                        --- C1
                        _|_
                         -
```

The time constant (R1+R2+R3)*C1 controls the total time. R1*C1 controls the minimum length of the charge (high) time. R2*C1 controls the minimum length of the discharge (low) time.

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-- end V1.91b --

Sam's Strobe FAQ

Notes on the Troubleshooting and Repair of Electronic Flash Units and Strobe Lights

- and -
Design Guidelines, Useful Circuits, and Schematics
Version 2.53

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

- Sam's Strobe FAQ Components - HTML, diagrams, photos, and schematics.

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Preface

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Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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DISCLAIMER

Many of the circuits have been reverse engineered - traced from various schematics or actual hardware. There may be errors in transcription, interpretation, analysis, or voltage or current values listed. They are provided solely as the basis for your own designs and are not guaranteed to be 'plans' that will work for your needs without some tweaking.

The power supplies for electronic flash and strobe equipment operate at extremely lethal voltage and current levels. The energy storage capacitors in even the smallest disposable camera flash operating from a 1.5 V AA battery can be deadly under the wrong conditions. Line powered strobes have added danger of high power at high voltage AND are often non-isolated (no power transformer. Do not attempt to troubleshoot, repair, or modify such equipment without understanding and following ALL of the relevant safety guidelines for high voltage and/or line connected electrical and electronic systems.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Acknowledgements

Thanks to Don Klipstein (don@misty.com or klipstei@netaxs.com) for his comments and contributions to this document. His Web site (http://www.misty.com/~don/ mirrored at http://www.netaxs.com/~klipstei/) is a valuable resource for information relating to lighting technology in general and also includes additional articles dealing with strobe principles and design, high voltage circuits, and other interesting topics.

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Introduction

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Scope and Purpose of This Document

This collection of material started out in life as a simple repair manual for electronic flash units. It has since evolved to include design information for a variety of types of equipment including many shapes, sizes, and styles of electronic flash units and repeating strobes. In addition, there are numerous circuit ideas and over a dozen complete schematics for commercial and home-built systems covering a range of power levels and power sources.

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Organization of This Document

For the most part, we assume that your are somewhat familiar with basic electronics and your intended application - be it for photography, measurement, or entertainment. Perhaps you are just curious about how all those flashing lights work!

PART I provides a basic description of the characteristics and principles of operation of electronic flash and related devices based on the xenon flashlamp. Especially important if you intent to be working inside this equipment is the SAFETY information. It is all too easy to electrocute yourself on the energy storage capacitors or line powered circuits.

PART II deals with troubleshooting and repair with emphasis on the kinds of electronic flash units found in photographic equipment - from tiny disposable cameras to high power studio 'speed lights'.

PART III provides information on the design of small to medium size electronic flashes and repeating strobes including basic design guidelines, shortening or lengthening flash duration, power supply component selection. There is a detailed discussion on retrofitting an old camera to use a modern electronic flash. And, there are a variety of circuits for repeating flashes, trigger circuits, inverters, and more.

PART IV provides over a dozen complete (well, very nearly complete, anyhow) schematics for electronic flash units from disposable cameras, external (Hot shoe or side mounted) strobes, higher performance line powered units, as well as repeating stroboscopes and even a timing light.

Note: Links to all the diagrams and photographs referenced from this document can be found in Sam's Strobe FAQ Files.

The single largest collection of hobbyist type xenon flash and strobe information can probably be found at the Don Klipstein's Lighting Technology Web Site which is a valuable resource for information relating to lighting technology in general and also includes additional articles dealing with strobe principles and design. Don's Xenon Flash and Strobe Page also includes a guaranteed late model version of Sam's Strobe FAQ.

A large collection of lighting and strobe related schematics and links can be found Tomi Engdahl's Lights and Electronics Page.

There are many other documents at the Sci.Electronics.Repair (S.E.R) FAQ Web site or one of its mirror sites which may be of use in the design, testing, and repair of strobe equipment. The Main Table of Contents (ToC) provides links to a variety of information on troubleshooting and repair of many types of equipment, general electronics, an assortment of schematics, over 1,000 technology links, and much more. Most of these documents are nicely formatted, indexed, and cross-referenced. (Silicon Sam's Technology Resource, which may be present at this site and others, usually contains slightly more recent versions of many of these same documents but most of those under the S.E.R FAQ Main ToC are easier to use and the actual content differences are likely to be minor.)

- Information on isolation transformers (essential for safety) and variable transformers (Variacs), series light bulb adapter, and other Incredibly Handy Widgets(tm) for your test bench will be found in the document: Troubleshooting and Repair of Consumer Electronic Equipment and possibly in the specific document for each type of equipment.

- Schematics associated with the testing of capacitors, transistors and other semiconductor devices (includes simple curve tracer design), flyback and other transformers, etc., will be found in the document dealing with each of these typse of devices.

- Various Schematics and Diagrams includes a variety of circuits that may be useful in generating the high voltage for xenon flashes and strobes.

- Sam's Laser FAQ, a large collection of information on lasers and laser related equipment, includes among other things, an extensive set of power supply and other schematics as well as a large list of electronics suppliers. Some of this may come in handy with respect to xenon strobe circuits and parts.

- Salvaging Interesting Gadgets, Components, and Subsystems for unconventional sources and uses for neat, useful, and otherwise discarded or neglected parts and equipment.

See the Home and Mirror Site Locations for other possibilities which may be faster from where you live.

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Electronic Flash and Strobe Principles of Operation

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Electronic Flash Fundamentals

All modern electronic flash units (often called photographic strobes) are based on the same principles of operation whether of the subminiature variety in a disposable pocket camera, high quality 35 mm camera, compact separate hot shoe mounted unit, or the high power high performance unit found in a photo studio 'speed light'. All of these use the triggered discharge of an energy storage capacitor through a special flashlamp filled with xenon gas at low pressure to produce a very short burst of high intensity white light.

The typical electronic flash consists of four parts: (1) power supply, (2) energy storage capacitor, (3) a means of generating a trigger pulse, and (4) flashlamp, as shown below:

```
       HV+ o------/\/\-------------+----------------+
                Current            |         Anode _|_
     DC Power   Limiting       C1  |              | | |
      Supply    Resistor   Energy _|_+       FL1 |   ||
      (300 V              Storage ---       Xenon |   ||---- Trigger Pulse
      typical)          Capacitor  | -  Flashlamp |   ||
                                   |              | | |
                                   |       Cathode'-|-'
    HV Ret o-----------------------+----------------+
```

An electronic flash works as follows:

1. The energy storage capacitor connected across the flashlamp is charged from a 300 VDC (typical) power supply. This is either a battery or AC adapter operated inverter (pocket cameras and compact strobes) or an AC line operated supply using a power transformer or voltage doubler or tripler (high performance studio 'speed' lights). These are large electrolytic capacitors (100 to 1,000+ uF at 300+ V) designed specifically for the rapid discharge needs of photoflash applications.

2. A 'ready light' indicates when the capacitor is fully charged. Most monitor the voltage on the energy storage capacitor. However, some detect that the inverter or power supply load has decreased indicating full charge.

3. Normally, the flashlamp remains non-conductive even when the capacitor is fully charged.

4. A separate small capacitor (e.g., .1 uF) is charged from the same power supply to generate a trigger pulse.

5. Contacts on the camera's shutter close at the instant the shutter is fully open. These cause the charge on the trigger capacitor to be dumped into the primary of a pulse transformer whose secondary is connected to a wire, strip, or the metal reflector in close proximity to the flashlamp. An SCR or triac can substitute for the contacts

if electronic, remote, or slave triggering is required.

6. The pulse generated by this trigger (typically around 4 to 10 kV depending on the size of the unit) is enough to ionize the xenon gas inside the flashlamp.

7. The xenon gas suddenly becomes a low resistance and the energy storage capacitor discharges through the flashlamp resulting in a short duration brilliant white light.

While details differ, everything from the flashing lights at your local disco to the flashlamps in monster pulsed lasers operate on essentially the same principles.

The energy of each flash is roughly equal to $1/2*C*V^2$ in watt-seconds (W-s) where V is the value of the energy storage capacitor's voltage and C is its capacitance. Not quite all of the energy in the capacitor is used but it is very close. The energy storage capacitor for pocket cameras is typically 100 to 400 uF at 330 V (charged to 300 V) with a typical flash energy of 10 W-s. For high power strobes, 1000s of uF at higher voltages are common with maximum flash energies of 100 W-s or more. Another important difference is in the cycle time. For pocket cameras it may be several seconds - or much longer as the batteries run down. For a studio 'speed light', fractional second cycle times are common.

Typical flash duration is much less than a millisecond resulting in crystal clear stop action photographs of most moving subjects. However to capture really high speed motion like a the splash of a water droplet or a speeding rifle bullet flashes down to 1 millionth of a second or less are needed. These can be provided by specially designed strobe equipment but still based on principles very similar to those used in a pocket flash.

On cheap cameras (and probably some expensive ones as well) physical contacts on the shutter close the trigger circuit precisely when the shutter is wide open. Better designs use an SCR or other electronic switch so that no high voltage appears at the shutter contacts (or hot shoe connector of the flash unit) and contact deterioration due to high voltage sparking is avoided.

Note that for cameras with focal plane shutters, the maximum shutter speed setting that can be used (X-Sync) is typically limited to between 1/60 and 1/120 of a second. The reason is that for higher shutter speeds, the entire picture is not exposed simultaneously by the moving curtains of the focal plane mechanism. Rather, a slit with a width determined the by the effective shutter speed moves in front of the film plane. For example, with a shutter speed setting of 1/1000 of a second, a horizontally moving slit would need to be about 1/10 of an inch wide for a total travel time of 1/60 of a second to cover the entire 1.5 inch wide 35 mm frame. Since the flash duration is extremely short and much much less than the focal plane curtain travel time, only the film behind the slit would be exposed by an electronic flash. For shutter speed settings longer than the travel time, the entire frame is uncovered when the flash is triggered.

For complete schematics of both battery and AC line powered equipment, see the sections starting with: Schematics for Pocket Camera and Externally Mounted Compact Flash Units.

Red-eye reduction provides a means of providing a flash twice in rapid succession. The idea is that the pupils of the subjects' eyes close somewhat due to the first flash resulting in less red-eye - imaging of the inside of the eyeball - in the actual photograph.

This may be done by using the main flash but many cameras use a small, bright incandescent bulb to 'blind' the eyes when the shutter is pressed to meter, then it goes off and the flash preserves the 'closed' pupils. This approach works. Using the main flash would require sub-second recycle time which is not a problem if an energy conserving flash is used (see the section: Vivitar Auto/Thyristor 292 Energy Conserving Automatic Flash. However, it would add significant additional expense otherwise (as is the case with most cameras with built in electronic flash). A separate little bulb is effective and much cheaper.

Failure of red-eye reduction or the automatic exposure control circuits will probably require a schematic to troubleshoot unless tests for bad connections or shorted or open components identify specific problems. However, some of these use fairly simple circuits with mostly standard components and can be traced without too much difficulty. For red-eye in particular, It is also possible for that extra incandescent light bulb to be burnt out but good luck replacing it!

Remotely triggered 'fill flashes' use a photocell or photodiode to fire an SCR (or light activated SCR) which emulates the camera shutter switch closure for the flash unit being controlled. There is little to go wrong with these devices.

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Automatic Exposure Control Electronic Flash Units

Automatic electronic flash units provide an optical feedback mechanism to sense the amount of light actually reaching the subject. The flash is then aborted in mid stride once the proper exposure has been made. This means that the flash duration will differ depending on exposure - typically from 1 ms at full power to 20 us or less at close range.

Inexpensive automatic flash units just short across the flashlamp with an SCR or second internal 'quench' tube (an internal small xenon tube that looks like an oversize neon indicator lamp) triggered by a photosensor. See the sections starting with: "Vivitar Auto 253 electronic flash circuit". With these units, the same amount of energy is used regardless of how much light is actually required and thus low and high intensity flashes drain the battery by the same amount - and require the same cycle time. The excess energy is wasted. Note that it is not the distance to the subject that matters but the amount of total light energy reflected back to the sensor. The travel time of the light has nothing to do with controlling exposure. True energy conserving flash units use only as much energy as needed and the batteries last much longer since most flash photographs do not require maximum power. Furthermore, when using low power flashes, the cycle time is effectively zero since the main energy storage capacitor does not discharge significantly. Therefore, multiple shots can be taken in rapid succession. See the section: Vivitar Auto/Thyristor 292 Energy Conserving Automatic Flash.

Many energy conserving flash units use a clever approach to avoid having to interrupt the 100 AMPS or more that may be flowing through the flashlamp. Like the non-energy conserving type, they bypass current around the flashlamp at the instant that the flash is to be terminated. But rather than dumping the energy to ground and wasting all of it, the current is diverted into a small capacitor. The voltage across the flashlamp drops to a low value just long enough for the flashlamp to revert to a non-conducting state. Only a small amount of energy is lost (that which goes into the bypass capacitor). More sophisticated units use something like a Gate TurnOff Thyristor (GTO) or high power Insulated Gate Bipolar Transistor (IGBT) to actually interrupt the flash discharge at the proper instant. These save virtually 100 percent of the energy and the circuitry is actually simpler, but the cost and availability of GTOs or IGBTs with the required peak surge rating of 100s of AMPS are a consideration in their design.

Although the high voltage inverter and actual flash tiggering circuitry is usually easy to trace, failure of the automatic exposure control circuit itself will probably require a schematic to troubleshoot unless tests for bad connections or shorted or open components identify specific problems. However, some of these use fairly simple circuits with mostly standard components and can be traced without too much difficulty though the compactness of modern flash units makes this somewhat more of a challenge. The most likely failures are still in the power circuits, not the control.

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Safely Working with Xenon Flash and Strobe Equipment

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Xenon Strobe Safety

There are two potential hazards in dealing with the innards of electronic flash and other xenon strobe equipment:

1. The energy storage capacitor. Even on small pocket camera electronic flash units, these are rated at 100 to 400 uF at 330 VDC. This is 5 to 20 W-s which is enough to kill you under the right (wrong?) conditions. Hot shoe or side mounted electronic flash units have energy storage capacitors which are usually larger - typically 300-1000 uF or more. High performance studio speed lights may have 10 times this capacity and at much higher voltages resulting in even greater energy storage. Xenon strobes for pumping of solid state laser rods and other industrial and scientific applications may use many kV power supplies with 1000s of W-s energy storage capacitors - touch one of these and you will be but a puff of vapor in the wind...

   High voltage with high energy storage is an instantly deadly combination. Treat all of these capacitors - even those in tiny pocket cameras with respect. Always confirm that they are discharged before even thinking about touching anything. On larger systems especially, install a shorting jumper after discharging just to be sure - capacitors have been known to recover a portion of their original charge without additional power input. Better to kill the power supply than yourself if you forget to remove it when powering up.

2. Line connected (no power transformer) have all the dangers associated with AC line power in addition to the large power supply and energy storage capacitors. Always use an isolation transformer when probing line connected systems. However, keep in mind that the power supply filter capacitors and energy storage capacitors remain just as deadly.

Additional important safety information regarding shock, excessively bright light, ultraviolet radiation, heat and fire hazards, and other hazards is available from Don's Xenon Strobe and Flash Safety Hints page.

Reading and following these recommendations and heeding the warnings is especially important when working with high power strobes.

General Safety Guidelines

Due to the dangers inherent in even the smallest electronic flash unit, it is imperative that you understand and follow ALL safety recommendations while working inside this equipment.

See the document: Safety Guidelines for High Voltage and/or Line Powered Equipment.

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Safe Discharging of Capacitors in Electronic Flash Units

A working electronic flash or strobe may discharge its capacitors fairly quickly when it is shut off but most DO NOT do this. Furthermore, do not assume that triggering the flash fully discharges either the power supply filter or main energy storage capacitors fully - especially if it is a sophisticated automatic unit.

The main filter capacitors in the low voltage power supply may have bleeder resistors to drain their charge relatively quickly - but resistors can fail. Don't depend on them. For battery powered equipment in particular, efforts may have been made NOT to bleed the energy storage capacitor to conserve on battery power should another shot be desired at a future time. Some units even keep the flash fully charged when supposedly turned off!

The technique I recommend is to use a high wattage resistor of about 5 to 50 ohms/V of the working voltage of the capacitor. This will prevent the arc-welding associated with screwdriver discharge but will have a short enough time constant so that the capacitor will drop to a low voltage in at most a few seconds (dependent of course on the RC time constant and its original voltage).

Then check with a voltmeter to be double sure. Better yet, monitor while discharging.

Obviously, make sure that you are well insulated!

For the power supply filter capacitors or main energy storage capacitors, which might be 400 uF at 350 V, a 2 K ohm 25 W resistor would be suitable. RC=.8 second. 5RC=4 seconds. A lower wattage resistor (compared to that calculated from V^^2 / R) can be used since the total energy stored in the capacitor is not that great (but still potentially lethal).

The discharge tool and circuit described in the next two sections can be used to provide a visual indication of polarity and charge for TV, monitor, SMPS, power supply filter capacitors and small electronic flash energy storage capacitors, and microwave oven high voltage capacitors.

Reasons to use a resistor and not a screwdriver to discharge capacitors:

1. It will not destroy screwdrivers and capacitor terminals.

2. It will not damage the capacitor (due to the current pulse).

3. It will reduce your spouse's stress level in not having to hear those scary snaps and crackles.

Capacitor Discharge Tool

A suitable discharge tool for each of these applications can be made as quite easily. The capacitor discharge indicator circuit described below can be built into this tool to provide a visual display of polarity and charge (not really needed for CRTs as the discharge time constant is virtually instantaneous even with a multi-M ohm resistor.

- Solder one end of the appropriate size resistor (for your application) along with the indicator circuit (if desired) to a well insulated clip lead about 2-3 feet long. For safety reasons, these connections must be properly soldered - not just wrapped.

- Solder the other end of the resistor (and discharge circuit) to a well insulated contact point such as a 2 inch length of bare #14 copper wire mounted on the end of a 2 foot piece of PVC or Plexiglas rod which will act as an extension handle.

- Secure everything to the insulating rod with some plastic electrical tape.

This discharge tool will keep you safely clear of the danger area.

Again, always double check with a reliable voltmeter or by shorting with an insulated screwdriver!

Capacitor Discharge Indicator Circuit

Here is a suggested circuit which will discharge the high voltage power supply filter capacitors and main energy storage capacitors of most types of electronic flash units and strobe lights. This circuit can be built into the discharge tool described above.

A visual indication of charge and polarity is provided from maximum input down to a few volts.

The total discharge time is approximately 1 second per 100 uF of capacitance (5RC with R = 2 K ohms).

Safe capability of this circuit with values shown is about 500 V and 1000 uF maximum. Adjust the component values for your particular application.

```
(Probe)
o-------+
 In 1   |
        /
        \    2 K, 25 W     Unmarked diodes are 1N400X (where X is 1-7)
        /                   or other general purpose silicon rectifiers.
        \
        |
        +-------+--------+
```

```
      __|__   __|__      |
      _\_/_   _/_\_      /
        |       |        \ 100 ohms
      __|__   __|__      /
      _\_/_   _/_\_      |
        |       |        +----------+
      __|__   __|__    __|__      __|__      Any general purpose LED type
      _\_/_   _/_\_    _\_/_ LED  _/_\_ LED   without an internal resistor.
        |       |        |    +     |     -  Use different colors to indicate
      __|__   __|__      +----------+         polarity if desired.
      _\_/_   _/_\_      |
 In 2   |       |        |
o-------+-------+--------+
(GND Clip)
```

The two sets of 4 diodes will maintain a nearly constant voltage drop of about 2.8-3 V across the LED+resistor as long as the input is greater than around 20 V. Note: this means that the brightness of the LED is NOT an indication of the value of the voltage on the capacitor until it drops below about 20 volts. The brightness will then decrease until it cuts off totally at around 3 volts.

Safety note: always confirm discharge with a voltmeter before touching any high voltage capacitors!

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Items of Interest

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Why do Roulette Wheels Sometimes Appear to Spin Backward?

Roulette wheels and wagon wheels spinning backwards represents a form of aliasing due to sampling. OK, the technical jargon aside this effect will only take place in a situation where images are captured at discrete intervals as they are in a motion picture or video - or when illuminated with a repeating strobe. For motion pictures, something like 24 frames per second are recorded; for video there are 30 frames per second (in the US, 25 in many other countries). However, the use of interlacing where a complete frame is scanned in two parts - the even and the odd lines - complicates the explanation so I will restrict the remainder of this discussion to motion picture film).

If the rotation rate of the wheel is such that one spoke or slot goes by a given position in exactly 1/24th of a second, the wheel will appear stationary since successive images will be identical. If it is moving a bit faster than this it will appear to be moving forward slowly. However, if it is going a bit slower, then it will be appear to be turning backwards slowly. The shorter the exposure with respect to the total frame time, the sharper will be the apparent effect. The number of slots per second of perceived motion will be equal to the difference in frame rate and number of slots per second passing a given point. So, a roulette wheel rotating such that 23 slots are passing by per second captured on a 24 frame per second camera will appear to be moving backwards at 1 slot per second.

The same applies to the use of a strobe light to freeze repetitive motion like the rotation of a shaft. It is all a matter of the relative speed of the sampling (the movie, video or strobe) with respect to an object which is periodic like a roulette or wagon wheel.

You can perform a simple experiment: run an electric fan under a fluorescent lamp (one with an ordinary magnetic ballest). The light from such a lamp is not continuous but pulses 120 times per second. Watch for stationary or slowly rotating blade patterns as the fan speeds up and slows down. See if you can compute the speed of the fan from this behavior.

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Kevin Attempts to Abuse a Strobe

(This from: Kevin 'Destroyer of Worlds' Horton (khorton@tech.iupui.edu))

Just for funsies, I decided to see how much torture I could inflict on the flashlamp and energy storage capacitor from one of those little Kodak cameras. The tube was 1.2" long, in a metalized plastic reflector, with a thin metal backing to hold it in. The capacitor was 120 uf, 330 V. I hooked it up to my inverter (12 V->300 V at high current) and fired 'er up! Pop, pop, pop, pop, pop, pop, pop, (turn up trigger oscillator frequency) popopopopopopopopopopopopop! It was firing about 30 or 40 times a second; it appeared as it was constantly on! I turned it down to about 15 flashes a second, and let it run. First thing I noticed was that wonderful scent of melting acrylic. Then, I noticed that the tube was kind of skewed in the reflector. The plastic was in full smoke-mode by this point. Still, the tube kept firing! (Let's see: 5 W-s times 15 flashes per second is 75 W average power, not bad for an itty bitty tube --- sam).

I left it on a bit more, and the plastic really started the smoke-signals! I noticed that one electrode was glowing cherry red. Even after all this torture, it kept going! The smoke was getting too much, so I hit the 'off' on my inverter. A few more gouts of smoke, and the little fire I created was extinguished. I let it cool down and then I examined the damage. The reflector was totaled; the tube had all but melted clean through. When I touched it, the little metal plate popped off.

On closer examination, the tube appeared to be in good shape. I couldn't see any visible damage to either the electrodes, or the glass seals. A quick test reveals that the tube still functions. As a side note, the storage capacitor got quite hot; probably around 35 degrees C. All in all, an interesting test, I must say. The next will involve connecting up a normal NE2 neon bulb and observing the results of high voltage and high current on it. I suspect it will be quite spectacular, so I'm taking precautions - It will be performed in a proper enclosure, so if the neon decides to really go 'pop', it won't do any damage.

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Really BIG Strobes for Stadium Sized Special Effects (or ET Comm link?)

(From: Ruben (ruben@worldaccess.nl).)

I used to design stage-effects, and played some time with strobes. Built a number, from 750 W-s at high rates to 22,500 W-s single flash. Philips makes xenon lamps, designed for photographic use - they are not flashtubes but burn continually - so using them as flashtube shortens their life span (assuming you increase power). They are expensive, from $250 for the smallest to $1,100 for the biggest.

For caps for the smaller (20 to 100 W-s) strobes, I used a huge array of MKT motor-caps. 10 uF at 630V is cheap, a few dollars, and building an array of these is not too hard. These caps are screw-mount, and you can just fill a board with them, and switch them in parallel. Keeps the ESR low, which is a requirement.

The monsters used larger caps, 680 uF each. My boss often visited executory sales and bought components and machinery. These caps (he had a number of crates full of them) sat on the shelves for a year before I decided to do something with them. Beautiful Siemens stuff. Very low ESR, large cap. Nevertheless, I did say "huge array" which was exactly that. Two boards (one for each set of lamps) filled with them, each board 1 by 1.5 meters, which dictated the size of the case. As I remember these caps were about 5 centimeters diameter, and something like 12 centimeters high, so - guessing - you could stack around 280 of them on a board, which sounds right.

All problems I had related to heat. The 750 and 1500 W-s models had a habit of melting their main wire. On typical stages one uses a lot of extension-wires, and its power consumption could be high enough to heat the extension to the point the insulation came dripping off, without blowing a fuse. Had to lower the amount of energy per flash at higher rates. The protective window in front was another problem area. Poly-carbonate covers work fine, but a single fingerprint absorbs enough IR to melt a hole in the cover. Glass won't melt, but shatters if dirty. Don't allow anything near it. Colored paper will catch fire within seconds, at max rate. Always use it to flash at a wall, never let the public look into such a bright flash.

The biggest used four larger tubes, flashing two by two, but charge-times were too long to make it usable as a real strobe. It was used to flash the ceiling of a large stadium. I considered it to be useless. I never solved the problems it had, like eating its eight, expensive, diodes (>$40 each) for lunch. It sucked dips in the mains, big enough to cause digital equipment to fail. Imagine all the effects of the audio-boys resetting after each flash. I kept it running for a few months, but when the edges of the window caught fire I scrapped it. I modified one off the triggers for the small strobe (750 and 1500 w-S) to allow multiple units.

I found a note in the same binder with a capacitor-free design for a strobe. The smallest Xenon tube made by Philips has a burning voltage low enough to start it on 220V. With a suitable choke and a diode in series it will burn - after ignition - for the rest of the half-cycle. The diode makes sure it dies when the polarity reverses. (Residual ionization will make it re-ignite without the diode) The choke will keep it from aggravating the utility-companies. I wonder if anyone knows a trick to enhance ionization. Fully ionized it has a burning-voltage of 50 Volts, but even after the 4 kV pulse it needs 200 Volts to get started. Only tricks I know are the 'normal' starter-pulse, microwave pulses, radioactivity and laser-pulses. Only the first one is acceptable with audiences around. It probably won't work with 110 V mains.

(From: Tomi H. Engdahl (then@cc.hut.fi).)

A friend of mine has around a 3 kW disco stroboscope. (It is really 3 kW as it blows a 230 V, 10 A fuse at full power. And you can guess that it is quite bright!) That stroboscope seems to be taking quite heavy (few tens of amperes) of current for one half wave when it flashes. The firing angle is controlled by the internal brightness control (dimmer).

What it looked inside on quick glance it seemed to have a heavy thyristor, rectifier, heavy line filter, one coil in series with the tube, the tube itself, and the triggering electronics.

(From: Sam.)

On 110 VAC you're out of luck if no caps are allowed and you don't want to use a stepup transformer. In any case, what you end up with is more of an arc lamp than a flashlamp since the current is limited to a few amps as opposed to 10s or 100s of A for even a tiny strobe.

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Recycled Defibrillator as Capacitor Charger

The following may come in handy when building that next high speed high power strobe or pulsed laser.

WARNING: Defibrillators are at least as good at stopping beating hearts as restarting misbehaving ones. The charge in their energy storage capacitor (typically 300 to 400 Joules) is enough to kill a half dozen healthy adults instantly. The operating voltage (up to 5 kV) doesn't respect common wire insulation and can jump 1/4" or more in air. There are no second chances.

(From: Steve Roberts (osteven@akrobiz.com).)

Older defibrillators are now showing up as inexpensive surplus because their ancient edmark waveform is being replaced with newer computer controlled biphasic waveforms.

So what do you get in a typical edmark waveform defibrillator:

1. Switching HV supply up to 5 kV with programmable shutoff voltage.
2. 32 uF Maxwell energy storage capacitor rated at 5 to 6 kV.
3. 47 mH inductor rated for the above cap's current.
4. A high pressure gas (SF6?) or BIG vacuum glass relay.
5. A second smaller vacuum relay.
6. A 50 ohm resistor for bleeding the cap and simulating a patient's chest.
7. Usually a vectorscope with an amber phosphor CRT and a GM20 or similar galvanometer if the unit has a chart recorder.

Notes: The relay is usually a 5 kV 50 A DPDT which has a short across one set of contacts to protect the patient. The other set of contacts goes to the capacitor common leads and to the patient via the paddles. So, presto! - apply 12 volts to the relay and you get up to 360 joules dumped into the victim or patient via the inductor to control the waveform. A patient's chest is assumed to be about 50 ohms impedance via the conductive cream to the paddles so the test circuit monitors what happens when the second smaller relay dumps the cap into the 50 ohm air cooled test resistor. The cap is also dumped during power-down.

I can't overstress the absolute need for safety when handling a 33 uF 5 kV capacitor. Newer defibrillators have a MOSFET H-bridge for bipolar switching and only go to two kV with smaller caps.

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Xenon Pressure in Typical Flashtubes

The following was prompted by my observation that many small flashtubes are not glass sealed but use a frit (sort of a solder for glass) or possibly even an Epoxy seal. However, at the relatively high xenon pressure (see below), leakage should be of little consequence even over a long period of time. As long as the sealing material can handle the heat during operation, even Epoxy should be fine.

(From: Don Klipstein (don@misty.com or klipstei@netaxs.com).)

I actually busted some smaller flashtubes in a cup of vegetable oil to get an idea of the xenon pressure! In the Radio Shack U-shaped tubes, the pressure is about 80 Torr. In a smaller cheap linear tube with the electrodes 19 mm. apart, the pressure is about 180 Torr. In at least one version of the tiny tubes often used in cheap and disposable cameras, the pressure is about 450 to 500 Torr. Most other small camera flashtubes are 100 to 300 Torr.

In many medium and large flashtubes, the pressure seems to be around 80 Torr, except one I have seems to have a little less - maybe 60 Torr. This was for three different professional photoflash tubes, a larger version of the popular U-shaped strobe tube, and a large photocopier flashtube. I estimated the pressure in these by passing a few milliamps through them from a neon sign transformer (operated at reduced voltage) and commparing the appearance of the discharge to that in tubes of known pressue.

Larger photographic flashtubes - mostly around 80 to 200 Torr:

- Norman FT-6 - lowish, 70 Torr (?).
- Spedotron MW8QW/14540 - looks like about 80 Torr.
- Photogenic C4-5 - looks like about 80 Torr.
- Lumedyne 090Q - higher, 120 to 160 Torr???.
- A sealed beam aviation strobe, NSN 6240-01-006-1260 - higher, around 200 (?). There is a slight trend for narrower tubes to have higher pressure and larger tubing diameter tubes to have lower pressure.

EG&G, Electro-Optics Division 35 Congress St Salem MA uses a standard pressure of 450 Torr in their superduper linear flashtubes, but won't hesitate to use a custom pressure at customer's request.

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BIG Strobe from Fluorescent Tube?

From a posting on the USENET newsgroup sci.electronics.misc:

> "I had an interesting idea. Get a small (2 watt) fluorescent tube, wrap several turns of wire round it, connect ends of tube to xenon strobe outputs, connect wire to HV trigger connection, switch it on. As far as I can tell, this would make one hell of a bright strobe! Any ideas???"

Depending on the voltage and size of the tube, you may not need trigger - it will break down at lower voltage than xenon tube. For your 2 W tube, this is a certainty.

It will also only likely work for one or at most a few flashes unless you use a much smaller capacitor. What happens is the filaments disintegrate. Fluorescent tubes are NOT designed for the high peak current of a strobe type circuit with a large energy storage capacitor. Go much beyond their normal ratings of a few hundred mA and they will fail.

Been there, done that. I once powered an 8 foot fluorescent tube from a six volt lantern battery pulse circuit and stepup transformer - and even such a large tube was destroyed after a few flashes. But the flashes WERE pretty bright. :-)

(From: Don Klipstein (don@misty.com or klipstei@netaxs.com).)

It is not as bright as xenon. Also, triggering characteristics will change as strobe duty changes the condition of the electrodes, also as temperature changes and mercury vapor concentration changes. I've tried it - the fluorescent tube changes too much with temperature and past history of strobe use.

One more thing: A strobing fluorescent tube is more conductive than a xenon tube, which means more of the energy stored in the energy storage capacitor is used to heat the capacitor, and less is dissipated in the tube. But enough is dissipated into the tube to beat up the electrodes!

(From: Craig Douglas (blackspear@hotmail.com).)

You can very successfully flash banks of fluorescent lamps by running a continuous low current through the lamps and increasing the current (the lamps appear off, but are actually still lit). This works well in the electric sign industry.

The same principle is used to flash standard incandescent bulbs, without the bulbs blowing continually. It is the spike in initial power that blows the filament, running a low current continually through to keep the filament warm minimizes stress on the filament which stops it from blowing.

(From: Sam.)

It should be noted that this will not increase lamp life significantly in normal operation but may extend it by a few percent.

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Strobe Parts Sources

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New and Surplus Parts

Common electronic components can be obtained from any large distributor. Even Radio Shack may have what you are looking for. However, many do not list any xenon flashlamps or trigger transformers.

1. Mouser Electronics, 1-800-346-6873. General electronics parts including trigger transformers, magnet wire, rechargeable batteries, laser diodes, photodiodes, much more.

   Mouser stocks a few xenon flashlamps and trigger transformers suitable for both small and medium power strobes.

2. Dalbani, 1-800-325-2264. Excellent Japanese semiconductor source, VCR parts, other consumer electronics, car stereo, CATV).

   Dalbani's current catalog lists a few types of xenon flashtubes - some of relatively high capacity (100s of W-s). Their selection used to be much larger. My guess is that they acquired someone else's inventory and have been selling this off without replenishing it.

3. Radio Shack stocks a couple of pricey strobe lights as well as a small xenon flash lamp. At least you can just walk over to your neighborhood store!

4. All Electronics, 1-818-904-0524. Large selection of surplus and new electronics and hobbyist items.

   A flashtube, trigger coil, and a more complete camera flash assembly are listed in their catalog.

5. Electronic Goldmine, 1-602-451-9495 or 1-800-445-0697.

   Some strobe kits, flashtubes, reflectors, flashtube-reflector combos, a trigger coil, a quench tube (!!), two different inverter transformers, and two complete strobe schematics, one of which is a 12 volt strobe using one of these transformers.

   The also sell small flashtubes by the bushel :-) about 1.2 inches long (~30 mm) by .15 inch (~3.5 mm) diameter. These cost 49 cents each, or 100 for $25. So, if you are planning on building your own New Year's Times Square celebration sphere, these may be ideal! These were offered in 1996 and may no longer be available but should be worth an inquiry.

6. (From: Gary M. Reese (greese@comteck.com).)

   High power capacitors (like 450 uf at 500 volts) and other strobe parts may be had though the list of strobe service centers at Lumedyne.

   However, it should be remembered that they are repair centers and do not normally sell parts at retail. I have ordered a capacitor like the one mentioned above from one them at a cost of $26.00 plus $3.50 S&H.

   (What this means is that (1) their prices may be quite high and (2) they may not be eager to sell to the public. --- sam)

7. (From: Scott Tilton (stilton@execpc.com).)

   The original Strobotac flashtubes were made by EG&G Optoelectronics. They used a FX6-A. I believe they now supply a FX7-A as a replacement. You can reach them at 1-800-950-3441.

   You might also try Quad Tech, which still manufactures the General Radio 1531AB, and other General Radio stroboscopes. They can supply spare parts. You can reach them at 1-800-253-1230.

Additional information including part numbers and minimum order amounts is available at Don's Where to Get Xenon Flashes/Strobes and Parts page.

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Previously Owned and Recycled Parts

1. Garage sales (and the like), flea markets, thrift stores. These are often good sources for cameras with a built-in electronic flash, photographic strobes, and other similar equipment. Your (or your Aunt Minnie's) attic or basement may even hold some of these treasures!

   The going rate for a typical cheap flash camera is generally $.50 to $1 at a garage sale or flea market. While these may in fact still work, they often use 110 size film so you won't feel too badly about gutting them for the flash unit or its parts.

   Although in principle the capacitor may deform after a long period of non-use, I have yet to see any real trouble having picked up over 2 dozen cameras and strobes from these sources. None of these have had any actual defective components (though a couple had bad connections or broken wires). My last acquisition was a completely functional variable rate stroboscope for $2.

2. Photo processing labs who accept disposable flash cameras may just throw the carcasses away after extracting the film. These may be available for the asking. Unfortunately for our needs, I have heard that the reusable parts are now being recycled. :-(

   (From: Scott Johnston (sj@thor.iac.net).)

Complete working strobe circuits are available for *free* at photo developing places (not K-mart, but the expensive places that actually do the developing in-house). When they develop film from those cheap weekend disposable cameras (you know, the kind that are made out of plastic and cardboard?), they rip out the film and throw away the camera housing. The disposables with flashes have a complete xenon strobe circuit (triggered by a tiny little switch on wire leads) powered by a single AA (1.5v) alkaline battery. Recently, I called the local photo developer, asked if they could save some of the kind with flashes, and a few days later I picked up a pile of 12 complete flash units, with almost unused AA batteries in all of them! Really fun, although I discovered quickly that the capacitors in those things don't have bleeder resistors...

(From: Alfred C. Erpel (aerpel@ptd.net).)

I was picking up my Halloween party photos from the 1 Hour Photo place at my local drug store and I noticed a trash box full of thrown out single use cameras, empty 35mm spools and plastic containers. I asked if I could have the entire box.

When I got home I found I had 27 cameras with usable flash units and most of the AA batteries were still good. My wife got the plastic containers for her Girl Scouts crafts. The inside of used Kodak film canisters contains a nifty spool which may make a useful bobbin for some types of coils.

Watch out for residual charge on the flash capacitor when you disassemble these! Also, observe the mechanics carefully because, although I'm not certain about this yet, it seems that some of the cameras are designed to purposely disable the flash circuitry by mechanically breaking an existing connection when the board is removed. Obviously this could be restored if you see where it is.

No doubt some places won't give you their trash (afraid of the potential for liability), but it can't hurt to ask.

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Flashlamp and Arc Lamp Manufacturers and References

Here are some of the major suppliers. Many also have a variety of useful technical information either on their Web sites or available in print.

- Perkin Elmer (used to be EG&G Electro Optics
  35 Congress St.
  Salem, MA 01970
  Phone: 1-800-775-6786

  Information is available for driving flashlamps (and other topics) in the Perkin Elmer (formerly EG&G) Technical Library. However, much of the product and technical info that used to be on the EG&G Web site is no longer present but this material is available on the Perkin Elmer CDROM, which includes complete product specifications and technical papers. The CDROM is accessed using your normal Web browser. Some flashlamp info is also available at Polytec PI France - Department Electro-Optique.

- Heraeus Noblelight, Inc.
  2150 Northmont Parkway

Duluth, GA 30096
Phone: 1-770-418-0707

General technical information on flashlamps and arc lamps may be accessed via their Laser Lamps Download Page.

- ILC Technology Inc.
399 West Java Drive
Sunnyvale, CA 94089
Phone: 1-800-347-2474

  Some very complete technical notes on driving and triggering of flashlamps has been published by ILC Technology (now part of Perkin Elmer). Some of these include:

  - Technical Bulletin #1: "An Introduction to Flashlamps".
  - Technical Bulletin #2: "A Guide to Flashlamps for Pulsed Solid State Lasers".
  - Technical Bulletin #3: "An Overview of Flashlamps and CW Arc Lamps".
  - (No publication number): "Linear Flashlamps".

  These were originally published around 1986 so there may be newer versions. As far as I know, they are not currently on-line but should be available in print by contacting ILC.

- Xenon Corporation
20 Commerce Way
Woburn, MA 01801
Phone: 1-800-XENONXL

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Electronic Flash Problems and Solutions

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Electronic Flash Problems

A variety of failures are possible with electronic flash units. Much of the circuitry is similar for battery/AC adapter and line powered units but the power supplies in particular do differ substantially.

Most common problems are likely to be failures of the power supply, bad connections, dried up or deformed energy storage or other electrolytic capacitor(s), and physical damage to the to the flashtube or other components.

Problems Unique to Battery or AC Adapter Powered Electronic Flash Units

- Power source - dead or weak batteries or defective charging circuit, incorrect or bad AC adapter, worn power switch, or bad or corroded connections.

  Symptoms: unit is totally dead, intermittent, or has excessively long cycle time.

  Test and/or replace batteries. Determine if batteries are being charged. Check continuity of power switch or interlock and inspect for corroded battery contacts and bad connections or cold solder joints on the circuit board.

- Power inverter - blown chopper transistor, bad transformer, other defective components.

  Symptoms: unit is totally dead or loads down power source when switched on (or at all times with some compact cameras). No high pitched audible whine when charging the capacitor. Regulator failure may result in excess voltage on the flashtube and spontaneous triggering or failure of the energy storage capacitor or other components.

  Test main chopper transistor for shorts and opens. This is the most likely failure. There is no easy way to test the transformer and the other components rarely fail. Check for bad connections.

Problems Unique to AC Line Powered Electronic Flash Units

WARNING: Line powered units often do not include a power transformer. Therefore, none of the circuitry is isolated from the AC line. Read, understand, and follow the safety guidelines for working on line powered equipment. Use an isolation transformer while troubleshooting. However, realize that this will NOT protect you from the charge on the large high voltage power supply and energy storage capacitors. Take all appropriate precautions.

- Power source - dead outlet or incorrect line voltage.

  Symptoms: unit is totally dead, operates poorly, catches fire, or blows up. Spontaneous triggering may be the result of a regulator failure or running on a too high line voltage (if the unit survives).

  Test outlet with a lamp or circuit tester. Check line voltage setting on flash unit (if it is not too late!).

- Power supply - bad line cord or power switch, blown fuse, defective rectifiers or capacitors in voltage doubler, defective components, or bad connections.

Symptoms: unit is totally dead or fuse blows. Excessive cycle time.

Test fuse. If blown check for shorted components like rectifiers and capacitors in the power supply. If fuse is ok, test continuity of line cord, power switch, and other input components and wiring. Check rectifiers for opens and the capacitors for opens or reduced value.

Problems Common to All Electronic Flash Units

WARNING: the amount of charge contained in the energy storage capacitor may be enough to kill - especially with larger AC line powered flash units and high power studio equipment. Read and follow all safety guidelines with respect to high voltage high power equipment. Discharge the energy storage capacitors fully (see the section: Safe Discharging of Capacitors in Electronic Flash Units) and then measure to double check that they are totally flat before touching anything. Don't assume that triggering a flash does this for you (especially for automatic units). For added insurance, clip a wire across the capacitor terminals while doing any work inside the unit. Better to blow a fuse than you if you should forget to remove it.

- Energy storage capacitor - dried up or shorted, leaky or needs to be 'reformed'.

  Symptoms: reduced light output and unusually short cycle time may indicate a dried up capacitor. Heavy loading of power source with low frequency or weak audible whine may indicate a shorted capacitor. Excessively long cycle time may mean that the capacitor has too much leakage or needs to be reformed.

  Test for shorts and value. Substitute another capacitor of similar or smaller uF rating and at least equal voltage rating if available.

  Cycling the unit at full power several times should reform a capacitor that has deteriorated due to lack of use. If the flash intensity and cycle time do not return to normal after a dozen or so full intensity flashes, the capacitor may need to be replaced or there may be some other problem with the power supply.

- Trigger circuit - bad trigger capacitor, trigger transformer, SCR (if used), or other components.

  Symptoms: energy storage capacitor charges as indicated by the audible inverter whine changing frequency increasing in pitch until ready light comes on (if it does) but pressing shutter release or manual test button has no effect. Spontaneous triggering may be a result of a component breaking down or an intermittent short circuit.

  Test for voltage on the trigger capacitor and continuity of the trigger transformer windings. Confirm that the energy storage capacitor is indeed fully charged with a voltmeter.

- Ready light - bad LED or neon bulb, resistor, zener, or bad connections.

  Symptoms: flash works normally but no indication from ready light. Or, ready light on all the time or prematurely.

  Test for voltage on the LED or neon bulb and work backwards to its voltage supply - either the trigger or energy storage capacitor or inverter trans- former. In the latter case (where load detection is used instead of simple voltage monitoring) there may be AC across the lamp so a DC measurement may be deceptive.)

- Trigger initiator - shutter contacts or cable.

Symptoms: manual test button will fire flash but shutter release has no effect.

Test for shutter contact closure, clean hot shoe contacts (if relevant), inspect and test for bad connections, test or swap cable, clean shutter contacts (right, good luck). Try an alternate way of triggering the flash like a cable instead of a the hot shoe.

- Xenon tube - broken or leaky.

  Symptoms: energy storage and trigger capacitors charges to proper voltage but the manual test button does not fire the flash even though you can hear the tick that indicates that the trigger circuit is discharging.

  Some xenon tubes have "getters", which are silver or dark silver coatings of a highly reactive metal, deposited on the inner surface of the flashtube at one or sometimes both ends. Less frequently, a getter may be found on a metal surface such as one of the electrodes inside the tube, but not on the tubing inner surface. The getter "gets" any traces of air or water vapor in the flashtube. If a flashtube with a getter is broken or leaky, the getter will be corroded into a powdery gray-white form. If you know there is a getter and it is corroded badly, the flashtube is no good. Please note that unrelated glass discoloration or staining that resembles corroded getters can occur in a heavily used or moderately abused flashtube that still works.

  Inspect the flashtube for physical damage. Substitute another similar or somewhat larger (but not smaller) flashtube. A neon bulb can be put across the trigger transformer output and ground to see if it flashes when you press the manual test button shutter release. This won't determine if the trigger voltage is high enough but will provide an indication that most of the trigger circuitry is operating.

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Electronic Flash Dead After Long Time in Storage

The unit may be totally dead or take so long to charge that you give up.

For rechargeable units, try charging for the recommended time (24 hours if you don't know what it is). Then, check the battery voltage. If it does not indicate full charge (roughly 1.2 x n for NiCds, 2 x n for lead-acid where n is the number of cells), then the battery is likely expired and will need to be replaced.

Even for testing, don't just remove the bad rechargeable batteries - replace them. They may be required to provide filtering for the power supply even when running off the AC line or adapter.

For units with disposable batteries, of course try a fresh set but first thoroughly clean the battery contacts.

See the sections on batteries.

The energy storage capacitor will tend to 'deform' resulting in high leakage and reduced capacity after long non-use. However, you should still be able to hear the high pitched whine of the inverter.

Where the unit shows no sign of life on batteries or AC, check for dirty switch contacts and bad internal connections. Electrolytic capacitors in the power supply and inverter may have deteriorated as well.

If the unit simply takes a long time to charge, cycling it a dozen times should restore an energy storage capacitor that is has deformed but is salvageable. This is probably safe for the energy storage capacitor as the power source is current limited. However, there is no way of telling if continuous operation with the excessive load of the leaky energy storage capacitor will overheat power supply or inverter components.

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Flashlamp Failure Behavior and Causes

(Portions from: Don Klipstein (don@misty.com).)

When a flashlamp fails, it may do so quietly or with a bang.

Generally, only laser pump flashlamps or similar ones with a lot of flash energy for their size will likely die spectacularly. When lower power flashlamps such as those used in small to medium size photographic strobes crack, they tend to stay in one piece or sometimes break apart surprisingly quietly.

- A hairline crack would enable air to enter resulting in a flashlamp that doesn't work but might remain intact, at least to casual handling. This is more common than spectacular failure.

- A crazed flashlamp may crack or break into two pieces when fired.

- A high mileage lamp may show discoloring, mostly around the area of the cathode.

- Low quality or old flashtubes may have traces of air in them due to imperfect seals. Oxygen and water vapor will make the flashlamp more difficult to fire. In a high power lamp where the electrodes get hot enough to react with any oxygen or water vapor, oxides can form and collect on the inner surface of the tube, resulting in a powdery discoloration. I have seen a whole batch of older camera flashes with leaky flashtubes with varying ability to fire.

As for failure modes due to abuse:

- Too much energy on a cheap glass flashtube - they just crack. 10 times too much and what they usually do is just crack all over and fall apart easily, but maybe they could explode. You may hear the tube crackling during the roughly two seconds after such a fatal flash. One that I had broke into two pieces and with no bang nor even a loud pop with about 3 times its rated energy.

- With moderately excessive energy the first big flash is not fatal. But a discolored area of the tubing will get hotter than an adjacent clear area during a subsequent flash, and this can crack the tubing. I once abused a flashtube this way (with about three times its maximum rated energy), and the first flash caused discoloration and the second flash cracked the tube around one edge of the discoloration.

- Excessive flash energy to quartz flashtubes with lower xenon pressure such as most photocopier and higher power photoflash lamps will usually just discolor them at an unacceptably high rate if the voltage is not also excessive. Seals could fail however. Obviously, there is some amount of energy that will cause the lamp to crack, break, explode, or melt or do a combination of these things.

- Excessive average power input to a cheap glass flashtube will cause it to crack, often not doing so until after some discoloration develops.

- Excessive average power input to a quartz flashtube usually causes accelerated discoloration or risks the seals, but if you're lucky nothing bad happens until the quartz tubing gets soft enough to slowly, slightly give way (900-1000 degrees C or hotter) and then cracks from stresses.

- High power quartz lamps that heat up to a few hundred degrees C or hotter should be clean. Ash, salts, and alkalis will slowly leach into hot quartz and cause stresses that may make the tubing crack.

- With too much voltage while pushing limits of energy or average power the flashtube may crack more easily from higher heating of the glass by UV.

- Exceeding some combination of voltage and flash energy will cause "wall ablation" - in which traces of the tubing material is vaporized. This happens from exceeding some combination of total flash energy and peak flash power. The vapor is mostly silicon dioxide and it will decompose in the hot xenon arc. The resulting oxygen will make the flashtube harder to fire. The tubing will also discolor or sometimes just get cloudy, usually unevenly if flash energy is low and voltage is extremely high. In high power flashlamps where the electrodes get hot enough to react with the free oxygen, powdery oxide can form and collect on the inner surface of the tube. But this process will remove some of the oxygen and can restore ease of firing the flashtube.

- Reverse polarity on a polarity-sensitive flashtube will sometimes impair flashing but usually not. Tube discoloration will occur more easily and may cover more of the tube more easily. But not all flashtubes are polarity sensitive.

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Transformer Replacement in Electronic Flash Units

While not as common a problem as many people believe (the hardest to find part must be at fault, right?!), the transformers in electronic flashes do fail occasionally, probably due to faulty manufacturing - damaged fine wire in the secondary which eventually breaks or a shorted secondary from arcing through an insulation layer.

Line voltage transformers: Most AC line powered flash units don't have any transformer so this isn't general a problem. For those that do (higher speed or other special types of strobes), it shouldn't be difficult to match up the secondary voltage and find a standard replacement that will be acceptable. These may be cobbled together from the power transformers for vacuum tube equipment (yes, they can still be found), small isolation transformers with multiple windings, and possibly the addition of some additional lower voltage windings in buck or boost phase to adjust the output voltage.

For safety reasons, I don't recommend attempting to repair transformers connected to the AC line, though this may be a possibility if all else fails.

Inverter transformers in battery powered flash units:

There is virtually no chance of successfully repairing any of these. The secondary winding uses wire so fine that it's almost impossible to even handle it. With a decent coil winding machine, a new spool of #45 or so wire, proper insulating tape (these are wound in 10 to 20 separate layers), and a few days of patience, it can be done but doesn't rank up there on my "fun things to do list". :) Furthermore, it's almost certain the core got destroyed in attempts to get at the windings. Thus, replacement is the only viable option.

There is NO chance of getting one of these from an electronics distributor as they are all custom. Since it's almost a certainty that the original manufacturer will have little interest in selling you a new one, salvage from other flash units is the best hope. These can be $1 garage sale specials (other 35 mm, 126, or similar cameras), disposable camera flashes, or shoe mounted units, depending on the physical size and energy (guide number) rating of your broken flash. The main problem will be the number of turns on the primary. If you can match those up by adding or removing turns to your replacement, there is a good chance it will work since they all seem to have roughly the same number of secondary turns (probably around 1,600 to 2,000). Even if the primary is buried, you can still add turns on top of the secondary in the appropriate direction to adjust the total net turns. Once its running, adding or removing an additional turn or two may be needed to tweak the output voltage.

Another option is to transplant the entire inverter if one can be found that operates on the same input (battery) voltage. I've done this successfully. without problems. See "Repair Brief #100: Minox ME1 Electronic Flash for Minox B Camera - Dead" in the document: Sam's Repair Briefs - Complete: 1 to 100.

Trigger transformers: Fortunately, these are fairly standard. Just match up the input voltage and select one that has an adequate output voltage for your strobe - 4 to 5 kV for most small strobes should work. The only remaining thing that needs to be determined is the wiring polarity. While the strobe may work with either polarity of the trigger pulse, one may result in reliable operation. Electronics distributors like DigiKey and Mouser should have a suitable replacement if a garage sale or disposable camera isn't handy.

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Xenon Strobe Design

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General Strobe Circuit Design

In addition to what is covered in this document, various circuits and design guidelines are available at: Don's Xenon Flash and Strobe Page.

Among the features that may be found there are:

- How to build your own trigger coil.
- A repetitive trigger circuit.
- Various parts sources including the use of Radio Shack stuff.
- Guidelines for estimate voltages and energy levels for flashtubes.

More details can be found on Don's General Xenon Flash and Strobe Design Guidelines Page which also includes some basic design equations.

Don's site is constantly evolving so more interesting articles will likely appear in the future.

See the section: Flashlamp and Arc Lamp Manufacturers and References for links to specifications as well as externsive technical information and application/design notes.

Specifications for the 1300 series linear flashlamps can also be found in the chapter on solid state lasers in Sam's Laser FAQ.

Design of Small Strobes

Here are some general guidelines for the design of a small (5-20 W-s) battery or line operated strobe.

Most small flashlamps will operate on about 300 V (some as low as 250 - or less). If the flashlamp voltage is too low, the tube may not fire reliably or at all. If the flashlamp voltage is too high, spontaneous firing or damage and/or shortened flashlamp life due to excessive current may be the result. For power, you will need one of the following:

1. An inverter putting out about 300 VDC from your battery. Some of the cheap disposable cameras use as little as 1.5 V but don't expect too much battery life. There are zillions of simple inverter designs that will work using either discrete transistors or ICs with some minimal external components. The easiest way to obtain the inverter is to rip one out of a dead camera. Try garage sales, flea markets, thrift stores, or your Aunt Patty's attic. Typical cost for a cheap pocket camera from these sources is $.50 to $2. I don't know what your Aunt charges. Otherwise, you can build one easily. The only difficult part is finding a suitable transformer. They are easy to wind but don't expect great efficiency unless extreme care is taken in the design. For designing IC based DC-DC converters, check out companies like Maxim and Linear Technology. These generally only require minimal external components like capacitors, diodes, and an inductor or two - but often no transformers.

   WARNING: If left charging for longer than needed to get the ready light to come on, the actual voltage on the energy storage capacitor may approach 400 V with some of these cameras! Take even more care.

2. A line operated voltage doubler for 110 VAC (just a rectifier for 220 VAC). When the peak voltage of the AC line is considered, these supplies will provide about 300-320 VDC. Common 1N4005/6/7 silicon rectifiers and small (e.g., 16 uF) 250 V electrolytics can be used for the doubler. Include a surge limiting resistor of about 22 ohms in the common as well as a current limiting resistor in the output (before the energy storage capacitor) to allow the flashlamp arc to quench (e.g., 100-1000 ohms). A line fuse, power switch, and power indicator are also essential. Warning: this is a non-isolated line operated power supply - see safety guidelines. Do not connect triggering circuit directly - use capacitive or transformer coupling for safety.

The rest of the items can be basically the same with eithr power source.

1. An energy storage capacitor. A 200 uF capacitor charged to 320 V will give you 1/2*C*V*V = 10 W-s. Xenon flashlamps are rated in terms of both maximum flash energy and maximum average power (as well as others but for small strobe units - under 25 W-s or so - these are the most critical). These ratings should not be exceeded. For example, a tube rated at 20 W-s flash energy and 5 W average power could be flashed at most once every 4 seconds at a 20 W-s level or at most once every second at a 5 W-s level. Use a smaller capacitor for more frequent flashing. While photoflash rated capacitors are desirable, you should be able to get away with any good quality electrolytic for this type of modest power application. Note that the typical pocket camera flash uses a 100-400 uF capacitor and puts out quite a lot of light.

2. A trigger circuit. This is usually a HV pulse transformer into whose primary you discharge a small capacitor - .1 uF at 100 to 300 V is typical. The high voltage secondary is designed to put out 4 to 10 kV depending on flashlamp size and type. If the voltage of the trigger pulse is too low, the flashlamp may not fire or may fire erratically. If the trigger voltage is too high, there may be arcing to the flashlamp electrodes or other components resulting in possible damage. The trigger output is connected with a short wire to an electrode (wire, foil, or metal reflector) that is in close proximity to the xenon tube. The high voltage pulse ionizes the xenon gas mixture allowing the storage capacitor to discharge through it. Trigger transformers are available from places like Mouser Electronics. These can also be constructed relatively easily. See: How to build your own trigger coil. Although not very compact, a TV or monitor flyback or automotive ignition coil will also work as a trigger transformer.

   An SCR can be substituted for physical switch contacts where electronic control of the trigger is desired. For the battery powered unit, there is no issue of line isolation and the cathode of the SCR can be tied directly to the ground of your logic circuits. However, with the line operated strobe, isolation is essential for safety - use capacitor or transformer coupling, or an optoisolator.

Strobe Design Parameters

The common photographic strobe is not really designed for very short flash duration. While a typical electronic flash is much much shorter than one of those antique flash bulbs, it is still long compared to what is possible. Typical flash duration for a full power flash is under a millisecond with the range of automatic units going down to 20 microseconds or less for a minimum energy flash. One of those antique flash bulbs, on the other hand, had a flash duration of between 5 and 20 milliseconds. For most common photography, 1 millisecond or less is for all intents and purposes, instantaneous. However, if you want to freeze the blades of a rotating turbine or stop bullet in flight, even 20 microseconds is way too long.

Some of the highest speed photographs using the light source to control exposure have been taken with spark gaps operating at many kV resulting in flash durations as low as fractions of microseconds. Even higher speed photography is possible using electronic image tubes. The first instants of conventional or nuclear detonations have been captured using this type of technology.

For more information on high speed photography, see the classic works by Harold E. ("Doc") Edgerton. The following are just some general comments:

Several design parameters influence flash intensity, duration, and maximum repeat rate. However, the relationships are not linear as a flashlamp is a gas discharge device with complex nonlinear resistance characteristics. It is necessary to consult the flashlamp manufacturer's data sheets to do any detailed design.

1. Voltage. For a given energy, flash duration varies inversely with flash lamp voltage. The higher the voltage, the shorter the flash.

2. Capacitor size in uF. Total flash light output is proportional to the energy storage capacitor uF rating. However, both the peak intensity and the flash duration will increase with a larger capacitor.

3. Impedance of discharge path. Since the circuit when triggered is basically a capacitor discharging into a low impedance load, both the duration and peak intensity are affected. In addition, for higher capacity strobes especially, controlling this impedance is critical to achieving optimal light output as well as maximizing the life of the flash lamp. Excessive peak discharge current as well as reverse current due to overshoot and ringing reduces flash lamp life through damage to the electrodes. Too much instantaneous current and the flashlamp may explode.

4. Flashlamp design. The diameter, length, material, gas pressure, and electrode construction, etc. all affect the performance and power handling capabilities.

5. Cooling. Convection, forced air, and liquid (water or oil) cooling may be used. Dramatically higher average power is possible using liquid flow cooling if the flash lamp design will permit this.

Some Guidelines for Designing Small Xenon Strobes

Flashlamp manufacturers publish very detailed data sheets for their products. For high power strobe design, all this information is essential. However, when building small strobe units (under 20 W-s), my general rules-of-thumb are:

1. Use a 250 to 350 V power supply for the energy storage capacitor. Depending on your application, this can be a battery or AC adapter powered inverter, transformer/rectifier power supply, a line operated voltage doubler for 110 VAC or a simple line rectifier and filter capacitor for 220 VAC.

2. Use a trigger transformer capable of 4 to 5 kV or more pulse output. The actual output trigger pulse voltage can be controlled by the voltage on the trigger capacitor. This is usually obtained from a voltage divider off of the energy storage capacitor. Too low and it won't flash reliably. Too high and arcing to nearby components may occur.

3. Follow the flashlamp manufacturer's ratings for maximum flash energy and average power. If you ripped the flashlamp out of something like a pocket camera, limit your flash energy to that provided by the capacitor contained in the unit or 10 W-s per inch of flashlamp length if the capacitor value is unknown. Limit the average power to this maximum energy every five seconds or the actual minimum full power cycle time if this known.

4. Use a photoflash rated capacitor if available but any good quality capacitor will probably work fine. No inductor is needed for these low power applications. For a 320 V power supply, flash energy is just about 5 W-s per 100 uF of energy storage capacitor rating.

5. Keep lead lengths between the energy storage capacitor and the flashlamp reasonably short (a few inches is fine). Minimize the length of the wire from the trigger transformer and make sure that it is well insulated and not in proximity to any other components.

6. Make sure human contact with all line connected and high voltage components is impossible during operation or at any time when a charge is present on the power supply or energy storage capacitors - by packaging everything in a plastic or grounded metal box, for example.

7. Always use capacitor, transformer, or optical isolation when triggering line powered strobe units from low voltage logic circuits or anything that a human may contact. This is recommended in general as it will assure that no high power transients find their way back into sensitive electronic circuits.

8. Don't neglect the essential power switch, fuse(s), and indicator lights. For logic controlled or computerized strobes, a mechanical test button using a hard set of contacts (i.e., across the SCR) is highly desirable.

The guidelines above will adequately handle typical small to medium size strobes - perhaps to 50 W-s or so depending on the extent to which the flashlamp maximum energy specifications exceed the power input you are using and the characteristics of other circuit components.

For higher power strobes, it is essential that appropriate flashlamps are used with photoflash rated capacitors. A series inductor - matched to the flashlamp, capacitor, and voltage - is critical to preserving the life of some flashlamps (perhaps beyond one flash!) and achieving maximum flash intensity. The flashlamp manufacturer's datasheets are probably the best source of this information. Also see the section: Super High Power (Laser Pump) Strobe Circuit.

The series inductor is often needed for laser pumping applications and other applications where the quantity of energy and/or the peak current are particularly great for the size of the flashtube.

For additional design information, see the section: Flashlamp and Arc Lamp Manufacturers and References as well as the chapters on solid state lasers in Sam's Laser FAQ.

Strobe Light Output Test Circuit

(Portions from: Don Klipstein (don@misty.com).) Where you are designing a strobe requiring a specific pulse shape and/or duration, it is desirable to have a way of measuring its output. If you have an oscilloscope (almost any will do), the following can't be beat for simplicity and cost - total component complement is a green LED (hooked up backwards to act as a photodiode) and a 3.3K Ohm resistor! I assume a red or other color LED would work just as well but haven't tried one.

```
    +5 to +15 VDC o--------|<|--------+----------o Scope input
                        Green LED     |
                     (Note polarity)  /
                                      \ 3.3K
                                      /
                                      \
                                      |
           Common o-------------------+------------o Scope Ground
```

The response of this circuit is quite decent, easily showing the shape of the light pulse in strobes with pulse durations in the 10s of microseconds. Voltage is proportional to light intensity as long as it doesn't approach the value of the power supply voltage (so there is still some bias on the LED turned photodiode).

Note that even with the power supply removed and the inputs shorted together, there is a photovoltaic response to light, but it quickly saturates and may give a false indication of the shape of the light pulse.

Identifying the Cathode and Anode of the Flashtube

If there is any doubt as to the polarity of a flashtube you are using in a new design, the following will help to confirm proper direction - running a flashtube with reverse polarity will adversely affect performance and life.

(From: Don Klipstein (don@misty.com or klipstei@netaxs.com).)

1. Any red markings or "+" markings indicate the anode.

2. With no markings but electrodes of unequal size, the larger one is the cathode.

3. If both ends look identical but the trigger electrode is closer to one electrode, or more coupled to one electrode, then that electrode is the cathode.

4. If the tube looks symmetric except for having a getter at only one end, it is probably preferable to make the getter end the cathode, especially if any getter material exists on the electrode itself. Any vaporized getter metal forms positive ions easily, and will be attracted to the cathode. Metal vapor released around the anode is more likely to condense all over the tube and discolor it.

5. If both ends of the flashtube look alike except for one electrode being shinier and with rounded edges, then the shiny electrode with rounded edges is the anode, and the steel-gray (tungsten) sharply cylindrical one is the cathode.

Transformers for Low Voltage Powered Strobe Inverters

It is usually not possible to determine all parameters of the inverter transformer when reverse engineering pocket camera strobes.

(The following is from: Kevin Horton (khorton@tech.iupui.edu))

This is *always* the kicker. I have devoting heavy amounts of time into figuring out how these transformers work. They are very, very special. *nothing* else will work in their place, or if it does, it'll be woefully inefficient. They are usually .4" or so cubed, but may be larger. The gap on the core seems to be pretty critical- it limits the overall current that the circuit will draw. In one particular strobe I disassembled, they had a 100 pf cap coming from the output of the HV winding directly tied to the base of the drive transistor! I finally figured out why: it controlled the frequency vs voltage of the oscillator, hence giving it more current as it was completing a charging cycle!

I've disassembled many of these small transformers. Unlike most ferrite transformers, these are usually held together by dipping them in wax, rather than varnish. Some transformers have the primaries wound on the core, while others have it on the outside. I haven't figured out exactly why this is. However, one one transformer I took apart, the feedback and drive windings were wound on the core; bifilar. The feedback was 11 turns, while the primary was 10. Both were #24. On top of that was thousands of turns of #40 or so wire.

It seems that the small sizes play a part in the efficiency of these transformers; since the magnetic field is contained in such a small core area, the losses are small.

Comments on Voltage Multipliers

To obtain 300 VDC from the 115 VAC line requires a voltage doubler; 450 VDC requires a tripler. This also applies to the use of alternative power sources with the following caveats:

- When using a 12V to 115 VAC inverter to provide the input to voltage multiplier circuits, cheap units produce a squarewave output with 115 V peak (since the RMS and peak value of a squarewave are the same). Therefore, the circuit will take this value and multiply it by 2 or 3 (or whatever) rather than the peak of a sinusoid (which is 1.4 times greater). Thus, a tripler will be needed to obtain 300 VDC when using one of these inverters rather than a doubler in the case of normal line input.

- Driving these circuits from a gasoline powered generator should not be a problem unless its voltage becomes excessive - in which case the flashes may not be coming only from the xenon tube! Such a unit (actually probably an alternator) should produce a decent sinusoid unless it is actually a low voltage generator and inverter (as above).

There are several considerations with respect to the design of these circuits. Capacitor size (uF value and voltage rating) is the one that generally has the most impact on performance and cost.

Depending on the circuit, the required voltage rating may be anywhere from the peak of the AC waveform to the maximum output voltage of the circuit (both with a safety factor). Using the highest value will always be safe and not that expensive for modest size capacitors.

For the capacitance value:

- If too small, output power will be inadequate. Damage can even result if one or more electrolytic capacitors becomes reverse biased under heavy load.

- If too large, cost will be excessive and performance will not improve significantly beyond a certain uF value.

For a classic voltage doubler, the main consideration is the ripple (as determined by capacitor uF value and load) and what the diodes and current limiting resistor can provide. This is because the caps in this case are really just filtering opposite sides of the half wave rectifiers. (Where they are then charging another larger cap (via some isolation diodes) but no series resistance, this may get somewhat messier.)

However, for anything with more stages or stages arranged where some of the capacitors are effectively in series with the output, analysis can become interesting (translation: I am not about to attempt it here!).

In these cases, the impedance of the capacitors at the line frequency (60 Hz in the U.S.) will affect the power available before the output drops and/or has excessive ripple.

My very rough rule of thumb just treats the impedance of the capacitors like a series resistance. Then, I would select the capacitor value so that this resistance is small compared to the needs of the circuit.

A 1 uF capacitor has an impedance (magnitude) of about 2.65K ohms at 60 Hz. A 10 uF cap is 265 ohms. The 22 uF capacitors in the tripler described in the section: Higher Power Photoflash with SCR Trigger have an impedance of about 120 ohms. Consider a load of 100 W at 350 VDC (average - which would be a high power strobe indeed). The load resistance is then: R = V*V/P = 1.22 K. Since this is large compared to the capacitor impedance - even if all capacitors are assumed to be in series - I wouldn't expect very much improvement with the use of larger capacitors.

Keep in mind that this is an edge of the envelope calculation so a factor of 2 (or 20) either way is possible (and likely!).

The ESR (Effective Series Resistance) of smaller electrolytic capacitors is also higher. This may result in excessive heat dissipation in the capacitor. There is also a 'ripple current' rating for capacitors which should not be exceeded. However, if your capacitors are from Radio Shack, this particular specification is probably not available :-).

A surge limiting resistor on the line input should be provided to limit the peak current through the diodes and capacitors.

Once a particular circuit has been constructed, test it under a dummy load which simulates the expected average power. If the output voltage drops excessively and/or there is too much ripple, try increasing the capacitor uF values (not all of them may need to be changed.) Check the waveform on each capacitor with a scope (you MUST use an isolation transformer for this!). The voltage must NEVER go negative for an electrolytic capacitor. Feel the capacitors for evidence of excessive heating.

Also see the section: Voltage Doubler Design Considerations.

Voltage Doubler Design Considerations

> "I have a problem. I am using a standard voltage doubler (2 diodes, 2 capacitors) in a strobe circuit. The doubler consists of two 4.7 uF 450 V caps and two 1N4005 diodes. The timing circuit is a neon-bulb relaxation oscillator that triggers an SCR, which in turn dumps a .1 uF cap into a trigger coil to fire the flashtube. The flashtube gets a 47 uF cap discharged through it, which equals about 2.5 watt-seconds.
>
> The problem is that the 4.7 uF doubler capacitors overheat and fail! The doubler voltage is 325 volts with no load, so a 450 V rating should be adequate. Should I be using more capacitance for these?"

(From: J. M. Woodgate (jmwa@thenet.co.uk).)

Well, you really haven't given enough information. The problem is likely to be that you are exceeding the ripple current rating of the caps. I guess that you are running the neon and SCR from the doubler and your neon takes a thump of current when it fires, even if you have set the duty cycle down so that the average current is low. Higher value capacitors usually do have a higher ripple-current rating. But first you need to find how much ripple-current you are producing, and this depends on the cap. value (at least to some extent). Very roughly, the ripple current is pi times the DC current, and you should look at the load current waveform with a scope and take the maximum value as the DC value, to be sure of not over-running the capacitors.

Why the Trigger Transformer Should be Next to the Flashlamp

(Portions from: Don Klipstein (don@Misty.com).)

When constructing systems where the size of the flashhead is critical and/or where the flashhead(s) are to be remotely located relative to the controller, one might be tempted to keep all the electronics with the controller.

While the energy storage capacitor(s) can be centrally located, this is not recommended for the trigger transformers as it is the risetime or dV/dt of the high voltage pulse that ionizes the gas and any length of wire - even if it is adequately insulated - will add capacitance - a few dozen pF may prevent reliable triggering.

Generally, the best approach is to locate the trigger transformer, its capacitor and associated charging resistors, and the trigger SCR (if used) in the flashhead.

- The main tube's resistance is nonlinear and varies during the flash and is frequently as low as about an ohm.

  This determines the minimum size of the wiring between the energy storage capacitor and flashhead(s) since its resistance should be low compared to this - say .1 ohm or less. For very long runs, the wiring inductance may also be a factor.

  Care must be taken if using multiconductor cables to assure that cross coupling from the high discharge current pulse(s) doesn't result in false triggering where multiple flashheads or other circuits are involved that aren't supposed to be activated simultaneously.

- The stray capacitance over the length of a long trigger line can load down the peak voltage of the trigger pulse. Things may work better if you keep the trigger transformer close to the flashtube.

  The typical trigger capacitor is only about .022 uF. The turns ratio of the trigger transformer is often about 13-plus, and has been known to exceed 20. Divide .022 uF by the square of the turns ratio, and this is the maximum capacitive load which will probably get a majority of the normal trigger pulse voltage. So you may want the stray capacitance of the high voltage trigger line to maybe not exceed maybe 150 pF or possibly as low as 60 pF! And that is optimistically! If you run the trigger wire along other wires or close to grounded or even remotely coupled-to-ground conductive surfaces, you can get this much capacitance in just a few feet (or maybe a meter) of wire. In the unlikely event you can run the trigger wire through the middle of the air with nothing nearby, you may get OK results with a few times this distance.

  If the trigger capacitor is larger, you can get more distance without loading down the peak trigger voltage too much - but there may still be bugs! If you try increasing the trigger capacitor, you risk blowing up/out parts of the trigger circuit. And just to sometimes put the odds against you for use of a long trigger line - the stray capacitance can slow down the risetime of the trigger pulse. Sometimes fast risetime is essential for the trigger pulse to get enough peak current through the tube to make the xenon conductive enough to flash at the main voltage. Sometimes not and you may get away with things...

I really recommend keeping the trigger transformer really close to the flashtube, even if this necessitates extra wires to the flash head. And a long wire between the trigger transformer and the trigger capacitor may have enough stray inductance to mess things up - you may want to keep the entire trigger circuit close to the flashtube if it is at all feasible to do so!

Inverters in Series to Boost Voltage

As noted in the section: High Speed (Short Flash Duration) Strobes, higher voltage on the xenon flashtube will reduce flash duration, all other factors being equal.

The compact inverters in pocket and disposable cameras and externally mounted flash units will charge an energy storage capacitor to about 300 to 320 VDC. What if you need more? Yes, it is possible to wire several of these in series.

- To avoid a meltdown, the high voltage side of the inverters must be isolated (this is often not the case) or rewired to be isolated if they are to share a power source (battery pack or AC adapter).
- For the special case of just two inverters, only the node between the two energy storage capacitors must be shared.
- If run off isolated and well insulated power supplies (e.g., individual AA battery packs!), then this type of isolation doesn't matter but you better be careful what you touch!

Depending on which of these schemes is used, there could be a substantial fraction of the total output voltage between the secondary and primary of one or more of the inverter transformers. Given that these sorts of inverters are already designed to within an inch of of their lives with respect to arcing over even when used in the normal fashion, I don't know how far you can push this before the inverter transformer insulation breaks down.

The trigger circuit can be one of those associated with any of the inverters or a totally separate unit.

A Discussion of Triggering and Other Design Issues

Here is an example of what one person did using inverters in series (see the section: (Inverters in Series to Boost Voltage) and some non-conventional trigger experiments:

(Replies from: Andreas Nowatzyk (agn@acm.org) and Sam).

(From: Local Echo (localecho@aol.com).)

> "Yesterday, I hooked a small photoflash tube desoldered from a discarded photoflash unit to a power supply of 1.2 kV (Also using parts from photoflash units (I used 4 small Fuji disposables), mainly the inverters- the trigger capacitors were placed where the normal discharge capacitors were.). I noticed that at this voltage it would sometimes trigger on it's own, so I carefully adjusted things to conditions just before this happens. What's interesting is that I was able to trigger the tube with the trigger electrode (An alligator clip connected to a trigger transformer) up to 5 cm away from the center of the tube's wall. I was even able to trigger one with only 235 V across it even when the trigger pulse was

> generated from a separate circuit with no return path. (Though, the separate one was not able to trigger the tube at distances greater than .5 mm away from the tube's wall.) Also, it seems that the orientation of the trigger electrode makes a huge difference (Such as being parallel or perpendicular to the discharge path). Why is this? (I have a few ideas, but I don't wish to bias any answers.)"

(From: Sam.)

Interesting.... Realize you are running that tube at roughly 4 times its normal energy so don't be surprised if it explodes.>>

(From: Local Echo.)

> "Yes, that was one thing I was worried about so I made sure the capacitance connected to the tubes was very low (is only .0025 uF). The arc is bright, but well confined."

(From: Andreas Nowatzyk.)

The energy is = 1/2 * C * U^2, so a much smaller capacitor at a higher voltage can have less discharge energy.

(From: Sam.)

The closer the tube voltage is to its breakdown voltage, the less trigger energy you need. So, at 1.2kV, you are on the hairy edge.

(From: LocalEcho.)

> "Are the dynamics different from that of a tube not on the borderline (Such as commutation time, for instance)?"

(From: Andreas Nowatzyk.)

Yes, pulse duration will be shorter. I experimented with flash tubes from disposable cameras for the purpose of generating short light pulses. Under normal operating conditions (electrolytic capacitor at 300V), the typical pulse duration was about 5msec. With 0.05 uF at 4 kV (low inductance, HV capacitor), pulse duration is down to 0.9 us.

Unfortunately, there is a downside to short pulses: they create a shock wave inside the tube that erodes it slowly. Micro-cracks are formed and eventually the envelope shatters. The tubes from disposable cameras lasted 20 minutes on average when pulsed at 25 flashes a second (with proper cooling).

This can be avoided with a pulse forming network, typically consisting of a series inductor and a diode to avoid ringing. However, that causes much longer pulses, say 250 us.

(From: Local Echo.)

> "One other neat thing a friend noticed is that the trigger transformer isn't necessary at this point. We were able to trigger it by bridging a wire from one of the electrodes (In this case, the cathode) to the center of the tube. Eventually, the tube would become unresponsive (after about 20 or so discharges). So, still operating on the assumption that it's a capacitive effect, we used the anode connection instead. Instead of the multiple or fragmented arcs we normally saw, the discharge was very uniform (and

> occupied the entire volume of the tube). This seldom happened after that except an occasional arc of non-uniform density. This entire sequence can be repeated over and over. Also, the plasma seems to avoid the general area of the trigger electrode at times."

(From: Andreas.)

Since the trigger pulse is capacitively coupled into the tube, instabilities about the trigger arise from charge that is deposited on the surface of the fused silica envelope. Hence a larger pulse with fast rise times is desirable to minimize jitter and get a reliable trigger. Because of this problem, flash tubes for strobe applications use internal trigger electrodes and large tubes - say for pumping a laser - are triggered via a trigger pulse superimposed on the discharge voltage.

(From: Sam.)

Since the idea is to ionize the xenon gas in the tube, it orientation would be critical especially as you move further away.>>

(From: Local Echo.)

> "Which orientation would be best? (It seems to be perpendicular to the arc, but I could somehow be introducing bias.) Speaking of bias in a different sense, in certain schematics there are provisions for biasing the trigger electrode. I wish I knew more about it."

(From: Andreas.)

The trigger electrode is more effective if the capacitance between it and the plasma discharge path is maximized. Larger tubes tend to have trigger electrodes that consist of a small wire that is wrapped along most of the envelope. This provides a path for an initial discharge that is "fueled" by discharging the linear capacitor that is formed between the electrode, the silica wall and the discharge column. A DC bias generally doesn't do anything because *clean* fused silica is a good isolator. Things change when the tube is dirty or very hot.

(From: Sam.)

The fact that it isn't connected to a return is quite reasonable - with those sharp pulses, there is enough stray capacitance between the tube electrodes and your trigger circuit to create an adequate return.>>

(From: Local Echo.)

> "I thought about that and I'm assuming that is correct. Although the trigger electrode was about 5 cm away from the tube's wall, the transformer is located about 4 cm from even that. Is the capacitance still significant?"

(From: Andreas.)

Hard to tell. Under these conditions, you should take the phase of the moon into account. Basically, any electrostatic disturbance can cause the discharge, as well as natural radioactivity: A tube that is run very close to its breakdown voltage becomes a crude Geiger-counter and can trigger by any change in the electrostatic environment. Note that the breakdown voltage will change a lot depending on the tube temperature, the charge that has accumulated on the envelope from prior discharges and erosion of sharp features of the electrodes of a new tube. For example, a new tube from a disposable camera can trigger a 2 kV. After running it for a while, you may find that it needs 5 kV.

Adjustable Energy Strobes

Automatic flashes using quench tubes and thyristors have been discussed elsewhere. Modifying a commercial automatic flash to provide adjustable flash output/duration may be as simple covering the sensor (e.g., putting it on manual mode) and installing a variable resistor across the sensor. The resistor value and other Details would depend on the particular model.

But what about providing fixed, but selectable, flash energies? Over a range of perhaps 2:1 to 4:1 in flash energy, the input voltage to the flashlamp can be used to control flash energy. This range would be between the minimum voltage specification for the flashlamp and the self-triggering spec. However, this range can be extended by simply having a small fixed capacitor (call it C1) to maintain the required voltage for reliable triggering of the flashlamp backed by a much larger capacitor (or capacitor bank, call it C2) whose voltage can be varied to control the flash energy. The two capacitors are separated by a high current diode. Once triggered, C1 provides the initial discharge current to the lamp. As the voltage drops, current starts flowing from C2 and continues to do so until the voltage on the flashlamp drops below the maintaining voltage (usually about 50 V) with no inductance in the circuit. This simple approach can work over a very wide range of repeatable flash energies. There are only two catches:

- One is the high current diode required between C1 and C2 to allow C1 to charge to a higher voltage than C2 (from a separate supply feed). Peak flashlamp current will be several hundred AMPS and the diode needs to handle this without exploding. However, diodes with single cycle peak currents in this range aren't unusual or particularly expensive.

- The other is that as with any scheme where the flashlamp peak current changes with flash energy, the color temperature of the flash will also vary being somewhat more yellow at low energies and somewhat more blue at higher energies.

Integrated Circuits for Strobe Chargers

Although most of the circuits shown here and used in electronic flash and strobe circuits have used discrete components for the high voltage generation, it is, of course possible to apply many of the literally hundreds of switchmode power supply ICs to this task. As these, and the required support components, come down in price, the elegantly simple designs of the past will probably disappear.

For example, see the Linear Technology Design Note 303: Photoflash Capacitor Charger with Automatic Refresh. This uses the LT3420, an IC designed specifically for photoflash applications, in a simple flyback converter to charge capacitors to 320 V from a 1.8 to 10 VDC source. While the lowest input voltage is too high for operation on a single cell battery and requires 2.5 to 5 VDC source for the chip itself, it would be suitable for most pocket camera applications. Digital control of charging is built in.

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Special Design Considerations

Techniques for Boosting the Repetition Rate of Small Strobes

Cycle time on commercial electronic flash units is typically 1 to 10 seconds depending on design and the battery's state of charge. How can this be improved without overstressing the circuitry?

Without redesigning the inverter circuit for higher power and using a larger flashtube, the only variable you have to play with is the size of the energy storage capacitor:

- Cycle/charge time will be proportional to its uF rating.

- Flash energy will be proportional to its uF rating.

- Light output will be proportional to flash energy.

- Perceived brightness will be a sub-linear function (not a proportional one) of flash energy. A simple approximation is flash energy raised to the .5 power (square root).

Thus, depending on your needs, reducing flash energy may still result in adequate brightness. For example, cutting the uF rating of the energy storage capacitor to 1/4th of its original value will still result in about 1/2 the perceived brightness (not 1/4 the brightness). An easy way to do this is to put two identical flash caps in series (no equalizing resistors are needed). However, if you need the same intensity (i.e., to use the same F-stop), then the distance between the flash and the subject will have to be reduced by half in this case

Since power dissipation is still limited by the inverter, the flashtube should not overheat. The only concern is that the trigger capacitor has enough time to charge up - check its time constant and reduce its charging resistor if necessary to assure that the voltage on the trigger capacitor is high enough (close to what it would be for the unmodified circuit).

What you DON'T want to do is use a higher voltage on the input. That would almost certainly blow the inverter transistor (either immediately or from overheating) and/or the transformer, energy storage capacitor, or flashtube.

Where reducing the size of the energy storage capacitor is not adequate, here are some guidelines for more extensive redesign:

(From: Don Klipstein (don@misty.com or klipstei@netaxs.com).)

1. For faster flash rates, you want lower energy levels to avoid overheating the flashtube. The smaller U-shaped tubes may take about 5 watts of average power at faster flash rates, and about 4 watts at really fast flash rates. This means you probably want a flash energy under 1 W-s. The efficiency is also lower at lower energy levels, giving you more heat and less light. With lower energy levels (under about 2 W-s or so with a smaller U-shaped tube), the tube works better with unusually high voltages near or even above 400 volts. You would also use less capacitance, to get your desired flash energy with a higher voltage. You will probably have better flash extinguishing with more voltage and less capacitance.

2. Add an inductor in series with the power feed into the energy storage capacitor. This makes the capacitor hardly recharge at all for a few milliseconds, allowing the flashtube to extinguish.

   A 15 watt fluorescent lamp choke ballast will probably work for this. This goes in series with the power feed to the capacitor, not in series with the flashtube. CAUTION: This inductor may cause a voltage overshoot of the energy storage capacitor - probably to your favor if the capacitor can take the extra voltage.

   By my quick calculations, such a choke is order of 1 to 2 Henries of inductance so you could use an actual inductor if you have one handy. You won't beat the price though - a 15 W ballast is about $3.

Use two capacitors, with the inductor between their positive terminals, if the power feed requires a capacitor load. The first capacitor can be the larger value original energy storage capacitor. The second capacitor will be the low uF value one used for flashing, and will need to withstand extra voltage.

Caution: While it may be possible to totally eliminate (or greatly reduce size of) the series resistor in if you use an inductor, there is a chance of a meltdown if for some reason the arc didn't quench as might happen if the flashtube overheated - an inductor eventually looks like a short circuit to the power line while a resistor still has resistance :-). Make sure you have it fused!

For a typical variable rate stroboscope circuit, see the section: Welch Scientific Model 2153C Stroboscope.

Due to the drop in efficiency, trying to use this approach to create a continuous-appearing light source isn't worthwhile. It is easy to reduce the energy to a level that is safe to repeat 60 times a second, but a usual cheap glass flashtube will not be especially bright - almost certainly dimmer than a halogen lamp consuming the same amount of power. There may also be a slight "flicker" effect from the discharge being "sparklike" instead of uniformly filling the tube, and taking a different path through the tube on each flash.

High Speed (Short Flash Duration) Strobes

The typical integrated or camera mounted electronic flash unit has a flash duration of under 1 ms at full power. This is short compared to a flash bulb and adequate for most common photographic applications. However, when attempting to freeze high speed machinery or other rapid action, this may be way too long.

All other factors being equal, flash duration is roughly proportional to the size - uF rating - of the energy storage capacitor.

Where lower flash energy is acceptable and/or the strobe can be moved closer to the subject and/or faster film can be used, the normal energy storage capacitor in your electronic flash can be replaced with one that is smaller. Flash duration and energy will then be reduced in proportion to the ratio of the capacitor's uF ratings.

Using a higher voltage will enable the uF rating of the capacitor to be decreased and still achieve the same total light output - the required uF (and flash duration) goes down as 1 / (V * V). Of course, since the same energy is involved, the physical size of the capacitor doesn't change much. There is no free lunch :-).

For example, the typical small electronic flash unit uses a capacitor voltage of about 300 V. Designing a strobe with a 3 kV energy storage capacitor will permit its uF rating and flash duration to be cut by a factor of 100!

High voltage flashtubes and capacitors must be used but the basic principles of operation of these strobes are unchanged. Power to charge the capacitors can be provided by a line operated transformer or high frequency inverter either directly using a rectifier or doubler, or diode-capacitor voltage multiplier. For ideas, see the chapters on helium neon lasers in Sam's Laser FAQ as the operating voltage requirements for HeNe lasers are similar. Where fast cycle time is not critical or your required flash energy is modest, one of the sample circuits may be acceptable.

Those pictures of bullets in flight were likely made with air spark gap light sources with 10s of kV on the energy storage capacitors resulting in flash durations in the microsecond range.

Lengthening the Duration of a Flash

If you long for the blur of a real flash bulb, this may be for you!

In some cases, simply adding an inductor in series with the flash tube can provide some increase in flash duration. However, where you want 20 ms instead of less than 1 ms, this is not going to work. If the inductor is too small it won't do much of anything. Once it starts to have an effect, the effect will be to simply cut off the flash.

What should work better (and I have not tried this) is to add a high current constant current driver between the capacitor and the tube. For example, assuming a small flash with say 500 uF at 300 V results in roughly a 200 A peak current assuming a 1 ms flash duration. This is an equivalent resistance of about 1.5 ohms! To extend the flash duration to 20 ms requires dropping the current to 10 A.

One way to do this is with a constant current series regulator set for 10A:

```
                +-------+         R1
  +300 o---+----|-    |-|---------/\/\------+-----------+
           |    +-------+         1         |           |
           |       FL1                      |           |
 Main      |                           +-----------+     |
 Energy + _|_ C1                       | Constant  |   +_|_ C2
 Storage  --- 500uF                    | Current   |    --- 10uF
 Capacitor |  350V                     | Regulator |   - |  350V
           |                           +-----------+     |
           |                                |           |
           |                                |           |
Return o---+--------------------------------+-----------+
```

The use of a high frequency switchmode (buck) converter will almost certainly be necessary unless you have some really HUGE transistors floating around in your junk box. The problem isn't the voltage or current rating - a common BUT12A would meet these requirements - but rather maximum power and SOA (Safe Operating Region). Peak power dissipation in a linear regulator would be about 2,500 W!

C1 provides a sink for the flash tube current until the regulator can start up. It may be necessary to play with their values to achieve reliable operation. An alternative is to bias the transistor from a separate power source prior to triggering.

Also see the section: Driving Continuous Output Xenon Arc Lamps.

Details are left as an exercise for the student :-).

Another alternative that may be adequate for some applications is to split the single high intensity short duration flash normally provided by a standard strobe circuit into multiple lower energy flashes spread over a longer time.

As a starting point, consider the schematic of an energy conserving flash like the unit described in the section: Vivitar Auto/Thyristor 292 Energy Conserving Automatic Flash. Bypass the light sensor to control flash intensity directly. I guestimate that on a single charge of the energy storage capacitor, you should be able to get 10 or so short flashes spread over, say, 20 ms, at 50 percent efficiency. Depending on your needs, the discrete nature of these multiple flashes may be a problem - or a feature :-).

Driving Continuous Output Xenon Arc Lamps

These approaches can probably be applied to regular xenon flash lamps as well. See the section: Lengthening the Duration of a Flash.

(From: (macy@global.california.com).)

Take a look at the Xenon arc tubes made by ILC of Sunnyvale which is used in lighting those invasive tiny little arterial cameras. The light comes from a xenon arc tube and is transferred down the arteries via fiber optics.

I believe ILC used to provide these tubes on the open market (may still be) through Edmund Scientific, but they were too difficult for the general hobbyists and the market was zilch.

As I recall, they fire at around 300-400 volts and then the arc sustains at something like 20 volts 10-20 Amps or such. The drivers for these consist of the lower voltage high power drive with a transformer winding in series with the output lead (capable of the high current). The high voltage would "spark plug" the arc until it fired, then the low power supply sustained the arc producing *very* bright, pure light.

You could make such a driver where a lower voltage cap stores horrendous energy and use a "tickler" drive to fire the arc. Probably even get away with using the shorter duration arc you now have.

This tube is made for constant high power. The arc electrodes are mounted inside a cylinder shape about 1 1/4 inch diameter by 1 1/2 inch length. The electrodes are mounted along the axis of the cylinder with a parabola reflecting cup and tripod mounting of the outgoing electrode (to not block the light much)

The whole thing is clamped for heat exchange and electrical contact.

Originally, the "bulb" was used for headlights on tanks because they survive shock so well. [I'd heard some guy put a row on top his 4 W sport and when he turned them on, he could see 2 miles down the road. - makes a good story but I can't confirm it.]

Sometime in the 70's I met the man at Eimac (division of Varian) who invented the tube and he was looking for other applications. He had mounted it inside a 16mm projector to make a brighter, cooler light source. You could actually freeze the frame without having to dim because there was so little infrared in the light energy.

It is bright. I saw a movie being projected overhead on a 16 foot screen in a drafting room and you could watch the movie easily! Plus the colors made for a beautiful rendition of the film.

He saw this as a great potential market, until ..well the tube's light is so potent that it makes ozone and the ozone would "eat" up the aluminum parts on the projectors in 2 to 6 months. so that idea died.

At least it finally found its way into a very useful application - medical.

Strobe Design for Multiple Flashing

These are often seen in safety related applications - warning lights, for example, where a typical cycle might be two flashes .2 seconds apart with a .8 second dead time.

Here is one approach to designing a strobe that will double (or multiple) flash from a battery powered inverter of limited capacity.

Charge a large buffer storage capacitor from the DC-DC converter, then have its output feed a smaller flash energy storage capacitor through a resistor small enough to give you a fast recharge but large enough to allow the flashlamp arc to quench.

Building the DC-DC converter is pretty easy and you should be able to make it run off of a battery without any problem. You can use a simple power oscillator feeding a home-wound step-up transformer. With the energy buffer, the inverter only needs to satisfy the average power requirements of the multi-flash cycle. See the section: General Strobe Circuit Design.

For example, a small unit using a 100 uF 330 V capacitor for the flash could use a 1000 uF cap. for buffer storage separated by a 250 ohm power resistor. That would provide a 100 ms or so cycle time. The 1000 uF cap provides a reservoir between the relatively low power DC-DC converter and the tube as long as you do not flash too quickly - faster than your DC-DC converter can keep up.

This should be much easier than trying to interrupt the 10s-100s of amperes of current flowing in the tube during the flash.

Strobe Systems with Multiple Flashheads

Have you seen the 'new' ball used for the New Year's celebration on top of the tower in Times Square? Is uses something like 144 computer controlled xenon lamps. Sort of gives you something to strive for!

Several approaches can be taken in designing such systems depending on the needs:

- If only one flashlamp is to fire at any given time, a single energy storage capacitor can be shared by multiple flashlamps assuming the distance between it and any flashlamp is not excessive (probablyless than a couple of feet).

- Where multiple flashlamps may fire in an arbitrary sequence (but the average rate is known), each flashlamp can be connected to its own energy storage capacitor fed through a current limiting resistor from one high capacity power supply.

- If the maximum rate for each flashlamp is known, each head can have have its own independent inverter. For example, the flash units from disposable pocket cameras can be modified with beefed up heatsinks for the chopper transistor, suitably sized energy storage capacitors, and remote triggering capability.

Hybrid systems using a combination of these techniques are also possible.

In all cases, each flashlamp must have its own trigger transformer and it should be mounted in the flashhead near the xenon tube. See the section: Why the Trigger Transformer Should be Next to the Flashlamp.

An optoisolated SCR can then be controlled from a logic level signal - the output of a PC's parallel port or a dedicated bus. For long runs, use Schmitt Trigger gates or differential line drivers/receivers to prevent false triggering due to interference from the high voltage and high current pulses associated with each flashlamp's firing.

Multiple Xenon Tubes in Series/Parallel

For some applications, it might be desirable to use a bunch of small xenon tubes rather than a single large one. This might be the case if you happened to inherit a bucket load of someone's excess inventory. :) Or, the physical constraints of whatever you are building are better satisfied with many small tubes. This could be a single series string, a single parallel arrangement, or a parallel set of series strings.

Of course, it might be possible to use individual flash heads (e.g., from disposable cameras) each with their own electronics. However, sharing a single large energy storage capacitor and trigger circuit could be much more compact, efficient, and cost effective.

For series connections, the voltages add so you will need the energy storage capacitor to charge to n times the individual flashtube ratings (typically around 300 V for camera flashes). Problems with this approach are that with the higher voltage, peaks currents can be much higher than with normal designs and some means may be needed (e.g., series inductor) to limit this.

For parallel connections, the voltage is unchanged but some means must be provided to equalize the currents among the tubes. This usually means some low value resistors in series with each tube or series string of tubes. Since they are have a negative resistance, the tube that triggers earliest may end up with all the current and explode! Also, triggering must be 100 percent reliable else the tubes that end up triggering will see all the current and likewise, may be damaged or destroyed.

In both cases, a much larger trigger transformer or multiple trigger units will be needed. An automotive ignition coil might be appropriate for the single trigger approach.

I would try to avoid these sorts of setups unless there is no other choice. With the parallel one, in particular, too many things can go wrong and power will be wasted in the equalizing resistors.

Strobe Voltage Considerations

There are a variety of issues that determine the selection of the voltage used across the flashtube. Here are just a few:

(Portions from: Don Klipstein (don@misty.com or klipstei@netaxs.com).)

1. Other factors being equal, higher voltage results in shorter flash duration for a given energy.

2. Higher voltage should be very slightly more efficient since there is a fairly constant voltage left on the capacitor after the flash unless an actual pulse forming network (including inductance) is included to fully discharge through the lamp. For a typical small flashtube, this is about 50 V.

3. The length (and other characteristics) of the flashtube determines the maximum voltage before it will self-trigger. Thus, size and cost of compact flash units are limiting factors.

4. Higher voltage energy storage capacitors (above 450 to 500 V) must be made from multiple lower voltage caps in series with equalizing components. This adds complexity and cost, and decreases reliability.

5. Another factor to consider: Internal resistance of the capacitors. Typically, this becomes significant with flash durations shorter than a millisecond. Internal resistance is usually less with axial lead electrolytics such as Sprague's TVA series than with "radial" lead electrolytics.

6. Higher voltage results in a slightly higher color temperature and usually disfavors the major bunch of IR spectral lines around 820 to 1000 nm. Disfavoring these lines results in higher efficiency.

7. Any given flashtube has a minimum capacitance to get a good continuous spectrum. Lower capacitance results in a line spectrum unless the voltage is too low for good efficiency anyway. This "critical capacitance" is not a sharp limit, but does not seem to vary with voltage.

8. There is some upper limit to voltage, since exceeding some combination of peak power and total energy causes some of the flashtube wall to vaporize. This is called "wall ablation". I will have to dig out some of my still-packed literature to find out (numerically) what this limit is.

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Nifty Strobe Circuits and Notes

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Converting a Pocket Camera Strobe into a Repeating Strobe

The little inverter in those units cannot put out enough power to charge the normal energy storage capacitor any faster. It is quite easy to replace the inverter with a voltage doubler off the AC line (with a current limiting resistor! Warning: non-isolated power supply). Using a smaller energy storage capacitor would also permit a much higher flash rate at reduced brightness and this would prolong the life of the flashtube as well.

With too high a repetition rate at high power, the problem is heat dissipation in the tube. Above a flash rate of once every couple of seconds, your poor little tube will degrade fairly quickly and it may not turn off properly as well due to overheating of the electrodes.

It will probably be necessary to use an SCR instead of a set of switch contacts to allow triggering from a 555 timer or other logic level input. For a basic constant frequency strobe, a relaxation oscillator using a unijunction transistor or neon lamp, an astable multivibrator built from a couple of general purpose transistors, or a counter operated from the AC line zero crossings or a crystal oscillator would be perfectly adequate.

However, a very simple repeating trigger can be made from a motor driven cam operated microswitch. Using a variable speed motor would implement a basic adjustable frequency stroboscope with no additional electronic components.

For a simple electronic modification:

(From: William "Chops" Westfield (billw@cisco.com).)

> "In fact, some types of disposable (or other) camera electronic flash units can be converted to repetitive flashers (not quite a strobe, but useful as a safety-beacon sort of thing) by connecting a couple neon bulbs or a 130 V (or better) 'Sidac' or diac across the existing trigger contacts. This is a nice trivial modification."

The resistance of the trigger capacitor charging circuit will affect the repetition rate and the RC time constant must be long enough for the main energy storage capacitor to charge to a high enough voltage for the xenon tube to fire reliably. Details are left to the student :-).

However, I wonder about flashtube life if the original energy storage capacitor is used. So, you might want to replace it with a smaller one if adequate for your needs.

In any case, if you retain the inverter, use an AC adapter or other power supply instead of batteries for testing at least. Otherwise, let me know which battery company's stock I should buy!

I've added the following little circuit to a Kodak MAX type disposable flash after replacing the original 160 uF energy storage capacitor (C2) with a 5 uF, 400 V motor run type (5 uF was selected because I had that value in my junk box).

It's obviously not nearly as bright as the original (1/36th the energy) but is quite adequate for attention getting, a safety beacon, etc. The repetition rate is adjustable from about 1 to 5 flashes per second with the component values shown. Many variations are possible.

Please refer to the Kodak MAX Flash Unit Schematic for connection information.

```
                                                   Top terminal of S2
                R4                                                o
    C2- o----+----/\/\-----+                                    __|__ Q4
             |    470K     |                     IL2            _\/\_ L601E3
             |             /      R7          R8    +---+      / |    600V
             |          R5 \<---/\/\---+----/\/\---|o o|----'  |    1A
             |          2M /     10M    |     220    +---+        |
          -_|_ C2          \            |            NE2          |
           ---  5uF         |            |                         |
          + |   400V        /          _|_ C4                      |
             |          R6 \           ---  .05uF                  |
             |        1.2M /            |   400V                   |
             |             \            |                          |
             |             |            |                          |
    C2+ o----+-------------+-----------+------------------------+
```

This forms a relaxation oscillator using the NE2 neon lamp as the trigger device. If you have higher value resistors, C4 could be reduced to a smaller uF value to get the same flash rate. A somewhat higher repeat rate may be possible. Without modifying any other parts of the Kodak MAX circuit, the charge button (S1) has to be pressed to start the unit. Where the flash rate is at least 1 Hz, S1 can be the original momentary pushbutton. However, if you want a slower flash rate, there is enough leakage to to cause the voltage on the trigger circuit to decrease too much between flashes (recall the much smaller C2 resulting in a proportionally shorter time constant) so the flashing may stop. Higher value resistors for R4, R5, and R6 would help, or replacing S1 with a toggle switch will force the inverter to run as needed to top off the charge (but will help eat more batteries in the process!).

It may be necessary to experiment with component values since at low speed, the circuit as shown is critically dependent on the breakdown voltage of the neon lamp (about 90 V for an NE2). To increase the time constant of the decay of the C2 voltage between flashes, the 3.9M resistor (R3) feeding the ready light (IL1) can be removed. This results in slightly more overshoot when the inverter charges C2 but it appears to be within safe limits. The ready light then only comes on for a second or so when the inverter cuts off and the decay of C2 voltage between flashes is only dependent on component leakage and the resistance of your external circuit.

CAUTION: DO NOT remove IL1 itself and note that the end of R3 connected to D2 also acts as a via on the printed circuit board and must NOT be removed (or a wire should be put in its place). Else, there is no regulation and the voltage probably climbs to a point where something explodes. :(

So, to implement this enhancement on a Kodak MAX type flash (most others are quite similar):

1. After discharging the existing energy storage capacitor, C2 (!!), remove it and attach red and black wires to its positive and negative pads.

2. Solder a different color wire to the solder pad of S2 which goes to the trigger transformer.

3. Solder a remote on/off switch in place of or in parallel with S1. For flash rates of less than 1 Hz, a momentary switch can be used - to start, press and hold until the first flash occurs. Stop by removing power. Else, short across S1 and use a separate SPST switch to control power.

4. Construct the circuit above on a piece of perforated or prototyping board and attach the C2+, C2-, and S2 wires. CAUTION: Note polarity - for the Kodak MAX design, common is positive (red) on the HV side.

At 1 or 2 flashes per second, the inverter transistor gets warm but not hot after a few minutes using 5 uF for C2. At higher rates, it does get rather toasty - a clip-on heatsink would be advisable. The flashlamp should tolerate an average power of a few watts - with 5 uF for C2, it is a only about 1.25 W at 5 Hz. I don't know about long term reliability of the overall system or how much larger C2 can be made while running at the same speed.

If you have a handy source of low voltage DC, you could use a real 555 timer to trigger the Triac and not have to deal with multi-megaohm resistors! For other options for inverter control and triggering, see the section: Digital Control of the Kodak MAX Flash Unit.

For an even simpler modification resulting in a fixed-rate repeating strobe, see Don's Hack Kodak MAX to Strobe Page. To make this variable, replace R2 with a series combination of a fixed resistor (to limit current) and a pot for speed adjustment. As above, for faster repeat rates, the uF rating of the main energy storage cap will need to be reduced.

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Repeating Strobe Trigger Generators

Here are two simple circuits for generating a continuously repeating strobe trigger.

It is assumed that the power supply and xenon tube can handle the average power requirements for the minimum desired cycle time.

Inadequate energy storage capacitor charging power will result in erratic or reduced intensity flashing. Excessive heating caused by too high a repeat rate may lead to damage to circuit components and/or the flashlamp or may result in the arc not quenching properly between flashes.

Inadequate trigger charging power (RC time constant too long) will result in missed or erratic triggering.

Repeating Trigger Using 555 Timer

This is a common 555 timer operated in astable mode. For a detailed description of the circuit operation, see the 555 timer datasheet any databook which includes the 555 timer chip.

Component values have been selected to cover a range of about 1 to 10 seconds between flashes.

```
                                              +---+
                                              |    V  R1
```

```
    Vcc o---+----------------+---+---------+-/\/\--+
    (+5 to  |                |   |          200K  |
   +15 VDC) |                |   |                 /
            |         +------|---|------+          \ R2
           _|_ C3     |      |8  |4     |          / 5K
           --- .1 uF  |   +---------+   |          \
            |         |  2| VCC  R  |3  |          |
            |   +-----+---|TRG     Q|--------------|--------o Trigger-N
            |   |         |   U1    |7  |          |  (Negative going pulse)
            |  _|_ C1     |  555 DIS|--------------+
            |  --- 100   5|         |6  |    R4    |
            |   |  uF +---|CV  G THR|---+---/\/\---+
            |   |    _|_  +---------+       5K
            |   |    --- C2    |1
            |   |     | .01 uF |
    GND o---+---+-----+--------+
```

Trigger-N can drive an optoisolator (LED cathode, anode via current limiting resistor to Vcc), can be capacitively coupled to SCR gate (fire on rising edge), put through pulse transformer, etc.

Repeating Trigger Using Neon Tube (Indicator Lamp)

This is a simple relaxation oscillator using a common NE2 neon indicator lamp. As drawn, the repeat rate should be adjustable from about 0.1 to 10 Hz. Adjust component values for your particular needs. (Note: use of audio taper potentiometer would help to linearize the adjustment range.)

```
                           +---+
                  R1    R2 V   |
   +150 VDC o----/\/\----/\/\/-+----+--------+                +------o Out+
                  50K     20M       |        |                |
                                    |       +++               |
                                    |       |o| NT1           |
                                    |       |o| NE2         __|__ SCR1
                                    |       +++             _\_/_ TIC106D
                                    |        |    C2*       / |   400V,6A
                                  +_|_ C1    +----||---+---'  |
                                   ___ 2 uF  |  .01 uF |      |
                                  - |        /   400 V /      | (To trigger
                                    |        \ R3      \ R4   |  capacitor/
                                    |        / 10K     / 1K   |  transformer)
                                    |        \         \      |
                                    |        |    C3*  |      |
     Return o-----------------------+--------+----||---+------+------o Out-
                                                .01 uF
                                                 400 V
```

Relaxation Oscillator Operation

The neon indicator, NT1, is a negative resistance device. It becomes conductive when the voltage across it exceeds about 90 V but then only requires about 60 V to maintain conduction. This circuit has an RC network formed by R1, R2, and C1. C1 charges through R1 and the repeat rate adjustment potentiometer, R2. When its voltage exceeds the NE2 breakdown voltage, C1 discharges through NT1 resulting on a pulse on R3 coupled by C2 to the gate of SCR1. The SCR fires and discharges the trigger capacitor (not shown) into the trigger transformer of the strobe firing circuit.

Once the voltage across NT1 has decreased below about 60 V, it turns off and the cycle repeats. Since the voltage across NT1 is swinging between about 60 and 90 V (out of 150 VDC total), the repeat frequency should be between 4 and 5 times 1/(RC). It is assumed that SCR1 (Out+/-) takes the place of the shutter contacts, is the SCR, or in parallel with the SCR shown in the strobe circuits shown elsewhere in this document.

For other values of VPP between about 100 and 300 V, adjust resistance values appropriately.

Note that C3* and C4* are essential to provide safety isolation for line powered strobes.

Please note that the characteristics of neon lamps sometimes change with age, temperature, and use. The SCR should have a sensitive gate since some neon lamps do not reliably conduct more than a few milliamps when they ionize in a relaxation oscillator.

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Optoisolated Remote Trigger from low Voltage Logic or Signal

Here is a circuit for an optoisolated trigger interface. This will permit control of line-connected (non-isolated) strobes from logic or other lower voltage signals. This is probably the safest way to deal with the isolation and safety issues as the insulation resistance of typical optoisolators is several kV (7.5 kV for the specific part shown). Also see the next section for a specific application of a similar circuit.

Another important reason to consider this approach is to assure reliable triggering in an electrically noisy environment. Such interference may be external (e.g., power cables, digital busses) or internal. Even where there are only two flashtubes, the current pulse when one of these fires could falsely trigger the other. Minimizing the length of sensitive trigger wiring and low pass filtering the trigger signals (i.e., RCs on the input to the SCR) will help. However, the best way to prevent false triggering is to use light rather than electrical signals to trigger the flash heads. Instead of running long wires with low level signals, use individual fiber optic cables for each channel between its LED and photodetector (rather than an opto-isolator) in the circuit below. Such a design will even be immune to the EMP resulting from a nuclear blast - should you care :-).

This basic design would be suitable for a wide variety of applications requiring microprocessor, PIC, or PC control. A multiheaded strobe pulsing to a musical beat (high power color organ) could be implemented by triggering several strobe units from an audio amp's speaker output via audio filters of various cutoff or bandpass frequencies.

```
                          VPP
                           o
                           |
```

```
                                         \ R3
                                         / VPP.GT.10V: R3~=(1K x VPP)-5K.
(+5 to +10 V)                            \ VPP.LT.10V: R3=1K, R4 not needed.
IN1 (DC) o------+                        /
            C1  |   R1                   |
IN2 (AC) o--||--+--/\/\--+-------+       +-------+-----+       +----o Out+
          .01 uF|  220   |       | OPTO1 |       |  C2 | 1 uF  |
                |        |    +--|-------|-+     /   +_|_      |
                \      __|__  |__|__   |/ C|  R4 \    ___    __|__ SCR1
             R2 /   D1 _/_\_  |_\_/_-> |   |  5K /   - |     _\_/_ TIC106D
             1K \ 1N4148 |    |  |     |\ E|     |     |     / |   400V,6A
                |        |    +--|-------|-+     +-----+    |  |
                |        |       |PC713V |       |          |  |
      GND o-----+--------+-------+  Typ. +-------|-----+----+  | (To trigger
                                                 |     |    |  |  capacitor/
                                                 |  R5 \ C3_|_ |  transformer)
                                                 |  1K /   --- |
                                                 |     \ 100|  |
                                                 |     | pF |  |
                                                 +-----+----+--+----o Out-
```

Optoisolated Remote Trigger Operation

The input signal may be DC coupled resulting is a high level triggering the strobe or AC coupled resulting in a positive edge trigger. R1 provides current limiting to the optoisolator's LED and R2 minimizes any possibility of electrical noise turning on the optoisolator. Change the values of R1 and R2 for a different input voltage range. D2 provides reverse voltage protection for the LED.

For VPP greater than 10 V, the voltage divider formed by R3 and R4 charges C2 to about 5 V. This is the most common case where VPP is derived from the strobe power supply and is typically 300 V. The time constant for this RC network is under 5 ms so it will not affect high speed repeat operation. C2 assures that there will be enough current from the optoisolator to trigger SCR1 even with the high value resistor which may be used for R3 to minimize power dissipation with a large VPP. For a VPP of less than 10 V, the circuit can be simplified to just a current limiting resistor (leave out R4).

When current flows through OPTO1's LED, it turns on the phototransistor which allows C2 to discharge into the gate of SCR1 which is connected to the trigger capacitor and transformer of the flashlamp firing circuit (not shown).

To minimize the possibility of false triggering, locate the optoisolator circuit in close proximity to the SCR. R5 and C3 are included to reduce the SCR's sensitivity to any electrical noise pickup as well.

VPP must be a positive DC voltage referenced to the terminal Out-. In most cases, this will be the energy storage capacitor's positive terminal. Adapter Circuit for Low Voltage Camera to High Voltage Flash

Optoisolated Adapter for Older Flash Units to Low Voltage Cameras

(From: Brian L. Zimmerman (blz@home.com).)

Many electronic flash units can have a very high voltage between the trigger contacts that are shorted to trigger the flash. For example, the trigger voltage of the "Digi-Slave" DSF-1s flash unit being sold in 2001 for use with digital cameras (See for example, Slave Flash Products) measures 218 V fully charged. This would be dangerous to use on many modern electronic cameras such as Canon digital cameras which specify no more than 6 V.

This design adapts such a high voltage flash for use on a low voltage camera by using an optocoupler to electronically isolate the camera's contacts from the high voltage. It can then be triggered by the camera using the 6 volt supply from the flash unit's batteries, but also works at a lower voltage. The use of a triac optocoupler has the added advantages of using fewer parts than other optocoupler designs and can use the power from the flash's trigger circuit to fire the SCR switch instead of a separate power source.

The adapter circuit can be inserted into the lines inside the flash unit going between the flash trigger circuit and the flash unit's contacts as shown below. Since there are only 4 small parts in this circuit, there is a good chance that you can build it right into the available space inside the flash unit's case.

(WARNING: High voltage precautions apply here - be sure to safely discharge all capacitors!)

System connections

```
              o--------------------- | ----------------------- (+)
   Flash hot-shoe contacts           |                Flash trigger circuit
              o--------------------- | ----------------------- (-)
                                    \|/
                               Cut and insert
                           adapter circuit below
```

Flash adapter schematic

```
                  +---------------------+      R2
 (-) o-----------(1)---+         +-----(6)----/\/\----+----o Flash Trigger (+)
                  |    |  OPTO1  |      |     5.6K    |A
 To Hot-Shoe      |  __|__   ____|____  |           __|__
 (and camera)     |  _\_/_-> _\_/_/_\_ (5)NC        _\_/_   SCR1
                  |    |         |      |           / |     400V,6A
 (+) o---+   +---(2)---+         |      |          |G | K   (RS#276-1020)
         |   | NC(3)             +-----(4)---------+  |
         /   |    +---------------------+             |
     R1  \   |          Optotriac                     +----o Flash Trigger (-)
    330  /   |           MOC3010
         \   |         (RS#276-134)
         |   |
         o   o
        (+) (-)
   To 6V Battery (Flash unit battery pack)
```

Parts list

1. SCR1: SCR, 400V, 6A, (RS#276-1020, $1.29, TIC106D, etc.).
2. OPTO1: Triac optocoupler (MOC3010, RS#276-134, $1.99)
3. R1: 330 ohm Resistor.
4. R2: 5.6k ohm Resistor.

RS# indicates Radio Shack part numbers. Total cost (October, 2001) is $3.75.

Operation

The camera shutter shorts the hot-shoe contacts, causing current to flow from the 6V battery through the IR-emitting diode at pins 1 & 2 of the OptoTriac. The current is transferred via light pulse which switches on the triac at pins 4 and 6 of the OptoTriac which is powered by the voltage from the flash trigger circuit. Current flows into the gate of the SCR, switching it on and causing discharge of the flash trigger through the anode and cathode of the SCR. The 330 ohm resistor (R1) limits the current through the hot-shoe to about 18 mA, and the 5.6k ohm resistor (R2) limits the current through the triac to about 40 mA. You may need to use a different value for R2 for your particular flash and SCR, since this is based on a 218 V trigger voltage. The triac can handle a larger current (1.2 A peak), but SCR's typically only use a small gate current for triggering.

Note

The circuit with component values shown seems to work reliably (at least so far) for this particular combination of Canon digital camera and slave flash. Others may be quite different. Some info can be found at Kevin Bjorke's: Non-Canon Strobe Page with a List of Trigger Voltages. Just knowing the trigger voltage isn't really enough information as it doesn't imply anything about the available current. Adding an input buffer using a transistor or CMOS gate would eliminate this as a concern.

SCRs and triacs should be driven hard when they are controlling high current sources to make sure they turn on quickly and minimize time where they are passing significant current with a significant voltage drop. The optotriac's output is current limited so this isn't much of an issue. However, the SCR discharges the trigger capacitor through the trigger transformer and this could amount to several A switched in a few microseconds. A gate current 10 to 20 times the minimum spec in the datasheet is recommended so long as this doesn't exceed the maximum rating in the datasheet. In any case, the worst that will happen is that the SCR will fail or become unreliable after running with marginal gate drive - no great loss considering its cost.

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Optically Activated Strobe Circuits

Light Beam Triggered Strobe Circuit

Here, the intention is to trigger a strobe should a light beam be interrupted or completed. Any of the electronic flash schematics can be modified for this purpose. This approach can also be used to implement a slave flash. However, for such a high intensity application, a Light Activated SCR (LASCR) would be suitable and result in a simpler circuit (as in 1 component). However, LASCRs may be harder to find.

Any light source with sufficient spectral content for the selected photodiode can be used to generate the beam including an incandescent lamp, visible or IR (light) emitting diode (LED/IR LED/IRED), or a visible or IR laser diode. A small convex lens will greatly increase the range of any of these light sources. For a slave flash trigger aimed at the main flash, a lens may or may not be needed depending on the energy of the main flash and its distance from the sensor.

The circuit below should work for the detector. Its output may need to be put through one (light beam completed or slave flash) or two (light beam interrupted) inverting Schmitt Trigger gates (e.g., 74LS14) to clean up its output and provide the proper polarity. It should be AC coupled to the gate of an SCR. The SCR will substitute for the camera's X-sync contacts and fire the strobe. Note that if this is a line operated unit, capacitor (or transformer) coupling is essential for providing the very important line isolation barrier absolutely required for safety.

For the case where the strobe is supposed to fire when the light beam is interrupted, when the light beam is unbroken, the photodiode is illuminated providing current to keep the transistor on and its output is low. When the beam is broken, the output goes high, is cleaned up by the Schmitt Trigger gates creating a rising edge to provide a pulse to trigger the SCR.

Any common IR or visible photodiode can be used for PD1. Sources include optoisolators, photosensors from dead VCRs, and optomechanical computer mice. IR photodiodes are usually sensitive to visible light and vice-versa so it may not be necessary to match source and detector precisely.

```
        Vcc o-------+---------+
                    |         |                               +------o Out+
                    \         \                               |
                    / R1      /  R3                           |
                    \ 3.3K    \  470 (1 or 2 Schmitt        __|__ SCR1
                    /         /       Trigger Gates)        _\_/_ TIC106D
                    |         |   +-----+    +-----+   C1     /|   400V,6A
                  __|__       +---| ST1 |----| ST2 |---||---' |
  Light beam ---> _/_\_    Q1 |   +-----+    +-----+ .001 uF  |
               PD1  |     B |/ C                      600 V   |
                    +-------|  2N3904                         | (To trigger
                    |       |\ E                              |  capacitor/
                    \         |                               |  transformer)
                    / R2      |                               |
                    \ 27K     |                               |
                    |         |                        C2     |
                    +---------+------------------------||-----+------o Out-
                   _|_                               .001 uF
                    -                                 600 V
```

Notes on Light Beam Triggered Strobe Circuit

1. CAUTION: Capacitors provide needed isolation barrier for line connected electronic flash units. Make sure they have adequate specifications.

2. For detecting a light beam being completed or for use as a slave flash trigger, logical inversion is needed. Therefore, use an inverting Schmitt Trigger or a single 74LS14 inverter.

3. For detecting a light beam being interrupted, no inversion is needed. Therefore, use a non-inverting Schmitt Trigger or a pair of 74LS14 inverters in series.

Simple Slave Flash Triggering

Here are a pair of really simple approaches to firing a slave flash unit from the light output of a master flash:

(From: David T Bupp (dtbradio@dtbradio.com).)

Here's one idea that I've used quite successfully to make a slave flash: Take a miniature (or standard-size if desired) green or yellow LED, and mount it directly into the front of the existing camera flash unit (I mounted mine at the lower right corner of the plastic cover plate by drilling a tiny hole just big enough to fit the body of the LED up to the flange). I then coupled the positive side of the LED to the base lead of a general purpose NPN transistor, and coupled the negative side of the LED to the emitter lead of the transistor. I used the transistor in an inverting full-on/full-off switch configuration with a 1K resistor from my positive supply (5-12 VDC) to the collector lead. I then used the collector lead to trigger the timing cycle on a 555 monostable timer circuit set for 1 ms pulse output, and coupled that pulse output into a triac-based opto-coupler and a separate triac to fire the strobe's trigger transformer when a flash was detected on the camera's built-in flash unit. Although the setup is rudimentary at best, it works very well, and has been quite reliable as far as triggering goes.

(From: Gordon Couger (gcouger@provalue.net).)

I used one solar cell and one triac (or SCR) to create a slave flash that works great indoors. The solar cell positive output simply drives the gate of the triac directly. The triac is used in place of the shutter contacts. No batteries required. :)

Some solar cells and some flash units may need current limiting resistors, and bypass capacitors are a must. But I was annoyed and in a hurry. Adding an RC network to drive the triac may be needed to prevent triggering from ambient illumination in some cases.

Additional comments at: Quick and VERY DIRTY Slave Flash for CoolPix 995.

Triggering a Slave Flash from a Dual Flash Camera

Many newer cameras (film and digital) activate the flash twice for each picture; once for red-eye reduction (which may or may not actually use the electronic flash itself) and the second time to take the shot. Where it is desired to use a slave fill flash, it may fire uselessly on the first burst of light. However, there is an easy solution if the slave can be electronically triggered. Use the trailing edge of the light pulse (the positive edge of the output at ST2 in the circuit above) to trigger a monostable whose output is low-ANDed (the NOR gate shown below) with its input. The output of the NOR gate can trigger the SCR as shown or drive an opto-SCR or opto-triac to trigger the slave flash. The first flash won't get through because the monostable won't be activated until it goes away. Select the pulse width for the monostable to be longer than the time between the dual flashes.

```
                            C       R
                          +-||-+---/\/\---o Vcc
                          |    |
          __   ___   __  +------+
  +-----+  |_|   |_|    |     Q| ____
```

```
 | ST2 |------+---------|>    _|     |_________   _____        _
 +-----+   P1 |  P2     |     Q|---------------o|     \  ______| |___
              |         +------+               | NOR   )--------------o Trig
              +--------------------------------o|_____/
```

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Kevin's Super Strobomatic

(The following is from: Kevin Horton (khorton@tech.iupui.edu))

I'm building a super strobe bar! It has 8 strobe tubes under computer control. (Actually a PIC processor, but hey, computer is a computer. I have all the stuff done except the control section, and I only have 2 of the 8 strobe units done due to the fact that I haven't found any more cheap cameras at the thrift store! (One Saturday morning's worth of garage sales and flea markets would remedy that! --- sam).

It runs on 12 V, at up to 6 A, and can fire the tubes at a rate of about 8-10 times per second. The storage cap is a 210 uf, 330 V model; it gets to about 250 V to 300 V before firing; depending on how long it has had to charge. Because of this high speed, the tubes get shall we say, a little warm. (Well, maybe a lot warm --- sam). I have it set up at the moment driving two alternating 5 W-s tubes. I'm pumping them quite a bit too hard, as the electrodes start to glow after oh, about 5 seconds or so of continuous use. I know, a high class problem, indeed! My final assembly will have 8 tubes spaced about 8 inches apart on a 2x4, with a Plexiglass U-shaped enclosure with a nice 12 V fan blowing air through one end of the channel to cool the inverter and the tubes. Stay tuned.

The following schematics provide some details of this design:

- Inverter - High power 12 V to 300 V inverter for high repeat rate medium power strobes: inverter.gif.
- Trigger - Opto-isolated logic level trigger for general electronic flash and strobe applications: trigger.gif.

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Tiny Tiny Inverter Design

(The following is from: Kevin Horton (khorton@tech.iupui.edu))

I have developed a cool little transformer circuit that seems to be very efficient. I built this inverter as tiny as I could make it. It runs off of 3V, and charges up a little 1 uf 250V cap all the way up in about 30 seconds; drawing about 5 to 8 mA in the process. The numbers by the windings tell the number of turns. The primary and feedback windings are #28, while the secondary is #46. Yes, #46! (Apparently, you can buy wire down (up?) to size #60 - less than .000350 inches in diameter! Check out MWS Wire Industries if you are really curious about fine wire.) I could hardly tell what gauge it was being almost too small to measure with my micrometer! It may have bee #44 or #45, but at these sizes, who knows? I used a trigger transformer for the wire. I used all the wire on it, to be exact; it all *just* fit on the little bobbin. The primary went on the core first, then the secondary, and finally the feedback winding. This order is very important. I used a ferrite bobbin and corresponding ferrite 'ring' that fit on it. The whole shebang was less than 1 cm in diameter, and about 3-5 mm high! I gave it a coat of wax to seal things up, and made the inverter circuit with surface-mount parts, which I then waxed onto the top. There are two wires in, and two wires out. It's enough to run a neon fairly brightly at 1.2 V, with a 3 ma current draw.

```
Vcc o----+--------------+ T1
         |            6T )::
         \           #28 ):: +-------o HV output
      R1 /               )::(
     47K \           +---+ ::(
         /  2N4401   |     ::(
         |        |/ C     ::(  450T
         |     +--|   Q1   ::(  #46
         |     |  |\ E     ::(
         |     |     |     ::(
         +--+  +---------+ ::(
         |  |        |17T )::(
     C1 _|_ |        |#28 ):: +-------o HV return
 .001 uF --- |        |    )::
         |  +-----------+
         |           |
Gnd o----+----------+
```

This schematic is also available as: teeny.gif.

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Super Simple Inverter

This circuit will generate over 400 VDC from a 12 VDC, 2.5 A power supply or an auto or marine battery. While size, weight, and efficiency are nothing to write home about - in fact, they are quite pitiful - all components are readily available (even from Radio Shack) and construction is very straightforward. No custom coils or transformers are required. If wired correctly, it will work.

Output depends on input voltage. Adjust for your application. With the component values given, it will generate over 400 V from a 12 V supply and charge a 200 uF capacitor to 300 V in under 5 seconds.

```
                    C1 1 uF                  D2 1N4948   R2
                 +------||------+        T1    1.2kV PRV  1K 1W
                 |              |           +-----|>|-----/\/\---+------o +
                 | R1 4.7K, 1W  |   red   ||( blk                 |
                 +-----/\/\-----+------+ ||(                      |
                 |                  yel )||(                    +_|_ C2
  + o----------------------------------+ ||(                     --- 300 uF
```

```
                |                  red )||(                 - |  450 V
                |     +-------------+ ||(                     |
                |  Q1  |              ||( blk                 |
6 to 12         |    |/ C               +---------------------+------o -
VDC, 2A         +----|    2N3055    Stancor P-6134
            D1 _|_   |\ E           117 V Primary (blk-blk)
        1N4007 /_\     |            6.3 VCT Secondary (red-yel-red)
                |      |
 - o------------+------+
```

Notes on Super Simple Inverter

1. Construction can take any convenient form - perf board, minibox, etc. Make sure the output connections are well insulated.

2. C1 must be nonpolarized type - not an electrolytic.

3. D1 provides a return path for the base drive and prevents significant reverse voltage on the B-E junction. Any 1 A or greater silicon diode should be fine.

4. C2 is shown as typical energy storage capacitor for strobe applications.

5. D2 should be a high speed (fast recovery) rectifier. However, for testing, a 1N4007 should work well enough. R2 limits surge current through D2.

6. The polarity of the input with respect to the output leads is important. Select for maximum voltage by interchanging the black output wires.

7. Mount Q1 (2N3055) on a heat sink if continuous operation is desired. It will get warm. Any general purpose NPN power transistor should work. For PNP types, reverse the the polarities of the power supply and D1, and interchange one set of leads.

8. Some experimentation with component values may improve performance for your application.

9. When testing, use a variable power supply so you get a feel for how much output voltage is produced for each input voltage. Component values are not critical but behavior under varying input/output voltage and load conditions will be affected by R1 and C1 (and the gain of your particular transistor).

10. WARNING: Output is high voltage and dangerous even without large energy storage capacitor. With one, it can be lethal. Take appropriate precautions.

11. For your less intense applications, a fluorescent lamp can be powered directly from the secondary (without any other components) in place of a flash lamp! This works reasonably well with a T5-13W or T8-15W bulb but Q1 does get quite hot so use a good heat sink.

12.
```
      |                          |           |
   ---+--- are connected;     ---|--- and ------- are NOT connected.
      |                          |           |
```

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Ultra-Compact 350 V Capacitor Charger

This pair of circuits, shown in Ultra-Compact 350 V Capacitor Charger, is based on the inverter transformer found in the flash units from disposable pocket cameras. They use only 4 required components in addition to the transformer, battery, and energy storage capacitor. See Photo of Ultra-Compact 350 V Capacitor Charger for an example of the compact construction (shown sitting on a U.S. dime). While not quite the simplest possible design, the inverter transformer only needs to have drive and HV output windings, no feedback winding or tap. Thus, it is likely that the transformer from almost any pocket camera flash unit can be used, or one can be relatively easily constructed. See the section: "Ultra-Compact 350 V Capacitor Charger" in the document: Various Schematics and Diagrams for more details.

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Radio Shack Low Power Strobe

This circuit was printed on the back of the Radio Shack trigger coil blister pack. It is suitable for various stroboscopic, signaling, engine timing, scientific, and other similar (relatively) low intensity applications.

The power supply for this strobe can be either a voltage doubler operating from the AC line (caution - no isolation) or a battery powered inverter. An isolated SCR trigger circuit can be easily substituted for the firing button. See the sample circuits elsewhere in this document.

(Original schematic provided by Robert Bullock (robert_bullock@pobox.tbe.com).)

```
           R1
  +V o----/\/\-----+-----------+---------------------+
        250 ohm    |           |                    +|
           2W      |        R2 /                    _|_
                   |       47K \   Fire button     | | |
                   |     1/2 W /   S1             ||   |
                   |           |  _|_    Trigger  ||   | Flashlamp
                   |           +--- ---+   T1 +---||   | FL1
                   |           |       |   ::(    ||   | RS 272-1145
                   |       C2 _|_     +-+  ::( 4  || _ |
                   | .0022 uF ---         )::( K   |_|_|
              C1 +_|_   400 V  |          )::( V     |
      2 to 20 uF  ---          |          )::(      -|
           400 V - |           +---------+    +-+    |
                   |           |    RS 272-1146 |    |
                   |        R3 /                |    |
                   |      150K \                |    |
```

```
                   |     1/2 W /              |    |
                   |           |              |    |
 Gnd o-------------+-----------+----------------+----+
```

Applied Voltage (+V): 200 to 300 VDC

Parts list:

C1 - Energy storage capacitor. 2 to 20 uF, 400 V.
C2 - Trigger capacitor. 0.0022 uF, 400 V.
R1 - 250 ohm 2 W.
R2 - 47K ohm 1\2 W.
R3 - 150K OHM 1\2 W.
S1 - Firing switch. SPST momentary pushbutton.
T1 - Trigger coil (transformer), 4 kV, Radio Shack 272-1146.
FL1 - Flashlamp, Radio Shack 272-1145.

Note: I could not find the trigger coil (RS part number 272-1146) in the latest Radio Shack Catalog - the flashlamp was there - so I do not know if it is still available from them. However, I don't see any reason why R2 and R3 cannot be combined into one resistor (at R2's location - 200K, 1W) permitting the use of a trigger transformer with a single terminal for the drive and HV return (more common) should the one from Radio Shack be unavailable.

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Digital Control of the Kodak MAX Flash Unit

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Description of MAX Modifications

Additional circuitry has been added to permit digital (e.g., TTL, CMOS, PIC, etc.) control of the Kodak MAX flash unit (see the section: Photoflash Circuit from Kodak Disposable 35mm Pocket Camera 2. This allows these dirt cheap or free flash units to be used for all sorts of other applications.

While it may be possible to construct the additional circuitry on the original MAX circuit board (there is quite a bit of free space), for my prototype, I added a mezzanine board held in place with an insulating treaded spacer. Even so, I ended up adding a few parts (like the triac and its drive components) to the back of the PCB. The battery clips were also removed and an external battery holder was added. However, for testing, I used the power supply described in the section: "1.5 V Alkaline Cell Eliminator" in the document: Various Schematics and Diagrams. The total cost of the modifications is about $2 (most of this being for the triac).

Note that for the simplified case of just trigger the MAX or similar flash unit electronically, the triac and associated components would easily fit on the existing circuit board. For instructions on disassembling Kodak MAX cameras, see Don's Hack Kodak MAX to Strobe Page.

Modified MAX I/O Specifications

Here are descriptions of the control and status signals:

- OPR-H: This logic signal controls the inverter:
  - RUN: (TTL High, 2 to 5 V) -> Inverter starts and runs but may be overridden by the OFF signal or built-in 300 V limiter.
  - CRUISE: (Open, Hi-Z or Tri-Stated) -> No Change. Inverter will continue running or remain off as determined by previous state. Note: The unit will also automatically recharge if fired with OPR open or tri-stated and Switching from OFF to CRUISE seems to start up the inverter - a high value resistor to ground may inhibit this 'feature'.)
  - STOP: (TTL Low, 0 to .4 V) -> Inverter stops. Note: Low must be .4 V or less while sinking 15 mA to guarantee off. Use OFF-H to force shutdown if your driving logic can't handle this.
- OFF-H: This logic signal disables the inverter regardless of state of OPR.
- FIRE-P: This pulse signal will trigger the flash on either edge with a sufficiently powerful driver (assuming the energy storage capacitor is charged). The driving output must be able to sink or source at least 15 mA to guarantee reliable firing (depending on whether you want a negative or positive or either edge trigger In order to prevent possible damage to the triac, Q6, it is important that this line be driven hard so assure that Q6 is never turned only partially on. A diode (D10) can be added in series with the gate of appropriate direction to select which edge is used for triggering. For testing, I just substituted a jumper for D10.
- READY-L: This output can be used as either a digital indication of full charge or an analog monitor of the energy storage capacitor (C1) voltage in the approximate range of 305 to 310 VDC.
  - As a digital status signal, READY goes low when the voltage on C1 reaches about 310 V. READY will remain active for a couple of seconds after the inverter cuts out. Therefore, to assure full charge, the inverter should be turned on prior to triggering flash until READY becomes active. Or, leave OPR active and the inverter will run every few seconds for a fraction of a second to maintain full charge.

    Note: READY changes relatively slowly - it does not have a sharp edge. If this is a problem for the type of logic being used for control, READY should be buffered with a Schmitt Trigger gate (e.g., 74LS14).

- As an analog feedback signal, READY actually tracks C1's voltage between roughly 305 and 310 VDC (READY goes from 5 V to 0 V over this range). Therefore, if precise control of the flash energy is desired, READY can be fed to an A/D or voltage comparator. The voltage on C1 can then be trimmed by pulsing OPR.

Modified MAX Circuit Operation

Please refer to the Modified MAX Flash Unit Schematic for the following discussion.

WARNING: The energy storage capacitor, C1, will retain a potentially lethal charge for quite a while. The time constant is greater than 6 minutes (via neon ready light, IL1, and 3.9M resistor, R8) down to about 200 V. Below this voltage (when IL1 turns off), there is essentially no discharge path other than the very small leakage of C1 and Q6. Take care!

The circuit changes were designed to take advantage of the way the MAX operated as part of the camera and to minimize rework to its printed circuit board. Where a new board is to be fabbed, the latter is not an issue but it turned out that this approach was still more-or-less optimal. See the section: Modified MAX PCB Layout.

Operation of the OPR signal for RUN and CRUISE is analogous to the original charge push-button of the MAX camera: A TTL high is the same as pressing the button while OPEN is like releasing the button. The addition of a diode (D8) allows a solid TTL low or ground to such enough current out of the drive circuit to kill inverter oscillation.

The OFF signal drives the base of Q5 which similarly shorts out the drive to stop oscillation.

The FIRE signal is capacitively coupled to the gate of the triac, Q6, to discharge the trigger capacitor, C3. This is exactly analogous to the way the original shutter contacts worked.

An additional circuit, very similar to that of the 300 V limiter, was added for the READY status signal. Its input is derived from the energy storage capacitor through the same high voltage neon bulb (IL1) and zener (ZD2) so it turns on at around 300 V. It was found necessary to add a sneak path prevention diode, D9, to block voltage making its way in from the TTL supply and restarting the inverter even if OPR was open.

Clamp diodes have been included on all signal lines. This is sort of insurance to prevent any glitch pulses generated at the time the flash is triggered from feeding back to the logic. I do not know if these are really needed at any time but 1N4148s are cheap enough!

Modified MAX Options and Precautions

The original MAX flash design charges C1 to slightly over 310 V based on the combination of the 110 V zener (ZD1) and the 200 V neon ready light (IL1). IL1 can be replaced with a zener diode if desired to change this value. However, I wouldn't recommend going too much higher without also using a C1 of greater voltage rating. The inverter itself will top out at about 350 VDC on C1 (with a nominal 1.5 V input) but its transformer may fail if pushed by more than even a small amount. Who knows? :)

As noted, with OPR set HIGH, the inverter will run as needed to maintain full charge. This means a few tenths of a second burst every few seconds. If R3, the load resistor for the Ready light (IL1), were removed, the charge would decay even slower. However, I am not sure of the implications for regulation without IL1 - the neon bulb would actually go off and on which may represent substantial hysteresis. However, this scheme should definitely work if IL1 were replaced with a 200 V zener.

Modified MAX Test Circuit

To test the modified MAX, I made up a simple set of switches and used a hex inverter (7404) for input buffers and to drive a the READY LED.

- OPR-H: SPDT center off toggle switch selecting +5 (RUN), open (CRUISE), or Gnd (STOP).
- OFF-H: Pushbutton to Gnd (with pullup) buffered by inverter.
- FIRE-P: Pushbutton to Gnd (with pullup) buffered by inverter.
- READY-L: Two inverters in series drive LED through 220 ohm resistor to +5.

For a more 'high-tech' approach, use a PIC or the parallel port of your PC.

Modified MAX PCB Layout

A printed circuit board layout is also available. The entire double sided circuit board is 2.2" x 1.6". Power can be provided by the built-in AA size battery holder (which may be removed by snapping along the score lines) or via an external 1.5 V power supply.

The layout may be viewed as a GIF file (draft quality) as: mmaxpcb.gif.

A complete PCB artwork package may be downloaded in standard (full resolution 1:1) Gerber PCB format (zipped) as: mmaxgrb.zip.

The Gerber files include the solder side copper, soldermask, top silkscreen, component side copper, and drill control artwork. The original printed circuit board CAD files and netlist (in Tango PCB format) are provided so that the circuit layout can be modified or imported to another system if desired. (Note: I don't guarantee that the parts *values* in the Tango PCB file are accurate - go by the schematic.) The text file 'mmax.doc' (in mmaxgrb.zip) describes the file contents in more detail.

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Retrofitting Older Cameras for Electronic Flash

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Whatever Happened to All Those Flashbulbs?

In what some would call 'the good old days', it was common to carry around a bag full of flashbulbs to provide photographic illumination. These were a pain to use, resulted in disposal issues, and were somewhat hazardous when used 'according the label directions' - exploding flash bulbs were common.

Of course, in the truly good old days, they had those exposed palettes with flash powder. They were really good at starting fires....

Individual flashbulbs were single use sources of light containing a wad of fine magnesium (or other active metal) wool with an electric or mechanical trigger. These produced an intense white light of relatively long duration (perhaps 40 ms as compared to 1 ms or less for an electronic flash).

With the march of technology individual flash bulbs gave way to to flashcubes, flashbars, and other multi-use source of light (at least for the weekend camera bug - the professional photographer still needed the higher power of individual bulbs),

While the electronic flash has been used professionally for at least 40 years, it is only within the last 10 years or so that all but the least expensive camera comes with a built-in electronic flash as standard equipment.

However, some people still would like to continue to use their older equipment for which no low cost electronic flash upgrade may exist. The information in this chapter is directed toward these die-hards. While written specifically for replacement of the Polaroid SX-70 Flashbar, little or no modification should be needed to interface to nearly any camera or lamp holder originally designed for electrically triggered flash bulbs.

The remainder of this chapter is based on material from: George Holderied (holderied@ubaclu.unibas.ch).) His web page: The Hacker's Guide to the SX-70 provides all sorts of useful information including more details on the flashbar retrofit described below.

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Flashbar Eliminator for SX-70 Polaroid Cameras

I have built a flashbar eliminator. It works fine with my Polaroid SX-70. As they stop selling flashbars in the US, it may be interesting for Polaroid fans to build an interface for common electronic flashes.

The flashbar contains five glass bulbs on each side that are filled with magnesium wool in an oxygen atmosphere. The magnesium is ignited by an electric pulse. The glass bulbs are plastic coated to prevent them from exploding. There is also an outer plastic wall which is another safety shield and corrects the light color.

The flashbar is contacted from the front (active) side.

```
+-----------------------------+
|   A    A    A    A    A     |
|   1    2    3    4    5     |  <- Flashbulbs
|   U    U    U    U    U     |
+-----------------------------+
          H123456                 <- Contacts
```

The wider contact (H) to the left shorts two contacts in the camera to indicate the presence of a flashbar. Contacts 1, 2 and 3 go each to one side of the bulbs 1, 2 and 3. Contact 4 is the common contact that goes to one side of each bulb. Contacts 5 and 6 go each to one side of the bulbs 5 and 6.

The flashbar wiring is shown below:

```
(4)o---+-----+-----+-----+------+
       |     |     |     |      |
     (B1)  (B2)  (B3)  (B4)   (B5)
       |     |     |     |      |
       |     |     |     |      |
      (1)   (2)   (3)   (5)    (6)
```

There are no electronics in the flashbar. The camera knows which bulb has been fired by measuring the resistance across the bulb. A good bulb has a resistance of a couple of ohms whereas a dead one has almost infinite resistance.

Replacing a Flashbar with an Electronic Flash

There are several reasons to use an electronic flash instead of the flashbars:

- Flashbars cost about US$4 and are becoming harder to obtain.
- They end up in the garbage.
- Bulb flashes, due to their longer duration, cause a dark spot in your field of view if looked into, that lasts for several minutes.

You can easily find cheap electronic flashes that replace flashbars.

A used one should not cost more than two flashbars. However, if you already have an electronic flash that you want to use instead of the bars, you need an interface.

Flashbars have a fixed light output that reaches to a distance of about 3 meters (10 feet). The SX-70 exposure control is based on the focused distance. The camera's maximal aperture (f-stop) is 8. It is recommended to use an electronic flash with the same light output as a flashbar. That flash would have a guide number of 75 (9,5 feet * 8), or a metric Leitzahl of ca. 25 (3.2 meters * 8) at 150 ASA.

Flashbar Eliminator Interface

A flashbar-compatible camera outputs an electric pulse of about 4V at 1.5A. However, an electronic flash has a voltage of about 250 V between the trigger contacts that are shorted to trigger the flash.

The interface is based on the general optoisolated remote trigger from a low voltage logic or signal. See the section: [Optoisolated Remote Trigger from Low Voltage Logic or Signal].

Flashbar Eliminator Schematic

```
                            +-----------------------+-------o Flash Trigger (+)
                            |                       |
                            \                       |A
                            / 1M                  __|__ Thyristor
                            \                     _\_/_ TIC106D
                            |                     / |   400V,6A
                      +-----+-------+          G |  |K
          22          |     |       |            |  |
(4) o--+-/\/--+       |    _|_.     | 2.2uf      |  |
       |      |       |   '/_\     _|_           |  |
       \    __|__   |/ C    |      ---           |  |
   3.5 /    _\_/_ ->|       | Z6.3  |            |  |
       \      |     |\ E    |       |            |  |
       |      |       |     +-------+------------|--+
(3) o--+------+       +-----------------+--------+  |
                                        |        |  |
             Optocoupler                /       _|_ |
              4N33 typ.              1K \ 100pF --- |
                                        /        |  |
                                        |        |  |
                                        +--------+--+-------o Flash trigger (-)
```

Flashbar Eliminator Operation

The 3.5 Ohm resistor tells the camera that there is a unused flashbulb in between the contacts 4 and 3. The 22 ohm resistor limits the current through the coupler's LED.

On the output side an electrolytic cap (2.2 uF) is charged from the flash's trigger voltage to 6.3 V. This voltage is limited by a zener diode. When triggered, the coupler's phototransistor discharges the capacitor into the thyristor's gate and fires the thyristor and thus the flash.

The whole circuit easily fits into an empty flashbar.

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Schematics for Pocket Camera and Externally Mounted Compact Flash Units

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General Description of Battery Powered Flash Units

These range from the tiny units inside pocket camers to larger, more powerful hot shoe or remotely mounted units. They all run on battery power and some also operate from the AC line. (See the section: Flash Circuits from Disposable or 'Single Use' Cameras for an introduction to those types specifically.)

The typical power input is between 2.4 V (from a pair of NiCd cells) to 6 V from 4 AA Alkalines or a Lithium battery. The DC-DC inverter produces around 300 VDC using some form of a blocking oscillator forward or flyback converter. High performance units include automatic exposure (external or TTL - Through The Lens). Some are quite sophisticated with microcomputer control. Since the only source of schematics I know of for these things is by reverse engineering the circuits, don't expect to see too many of the fancy variety in this chapter as these very quickly become too complicated and difficult to trace. There IS a limit as to how far I will go :-). However, contributions are always welcome!

If you are going to be experimenting with any of these in a serious way, I would recommend constructing a power supply to replace the batteries as their appetite for power is quite large. See the section: "1.5 V Alkaline Cell Eliminator" in the document: Various Schematics and Diagrams for a suitable circuit (just a transformer/rectifier/filter/IC regulator) since this basic design can easily be modified for whatever voltage is needed.

Here are some additional comments:

(From: Malcolm Watts (M.J.Watts@massey.ac.nz).)

I was browsing through this circuit collection when I came across the disposable camera flash circuits. I *think* from what I read that some areas of operation are still a bit of a mystery to some. Some years ago, I analyzed such circuits and have the following comments which you may find useful.

The inverter is basically a forward converter. As noted, it delivers energy to the capacitor on the power stroke. Note that the cap charging current is also the transistor base current and this gives it a power-on- demand characteristic. The inverter will not operate if the pri:sec turns ratio of the transformer is such that the base current is reduced below that which causes the transistor to go into saturation. In other words, the step-up ratio of the circuit is beta-limited. I should stress that the term "beta" is used loosely since the transistor current gain varies with collector current. Using a darlington to boost the transistor current gain is not an option in the low voltage supply version since the output stage of a Darlington cannot saturate and is limited by a B-E drop which subtracts from the battery voltage and wastes power with the high primary current demand. The best transistors to use are those with as low a Vcesat as you can find and also have as high a current gain as possible. See the section: Malcohm's Flashgun Charger for info and schematics of a relatively fast charging unit I built awhile ago.

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Flash Units from Cheap Pocket Cameras

Photoflash Circuit from Keystone Pocket Camera

This schematic was traced from an electronic flash unit removed from an inexpensive pocket camera, a Keystone model XR308. Other Keystone models are similar. Errors in transcription are possible.

Note that the ready light is not in the usual place monitoring the energy storage capacitor voltage. It operates on the principle that once nearly full charge is reached and the inverter is not being heavily loaded, enough drive voltage is available from an auxiliary winding on the inverter transformer to light the LED. It is also interesting that the trigger circuit dumps charge into the trigger capacitor instead of the other way around but the effect is the same.

```
           Inverter                                                  Flashtube
      +-----------------------------+---------------------+--+--------+---+
      |       1 K     Ready LED      |            S1 Power |  |        |   |
      |   +--/\/\-----+--|<|-----+   |           ______ On |  +-+ T2 +-+   |
 BT1  _   |    R1     |  IL1     |   |          |      \___|     )::(      |
 3 V ___  |    +------|--/\/\/---+   | C1       |    __ Off      )::(     +|FL1
2-AA  _   | ::(2 .4   |  R2 10       | Energy   |   |            )::(     _|_
     ___  | :: +-------------+       | Storage  |   +-------+---+ ::(    | | |
      |   | ::(5 .2   |      |      +|  280 uF  |           |     ::(   ||   |
      +---+ :: +------+      |     __|__ 330 V  | S2 Fire -|      ::(   ||   |
      |     ::(1      |      |     _____        | (Shutter) |        +--||   |
      +---+ ::(       |  C3  |       |          |     +-----+   Trigger ||   |
          3)::( 142  -|47 uF |      -|          |     |     |           || _ |
       <.1 )::(      _|_ 6.3 |       |          |  R1 \    _|_  C2       |_|_|
           )::(      ___  V  |       |          |  1M /    --- .02 uF      |
        +-+    +-+    |      |       |          |     \     |   400 V     -|
       C| 4 T1 6 |   +|      |       |          |     /     |              |
     B|/         |    |      |  D1   |          |     |     |              |
   +--| 2SD879   +--------------|<|--+----------------+-----+--------------+
   |  |\  Q1          |      | HV Rect.         |
   |   E|             |      |                  |
   |    +-------------+------|------------------+
   |                         |
   +-------------------------+
```

Keystone Everflash Flash Operation

1. The inverter boosts the battery voltage to about 300 V. This is rectified by D1 and charges the energy storage capacitor, C1.

2. The LED, IL1, signals ready by once C1 is nearly fully charged.

3. Pressing the shutter closes S2 which charges C2 from C1 through T2 generating a high voltage pulse (4 to 5 kV) which ionizes the xenon gas in the flashlamp, FL1.

4. The energy storage capacitor discharges through the flashlamp.

Keystone Everflash Flash Notes

1. The inverter transformer winding resistances measured with a Radio Shack DMM. Primary resistance was below .1 ohms.

2.
```
       |                          |           |
   ---+--- are connected;    ---|--- and ------- are NOT connected.
       |                          |           |
```

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Photoflash Circuit from Kodak Pocket Camera

This schematic was traced from an electronic flash unit removed from an inexpensive Kodak pocket camera, specifically an Ektralite 10 (uses size 110 film, remember that?). Errors in transcription are possible:

- Kodak Ektralite 10 Camera Flash Unit in GIF format.

Designs similar to this are used by a wide variety of small photoflash units.

Note that the chopper transistor for this particular model is a PNP *germanium* type! This tells you something about the age of this thing!

Kodak Ektralite 10 Flash Operation

1. The inverter boosts the battery voltage to about 300 V. This is rectified by D1 and charges the energy storage capacitor, C2.
2. The trigger capacitor, C3, charges through R3 and T2.
3. The neon bulb, IL1, signals ready by flashing at about 6 Hz.
4. Pressing the shutter closes S2 which discharges C3 through T2 generating a high voltage pulse (4 to 5 kV) which ionizes the xenon gas in the flashlamp, FL1.
5. The energy storage capacitor discharges through the flashlamp.

Kodak Ektralite 10 Flash Notes

1. Transistor was unmarked but ECG12 should be a suitable choice.
2. Resistances of T1 measured with Radio Shack DMM.
3. The power switch, S1, disconnects both the supply to the inverter and the return for the trigger to prevent accidental triggering with power off.
4.
```
       |                          |           |
   ---+--- are connected;    ---|--- and ------- are NOT connected.
```

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Flash Circuits from Disposable or 'Single Use' Cameras

For between $8 (basic model) and $16 (with electronic flash) these cameras pack quite a bit of technology into a package that you can take to the beach without worrying about expensive photo gear. And, they take remarkably good pictures (considering) for something make mostly of plastic including the lens.

The manufacturers like Kodak call them 'single use' cameras. I am calling them 'disposables' since this is what very often happens as the recycling incentives are not high enough and many/most are simply discarded - which is great for the experimenter since it is often possible to obtain the complete camera (minus aunt Sally's baby pictures) free for the asking from camera shops and one-hour photo places as long as the the lawyers (should the people in charge fear liability from charged capacitors and such) don't get wind of this. :-)

The circuits are all quite similar to those of other battery powered flash units except that these run on a single 1.5 V AA Alkaline cell (another bonus for salvage since the battery is usually very usable as well).

For experimentation, I recommend constructing a power supply to replace the AA cell since while a 24 exposure roll of film may not drain one of these, an afternoon's tinkering will easily go through a several. In addition, as the battery is depleted, the cycle time will increase. See the section: "1.5 V Alkaline Cell Eliminator" in the document: Various Schematics and Diagrams for a suitable circuit.

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Photoflash Circuit from Kodak Disposable 35mm Pocket Camera 1

This schematic was traced from an electronic flash unit removed from a Kodak disposable 'Funsaver with Flash' pocket camera.

Thanks to Bill Kennedy (hue@node1.frontiernet.net) for performing the reverse engineering. I then redid the schematic to match the style of the very similar one described in the section: Photoflash Circuit from Kodak Disposable 35mm Pocket Camera 2. The transformer windings number of turns and wire size were estimated based on that circuit as well which I completely disassembled down to the cores!

* Kodak Funsaver Flash Unit in GIF format.

I have also reverse engineered the flash in a Far East (probably) clone of this camera. The only obvious differences seem to be: C1 omitted, R1 = 200 ohms, R2 = 4.7M. Operation is essentially identical. Apparently, some component values may also differ slightly even on genuine Kodak units.

Kodak Funsaver Flash Operation

1. Pressing the 'charge' button (S1) enables base drive to the inverter transistor (Q1, 2SD965). The inverter boosts the battery voltage to about 300 V. This is rectified by D1 (1N4007) and charges the energy storage capacitor, (C2, 160 uF, 330 V).

2. The trigger capacitor, C3, charges through R2.

3. The neon bulb, IL1, signals ready by flashing at about a 5 Hz rate.

4. Pressing the shutter closes S2 (fire) which discharges C3 through T2 generating a high voltage pulse (4 to 5 kV) which ionizes the xenon gas in the flashlamp, FL1.

5. The energy storage capacitor discharges through the flashlamp.

Note that the battery is never actually disconnected from the inverter. Thus, a failure (shorted) of Q1 would result in draining the battery and potential overheating - I do not know if this has ever happened!

WARNING: If left on charge for longer than needed to get the ready light to come on OR if run on greater than 1.5 V, the actual voltage on the energy storage capacitor can be much greater than the nominal 300 V. It is not known at what point the capacitor or other components blow up but needless to say, this becomes even more dangerous!

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Photoflash Circuit from Kodak Disposable 35 mm Pocket Camera 2

This schematic was traced from an electronic flash unit removed from a Kodak 'MAX' disposable pocket camera. The basic circuit is virtually identical to the one described in the section: Photoflash Circuit from Kodak Disposable 35mm Pocket Camera 1 for the Kodak Funsaver with Flash camera. However, recall the warning about running for too long or on too high a voltage? Well, the Kodak MAX circuit has added a voltage limiter (regulator) which disables the inverter when the voltage on the energy storage capacitor (C1) exceeds about 300 VDC. It is only necessary to press and release the 'charge' button since it continues to run until fully charged and holding the 'charge' button in all day would do no harm since the regulator cuts it off! In addition, this unit automatically recharges after firing.

- Schematic of Kodak MAX Flash Unit.
- Photo of Kodak MAX Flash Unit with parts labeled.

For instructions on disassembling Kodak MAX cameras, see Don's Hack Kodak MAX to Strobe Page.

All newer Kodak disposable cameras including the "Funsaver Sure Flash" appear to use a similar, if not identical, circuit. Apparently, "ADVANTIX" flash units (at least some of them) use a pair of AAA cells instead of the single AA so some modifications had to have been made. And, later revisions of the MAX flash have gone to surface mount components (though I don't think the circuit has changed much). I haven't yet seen any of these circuits up close and personal. :)

It is easy to make modification to this basic circuit to provide other voltages for other applications from a 1.5 V Alkaline cell. For example, a simplified version was tested which generates about 4 to 5 V:

- Mini Power Supply Based on MAX Flash Inverter.

See the section: "Up to 350 VDC Inverter from 1.5 V Alkaline Cell" of the document: Various Schematics and Diagrams for details of these modifications.

(From: Source unknown)

After cracking open several Kodak Max cameras, I noticed that some had slight changes in circuit design. First, the 2SD879/2SD965 was replaced with a 2SA1585. Second, the zener had been replaced with a 330 volt MOV. The inverter transformer was smaller than usual. All resistors were SMD. There were three SMD transistors on the underside of the board labeled A6AU, 5DZ, and 1AM. I have not attempted to reverse-engineer yet.

(From: Sam)

Oh well, someday I'll have to find and dissect one of these. It sounds like some significant changes were made - possibly a totally different design with the 2SA1585 being a PNP transistor instead of the NPN variety that were used previously.

Kodak MAX Flash Operation

1. Momentarily pressing the 'charge' button (S1) enables base drive to the inverter transistor (Q1, 2SD965) via the emitter follower, Q2. The inverter boosts the battery voltage to in excess of 300 V (see note 3). The output of T1 is rectified by D1 (unmarked but presumably similar to a 1N4007) and charges the energy storage capacitor, (C2, 160 uF, 330 V).

   Inverter frequency starts at about 5 kHz with C2 completely discharged and increases to about 11 kHz just before cutoff.

2. The trigger capacitor, C3, charges through R2.

3. The neon bulb, IL1, signals ready when the voltage on C2 exceeds about 275 VDC. In addition, the current flowing through IL1 results in a voltage drop across R3 exceeds the rating of the zener diode (110 V), D2, Q3 disables base drive to Q1 and the inverter shuts off - around 300 VDC. This simple limiter can easily be designed into any inverter driven strobe circuit.

   The MPS2111 (Q3) is a PNP transistor which has an internal resistor network in its base-emitter circuit. These devices are sometimes called 'digital transistors' since they can be used as simple buffers or inverters without additional input components. The values of the series and shunt resistors are both 10K for this particular part. Special thanks to Paul Grohe (grohe@galaxy.nsc.com) for locating a datasheet for the MPS2111. However, a common 2N3906 PNP transistor DOES seem to work in place of this unusual device!

   While I am calling IL1 a neon bulb since it looks like a sort of a runt (shortened) version of the ubiquitous NE2, in order to operate as described above, its on-state voltage drop must be around 190 to 200 V - not the usual 60 V or so one would expect from an NE2. I confirmed this by measuring across one of these bulbs connected to C2 via a 1M resistor.

4. Pressing the shutter closes S2 (fire) which discharges C3 through T2 generating a high voltage pulse (4 to 5 kV) which ionizes the xenon gas in the flashlamp, FL1.

5. The energy storage capacitor discharges through the flashlamp. The inverter automatically restarts to recharge C2 after firing.

Kodak MAX Flash Transformer Construction

Since I acquired a bunch of these flash assemblies, I didn't feel too guilty about destroying the inverter transformer, T1, and the trigger transformer, T2, on one unit to determine their precise construction.

1. T1 consists of a pair of ferrite E-cores each measuring approximately .4025" x .219" x .187" (WxHxD). The center leg and outer legs are each .096" x .187" and .06" x .187" respectively. There are no core gaps. The plastic bobbin fits over the center leg and has 1,750 turns (give or take a few) of #45 AWG wire for the HV secondary. (Apparently, you can buy wire down (up?) to size #60 - less than .000350 inches in diameter! Check out MWS Wire Industries if you are really curious about fine wire - #45 is nothing to write home about!) This is wound first as one clump - distributed back and forth to create a fairly uniform layer without lumps. There were no separators as are often found in high frequency transformers to divide high mileage windings. After a layer of plastic tape, the primary consists of 6 turns of #25 AWG wire. A final layer of tape and there you have it! The entire inverter transformer fits in a cube less than .5" on a side.

   Since there is no core gap, this inverter does NOT operate in flyback mode but rather as a simple blocking oscillator with a stepup transformer. Therefore, I would predict the maximum voltage (if the limiting circuit were disabled) to be determined (in an ideal world) roughly by the turns ratio of T1 times the battery voltage (minus Q1's saturation voltage) or: 1750/6 * (1.5 - .3) or about 350 V for a fresh AA cell. This was confirmed on another unit by measuring the amplitude of the primary and secondary waveforms on T1 while operating with D1 removed.

2. T2 consists of a linear ferrite core, about .065" square by .265" long and a plastic bobbin with 12 turns of #33 AWG wire, insulating tape, and about 450 turns of #45 AWG wire on top of this, followed by more tape. The entire trigger transformer is about .210" x .210" x .275".

   Note: Some samples of these units appear to lack the ferrite core and are somewhat fatter. I haven't dissected any of these yet.

Transformers like T1 and T2 could be built at home if you have a coil winding machine. Otherwise, I would expect it to be quite frustrating since the #45 AWG or finer wire is so thin and fragile. The tensile strength of #45 wire is already significantly less than that of a human hair! But why bother since they can be salvaged easily enough! However, this information should help should modifications be desired.

Kodak MAX Flash Notes

1. Minor component differences may be found in samples of this unit. For example, Q1 may be a 2SD879 or 2SD1146 instead of the 2SD965 shown.

2. Some versions of this flash apparently have a 120 uF instead of 160 uF capacitor for C2. I wonder if the film speed and/or lens aperture are different in these cameras since the flash energy is only about 2/3 as much as with the 160 uF capacitor.

3. Extra precautions must be taken when experimenting with these circuits since they automatically recharge without pressing any buttons! Take care.

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Flash Units from Fuji Disposable Cameras

These are basically basic (1) and deluxe (2) versions of the same circuit from various models of Fuji disposable cameras. Virtually the same circuit board and physical arrangement are used though they aren't quite interchangeable.

The basic one requires that the charge button be held in until the ready light comes on and has a smaller energy storage capacitor (100 uF compared to 160 uF):

- Schematic of Fuji Flash Unit 1.

The deluxe flash seems to be functionally similar to the one used in the Kodak MAX and other newer Kodak disposable cameras. However, it is much more complex and yet smaller since the 'smart' circuitry is mostly surface mount (SMT) on the back of the printed wiring board. Except for 3 resistors, the SMT components are all related to the deluxe features.

- Schematic of Fuji Flash Unit 2.
- Photo of Fuji Flash Unit 2 with parts labeled.

(The photo of the basic flash would be virtually identical to this one except for the lack of all the SMT circuitry and 3 resistors on the top of the board.)

Instead of the sweet simplicity of the Kodak units, the Fuji flash uses extra parts to provide the feedback to keep the inverter running without keeping the 'charge' switch depressed. The cutoff when fully charged appears to operate similarly to the Kodak flash but with a 300 V zener instead of the combination of 110 V zener and 200 V discharge lamp combination that it used.

Except for the drive winding, the transformer specifications were estimated based on circuit similarities to the Kodak flash units. The 6 turn drive winding is visible and wound bifilar fashion with a pair of #26 AWG wires.

Like the Kodak MAX, this unit uses some strange transistors - all the more difficult to identify because they are surface mount parts. I believe, again thanks to Paul Grohe (grohe@galaxy.nsc.com), that these have internal resistors. Specifically, Q2 (marked 6E) has a series base resistor of 47K and Q3 (marked 6D) has series and shunt resistors of 47K and 10K respectively.

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Flash Circuits from Externally Mounted Flash Units

Electronic Flash Model ME1 for Minox B

This is a three-part unit for one of those teeny-tiny Minox spy cameras :-). The flash head itself is about as big as the entire camera with the power supply and charging adapter being somewhat larger. Actually, the power supply is a lot larger. I don't suppose spies generally like to use electronic flash in covert operations too often anyhow!

The inverter is of conventional design but, due to its age of at least 30 years (purchased in 1968), somewhat larger than is typical of modern strobes. In fact, compared to a modern disposable camera, the capacitor charging circuitry occupies about 8 times the volume and probably at much lower efficiency! (Also available in GIF format as [Minox ME1 Inverter and Energy Storage Capacitors].)

```
                                                                       J2-2
                                             +--------------------------o HV+
                                             |  S2 Flash +-----------+
      P1-1  S1 Power            o  T1        | Intensity |     R2    |
   BT- o---+---/ --+-------------+      o    |      High o   330,2W  |
           |       |              ):: +------+-+-------+->o---/\/\---+
           |       /        D 15T )::(         |   Low | o     R3    |
           |    R1 \          #20 )::(         |       +--+---/\/\---+
           |   150 /   +---------+ ::(         |          |  10K,1W  |
           |       \   |           ::( O 1950T |          |          |
           |       |   |        o  ::( #46     |      C2 _|_     C3 _|_
           |-      +---|---------+ ::(         |   260uF ---  260uF ---
     BT1   _       |   |          )::(         |    350V  |    350V  |
    2.4V  ___      |   |    F 15T )::(    D1   |    D2    |          | J2-1
    Sub-C  _       |   |      #30 ):: +---|<|--|-+--|<|---+----------+--o HV-
     NiCd ___      |   |     +---+       BAY90 | | BAY90
           |+      |   |  Q1 |                 | |
           |       |  C \|   |                 | |
           |   C1 _|_    |---+                 | |  O = Output
           | 47uF --- E /| AD136               | |  D = Drive
           |  10V  |   |   (PNP)               | |  F = Feedback
           |       |   |                       | |
      P1-2 |       |   |                       | |
 COM  o----+-------+---+-----------------------+ |
                                                 |
      P1-3                                       |
 CCAC o------------------------------------------+
```

Note: The BAY90 rectifiers cross to 1000 V, 2.5 A general purpose diodes.

No, that is not a typo - 1,950 turns of #46 (!!) wire in 7 layers (6 of 300 turns each and the first was 150 turns) for the Output winding! I counted every single turn because the Output winding was open and I was hoping to locate the break. Not likely! It was somewhere in the middle and the wire was so fine that it broke about 50 times while unwinding - so it could have been any one of those! (See the section: [Conversion of Minox ME1 Flash to Use a Modern Inverter] to find out how I repaired this unit.) The ferrite double E-core is about 1 inch on a side with each leg being 1/4 inch square. There were no core gaps.

The Flash Intensity switch, S2, selects between 12 W-s and 24 W-s. There are actually three positions. Apparently, you are supposed to pause in the middle one called "Hold 1 Sec" when switching between power levels for at least 1 second (surprise, surprise!) to allow the capacitor voltages to equalize! I would assume that the reason for this is to prevent damage to the switch contacts.

The flash head is separate from the power supply and appears to be very much like any of the other strobes. However, note the adjustment for the ready light!

I was not willing to completely disassemble this unit so some of the actual components and wiring were guessed (also available in GIF format as Minox ME1 Ready and Trigger Circuits).

```
         P2-2
      HV+ o---+-------------------------------------------------+
              |     R4                                         +|
              +----/\/\-----+---+--------+                     _|_
                  4.3M      |   |        |                    | | |
                            /  +++ IL1   |                   ||   |
                Ready R5 +->\  |o| NE2   |       Trigger     ||   |
                 Cal. 5M |  /  |o| Ready |          T2 +-----||   | FL1
                         |  \  +++       |          ::( o    ||   |
                  R6     |  |   |        |  C4      ::(      || _ |
              +---/\/\---+--+---+        +--||----+ ::(       |_|_|
              |   4.3M                   | .1uF    )::(         |
              |               Shutter o--+ 250V  o )::(        -|
              |                 Cable o--+      +-+    +-+      |
         P2-1 |                          |      |        |      |
      HV- o---+--------------------------+------+--------+------+
```

The wall adapter/charger provides both the current to charge the 2 cell NiCd battery and a high voltage AC output (CCAC) to power the flash when plugged into an outlet regardless of the state of the batteries. When operating from the wall adapter, D1 and D2 in the power supply unit in conjunction with C4 form a voltage doubler that takes the 130 VAC (>80 V peak) output of the adapter and produces over 300 VDC to charge the energy storage capacitors (also available in GIF format as Minox ME1 AC Line Circuitry).

```
                        T3     C5  J1-3
                           +---||----o CCAC (Capacitor Charge AC)
                 H o-----+ ||(   1 uF
                        )||(   350V
                        )||(
               110VAC     )||( 130V
                        )||(
                        )||(       J1-2
                        )|| +---------o COM
                 N o-----+ ||( 3.3V   J1-1
                           +---|<|---o BT-
                               D3
```

Note that unlike many modern designs, the flash will work on AC as long as the Output winding of the inverter transformer is intact and the HV rectifiers are good. The condition of the remainder of the circuitry including the inverter itself and battery is irrelevant !

Conversion of Minox ME1 Flash to Use a Modern Inverter

As a result of the inverter transformer having an open secondary, I was forced to improvise in order to repair a Minox ME1 flash unit. The result was a unit that appears to be every bit as good and possibly even has a faster cycle time and a greater number of shots per charge - only time will tell for sure.

There were several requirements to locate a compatible inverter:

- It runs on a pair of NiCd cells totaling 2.4 V so the circuitry out of a disposable camera is not appropriate, being designed for 1.5 V operation.

- The inverter may need to run continuously. For this reason as well, the disposable camera solution is unacceptable since they usually are activated by a push button and may only be designed for short duty cycle operation.

- AC operation must not be affected.

- The circuitry must fit in the case.

Checking the schematics for each of the other battery powered flash units in this chapter, it seemed that the one described in the section: Photoflash Circuit from Keystone Pocket Camera might work if it could accommodate the 2.4 V NiCd rather than 3.0 V Alkaline battery it expects. I would expect this to be the case since Alkaline voltage is not really constant at 3.0 V but drops gradually as they are used up (NiCd voltage is nearly constant until the charge is exhausted). Therefore, it probably should work down to about 2.0 V (but with longer cycle time). And, the lower effective series resistance of NiCds would partially offset the lower initial voltage. I have a couple of the Keystone units so it is easy to try.

A simple test jumpering 4 wires confirmed functionality. The actual inverter portion of the Keystone flash occupies a volume of about 1" x 1-1/4" x 3/4" or just slightly more than that of the original dead inverter transformer! Some quick action with a hacksaw and nibbling tool resulted in a cute little circuit board that could be tucked into the available space. Some electrical tape assured that there would be no nasty short circuits. The chopper transistor was left exposed so any heat from it would have somewhere to go.

The excised circuit was attached to the positive terminal of the battery, the negative (center) at the switch, and the two secondary leads of the inverter transformer, taking care to get the polarities correct (the waveform out of the inverter is asymmetric and it would not work well if reversed). Except for T1 (dead) and C2 which I removed, all other components were left in place since they shouldn't affect anything.

It seems to work fine on both power settings and on battery or AC. The voltage on the energy storage capacitors stabilizes at about 315 to 325 VDC in all cases. The battery charges fine. What more can you ask? :-)

At first, I thought there was one slight problem: When plugged into an AC outlet with the power switch in the 'on' position (meaning the inverter is also running - the flash operates from AC with this switch off), I was afraid the voltage will eventually climb beyond the safe limits of the capacitors. Then, about 3 AM the next morning I realized there was a missing plastic piece to prevent the switch from being moved into the 'on' position with the adapter plugged in (or vice-versa).

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Vivitar Auto 253 Electronic Flash circuit

The Vivitar Auto 253 is a typical small inexpensive automatic electronic flash. As is typical of these designs, the flashlamp is paralleled with a quenchtube. This is a small discharge tube that looks something like an oversized neon indicator light (but probably xenon filled). The quenchtube is triggered at a time after the main flashlamp fires which is determined by the light reflected from the subject and terminates the flash when adequate exposure has been achieved. The actual trigger circuit using an SCR to pulse a trigger transformer applying a 4 to 5 kV pulse to a foil wrapping on the quenchtube. Typical flash duration for small automatic electronic flash units vary from about 1/50,000 second for a minimum energy (closeup) flash to 1/1000 second for a maximum energy (distant subject or manual) flash.

The power supply portion of this unit is interesting as well. It can operate on either AC (220 V, it would seem from the circuit) or a 9 V battery. For AC, a simple half wave rectifier produces about 320 VDC needed by the flashlamp. On DC, it uses an inverter that operates on a 9 V battery rather than the 3 V which is typical of many cheap pocket cameras. This results in a fairly rapid cycle time of about 2 seconds.

The ready light looks like an ordinary NE2 neon bulb but must have a different gas mixture as it does not turn on until nearly full charge is reached on the energy storage capacitor. There appears to be no voltage divider. In addition, there is another lamp that provides a nice green illumination for the flash 'computer' dial. This looks like a neon indicator lamp but with an internal phosphor coating.

I have observed the spectrum of these things. I have seen two different gas fills in these that emit UV that makes the green-glowing phosphor do its stuff. One bulb type about the size of an NE-2H uses a mixture of neon and xenon. GE made those things (I don't know if anyone else ever did), which are called NE-2G lamps. The other type, a much smaller one that I found in Radio Shack's 272-708 green neon "cartridge", uses a mixture of neon and krypton. (Don Klipstein (don@misty.com or klipstei@netaxs.com).)

The Vivitar schematic is split into two parts with FL1, C1, and L1 duplicated to improve readability.

Vivitar Auto 253 Power Supply

```
                 AC   D3
             +-o IN o-|>|--+
    S1       |             |
  DC  AC     |      D1     |X D2                                   Flashlamp
+--o  o +-o  o +----|>|----+--|>|--+----------+-------+-------------------+
|    /..|.. /  |           |       |          |       |               FL1 |
|   |  +|  |   |           | LT1   +          |       |                   |
|   |  ___ +---|------+   +++   ::(           \       \                  +|
|   |   _      |      |   |o|   ::( L1        / R5    / R3               _|_
|   |  ___ BT1 |      |   |o|   ::(           \ 1.2M  \ 3.3M            | | |
|   |   _  9V  |      |   +++   ::(           /       /       Trigger  ||   |
|   |  -|      |  C3  |    |       +          |       |                ||   |
|   +---+ T1 +-+--||--+    |       |          |       |  C2      T2 +--||   |
|         ::(3    220 |    \ R2    |          |       +--||--+   ::(   ||   |
+-------+ ::(     pF  |    / 1,2M  | Energy   |       | .047 |   ::(   || _ |
|       2)::( 118     |    \       | Storage  |       |  uF  +-+ ::(    |_|_|
| R1 <.1 )::(         |    |       | 380 uF   | Ready |         )::(      |
/ 4.7K   ):: +---+    |    |      +| 350 V   +++      | Shutter )::(      |
```

```
  \    +--+ ::(5   |    +----+     __|__       |o| IL1  |-        )::(     -|
  /    |  4 ::( .2 |         |     ______ C1   |o|      | S2   +-+    +-+   |
  |    |       +--------+    |       |         +++      |      |        |   |
  |  |/ C      1   |    |    |      -|          |       +------+--+-----+   |
  +--|    Q1       |    |    |       |          |       |         |         |
  |  |\ E 2SB324   |  +_|_C4 |       |          |       / R4     _|_ C5     |
  |    |           |   ___   |       |          |       \ 3.3M   --- 100 pF |
  +----|-----------+  - | 10 |       |          |       /         |         |
       |  Inverter      | uF |Y      |          |       |         |         |
       +----------------+----+-------+----------+-------+---------+---------+
```

Vivitar Auto 253 Power Supply Operation

1. DC 9 V: The inverter boosts the battery voltage to about 300 V. This is rectified by D1/D2 and charges the energy storage capacitor, C1, through the inductor, L1.

   AC 220 V: The line input is rectified by D3 and D1 resulting in about 320 V peak which charges the energy storage capacitor, C1, through the inductor, L1.

2. The trigger capacitor, C2, charges through R3, R4, and T2.

3. The neon bulb, IL1, signals ready by glowing when the energy storage capacitor is nearly fully charged.

4. Pressing the shutter closes S2 which discharges C2 through T2 generating a high voltage pulse (4 to 5 kV) which ionizes the xenon gas in the flashlamp, FL1.

5. The energy storage capacitor discharges through L1 and the flashlamp.

Vivitar Auto 253 Exposure Control Circuit

```
                        |
  <--- Power Supply --->|<---------- Automatic exposure control----------->
                        |
      D2* Flashlamp       Quenchtube      R6
X o---|>|---+-------+---------+---------/\/\/\---------------------+-----+
            | FL1*  |         |                                    |     |
           _|_      +         | QT1                                |     |
    Main  | | |  ::(         _|_                    Quench          |     |
 Trigger ||   |  ::( L1*    | | |                  Trigger     C6 _|_    |
 From T2 ||   |  ::(        | o ||                        .047 uF ___    /
      ---||   |     +       |   ||------------------+ T3           |     \ R7
         ||   |     |       | o ||                   )::           |     / 1.2M
         || _ |   +_|_    |_|_|                    )::      C7    |     \
          |_|_|    ___ C1*    |                      )::  +----||---+     |
            |     - |  380 uF |                      )::(  .047 uF |     |
            |       |  350 V  |                      )::(          |     |
            |       |         |                      )::(          |     |
Y o---------+-------+---------+                  +--+    +--+------|-----+
```

```
                              |                  |          |      |     |
                              |                  +----------+      |     |
                              /                  |          |      |     |
                         R10  \                __|__ SCR1   |      |     |
                          1K  /      470K      _\_/_ M21C   |      |     /
       Flash Sensor           \  LS1  R8   C9  / |   200 V  |      |     \ R8
       Power Opening          |   +----+----+-'  |   .8 A  _|_ C8  |     / 2.2M
      ---------------    CDS  |  +++   |    |    |         --- 100 |     \
       Low   1/8"       Light |  |/|   /   _|_   |          |  pF  |     |
       High  1/32"     Sensor |  |\|   \   ---   |          |      |     |
       Man   Closed       --> |  |/|   /    |.05 |          |      |     |
                              |  +++   |    | uF |          |      |     |
                              +---+    +----+----+----------+------+-----+
                              |        |         |
                              |       _|_ C10  __|__
                              |       --- 100  _\_/_ D4
                              |        |  pF     |
                              |        |         |
                              +--------+---------+
```

Vivitar Auto 253 Exposure Control Operation

The power inputs, X and Y, may come from the Vivitar Auto 253 power supply circuit (above), other battery/AC adapter powered inverter, or other AC line operated power supply.

1. Quench trigger capacitor, C7, charges from energy storage capacitor, C1, through voltage divider formed by R7 and R8.
2. Flashlamp is triggered by 4 to 5 kV pulse from main trigger transformer, T2 (not shown) when shutter contacts close.
3. Because of series inductor, L1, voltage across flashlamp drops abruptly when current starts flowing. (Note: I am calling this an inductor - from appearance only - as it is unmarked. It may just be a small high current resistor).
4. This negative step is coupled by C6 to cathode of the quench trigger thyristor, SCR1. The anode-to-cathode voltage does not change but the cathode becomes negative with respect to the energy storage capacitor negative (common) terminal which feeds the gate circuit.
5. CDS light sensor, LS1, R8, and C9 form an RC network with a time constant inversely proportional to the light reflected off of the subject. Voltage on SCR1's gate increases as C9 charges.
6. When enough light has been detected indicating proper exposure, SCR1 is triggered dumping C7 through quench trigger transformer. Resulting 4 to 5 kV pulse ionizes (xenon) gas in quenchtube.
7. The quenchtube has a lower voltage drop than the flashlamp and thus bypasses any charge remaining on C1 around FL1 terminating the light output.

Vivitar Auto 253 General Notes

1. Cycle time is independent of flash duration as energy storage capacitor is always discharged nearly fully by either flashlamp or quenchtube.

2. Components in automatic exposure circuit denoted with * are duplicated from power supply section to improve readability of schematic.

3. Part numbers are consistent with the Vivitar Auto 292 schematic but have no correlation with actual Vivitar designations.

4.
```
        |                          |            |
     ---+--- are connected;     ---|--- and ------- are NOT connected.
        |                          |            |
```

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Vivitar Auto/Thyristor 292 Energy Conserving Automatic Flash

An energy conserving electronic automatic flash only uses as much energy from the energy storage capacitor as is needed for the particular photographic situation base on light reflected from the scene. This is in contrast to lower cost units (like the circuit shown in the section: Vivitar Auto 253 Electronic Flash Circuit) that simply dump the excess charge. With these, closeups use the same amount of the battery's capacity and require the same recycle time as long distance shots. With an energy conserving flash, battery life is greatly extended and recovery from low power flashes is instantaneous.

Although I did not totally reverse engineer this unit - not being willing to sacrifice my Vivitar 292 as I might never be able to get it back together after analysis - the construction is not what you would call modular - I was able to determine some of its basic operating principles.

There is an SCR - it looks like a regular SCR - in *series* with the negative lead of the xenon flashlamp. The SCR part number is Mitsubishi CR3DZ-8. I was not able to locate this part in my databooks bat based on the ECG Semiconductor Master Replacement Guide, similar devices are normal SCRs - typically 8 A at 400 V which would be suitable since these can pass short very high current (250 A) pulses without damage.

There is also a quenchtube. This is fired based on light returning from the scene to turn the SCR *off*. I believe that this is done by discharging a separate capacitor in reverse across the main SCR thus driving it into cutoff long enough for the flashtube to extinguish.

Other designs may use a small SCR in place of the quenchtube to apply reverse voltage to the main SCR. Alternatively, a Gate TurnOff (GTO) thyristor or high power Insulated Gate Bipolar Transistor (IGBT) may be used in place of the main SCR. GTO devices are designed for this type of application and requires only a modest gate pulse to switch them off. However, they aren't that common. I've see the IGBT used in one design but don't have specs for it. However, a peak surge rating of hundreds of AMPS will be required.

What I surmise is that operation of the Vivitar 292 is basically similar to that of the smaller Vivitar 253 automatic flash unit (see the section: Vivitar Auto 253 Electronic Flash Circuit (the circuitry on the photosensor board looks nearly identical) except that instead of the quenchtube dumping the entire charge on the energy storage capacitor, it is used to interrupt the current to the flashtube in mid-stride by turning off the SCR. The Vivitar engineers were probably able to add this energy conserving feature to the simpler 253-type strobe with minimal redesign of other parts of the auto exposure circuit.

Electronic flash units which incorporate manually selectable power levels can use a similar design. Instead of the light sensor triggering the quenchtube/thyristor, this would be accomplished with a timing or power measuring circuit.

If anyone has one of these or similar energy saving automatic flash units they would be willing to donate to the cause, I would fully reverse engineer the design and add it to this document.

Vivitar Auto/Thyristor 292 Exposure Control Circuit

This is what I expect the auto exposure portion of the Vivitar Auto/Thyristor 292 to be like. As noted, I have not fully reverse engineered this design.

Some part values have been estimated. I have assumed that the actual exposure determining and quench tube firing circuits are identical and have used part numbers from the Vivitar Auto 253 (which, of course, were also arbitrarily chosen).

The inverter and main power circuits are not shown but should be understood to be similar - but of higher energy capacity - to those of the smaller Vivitar electronic flash units.

```
                                   |
   ---------- Power Supply ------- | ----- Automatic exposure control------
                                   |
      D2  Flashlamp                    Quenchtube    R6
X o---|>|---+-----------------+--------------------/\/\/\----------+-----+
            | FL1             |  R11*                              |     |
           _|_                +--/\/\--+----+ QT1                  |     |
    Main  | | |               |   1K   |   _|_      Quench         |     |
 Trigger ||   |             ||C         |  | | |    Trigger     C6 _|_    |
 From T2 ||   |             ||C L1      |  | o ||          .047 uF ___    /
      ---||   |             ||C         |  |   ||----+ T3           |     \ R7
         ||   |               |        |  | o ||     )::           |     / 1.2M
         || _ |             +_|_       |  |_|_|      )::      C7   |     \
          |_|_|              ___ C1*    |    |        ):: +----||---+     |
            |       4 uF    - |  750 uF|    |        )::(  .047 uF |     |
            |       C11*      |  350 V |    |        )::(          |     |
    SCR2    +-----+--||-------|--------+    |        )::(          |     |
    CR3DZ-8 |     |           |             |    +--+    +--+------)-----+
    400 V __|__    /      +----+-------------+    |          |      |     |
    8 A   _\/\_    \ R12* |    |                  +----------+      |     |
          / |     / 10K  |    / R10                |          |      |     |
    T o--'  |     \      |    \ 1K          __|__ SCR1  |      |     |
            |     |      |    /      470K      _\/\_ M21C  |      |     /
Y o---------+-----+------+    \  LS1  R8   C9  / |   200 V  |      |     \ R8
                              |   +----+----+-'  |   .8 A  _|_ C8  |     / 2.2M
                         CDS  |  +++    |    |    |         --- 100 |     \
                        Light |  |/|    /   _|_   |          |  pF  |     |
```

```
                       Sensor |  |\|   \   ---   |          |      |     |
                          --> |  |/|   /    |.05 |          |      |     |
       Flash Sensor           |  +++   |    | uF |          |      |     |
       Power Opening          +---+    +----+----+----------+------+-----+
      ---------------         |        |         |
       Low   1/8"             |       _|_ C10  __|__
       Med   1/16"            |       --- 100  _\_/_ D4
       High  1/32"            |        |  pF     |
       Man   (Switch)         |        |         |
                              +--------+---------+
```

Vivitar Auto/Thyristor 292 Exposure Control Operation

The power inputs, X and Y, may come from the a circuit similar to the Vivitar Auto 253 power supply circuit (but of higher power probably), other battery/AC adapter powered inverter, or other AC line operated power supply.

1. Quench trigger capacitor, C7, charges from energy storage capacitor, C1, through voltage divider formed by R7 and R8. SCR shutoff capacitor, C11 charges from C1 through R11 and R12.

2. When shutter contacts close, a pulse is applied to the trigger of the main SCR (SCR2, or it is already triggered on continuously while the main filter capacitor is charged). Flashlamp is triggered by 4 to 5 kV pulse from main trigger transformer, T2 (not shown). Note: SCR2 must be turned on before flashlamp is triggered.

3. Because of series inductor, L1, voltage across flashlamp drops abruptly when current starts flowing.

4. This negative step is coupled by C6 to cathode of the quench trigger thyristor, SCR1. The anode-to-cathode voltage does not change but the cathode becomes negative with respect to the energy storage capacitor negative (common) terminal which feeds the gate circuit.

5. CDS light sensor, LS1, R8, and C9 form an RC network with a time constant inversely proportional to the light reflected off of the subject. Voltage on SCR1's gate increases as C9 charges.

6. When enough light has been detected indicating proper exposure, SCR1 is triggered dumping C7 through quench trigger transformer. Resulting 4 to 5 kV pulse ionizes (xenon) gas in quenchtube.

7. The quenchtube has a discharges C11 applying a voltage pulse in reverse across SCR2. This biases the SCR in cutoff long enough for the flashlamp to extinguish. Very little energy is lost.

Vivitar Auto/Thyristor 292 General Notes

1. Cycle time is a function of actual amount of light required for each shot. It is possible to fire off a half dozen or more low power shots without any recycle delay.

2. The values of components denoted with * have been estimated (i.e., guessed).

3. Part numbers are consistent with the Vivitar Auto 253 schematic but have no correlation with actual Vivitar designations.

4.
```
       |                         |           |
    ---+--- are connected;    ---|--- and ------- are NOT connected.
       |                         |           |
```

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Other Battery Powered Camera Flash Circuits

Photoflash/Strobe Circuit Using IC 1

This is the circuit board for some sort of flash or strobe application. These are/were available from Electronic Goldmine single for $1 or in 8-packs for $5. There is no energy storage capacitor or flashlamp, only the inverter and trigger circuit. From their main page, go to "Products", then "Strobe Items". It would be under "Micro Strobe Brains" unless sold out. Photos of the unit can be found in:

- Photo of Flash Circuit Using IC 1 - Top View
- Photo of Flash Circuit Using IC 1 - Bottom View

I originally thought this cute circuit was from a disposable camera but now rather doubt it as will become clear below.

The part of the circuit I am reasonably confident of is shown in:

- Flash Circuit Using IC 1

Don't take the cap values or number of turns on the transformer too seriously. They are basically guesses based on other flash circuits or what seems reasonable. However, the turns-ratio (as determined by driving the transformer out-of-circuit with a function generator) is around 1:10 - not the 1:100 or 1:200 of a typical flash running on 1.5 V. Another interesting thing is the use of an SCR for the trigger. This would imply the desire to be triggered by something other than simple shutter contacts. So, I suspect this was for some sort of pocket camera, but not a disposable type. Of course, it might not have been a camera flash at all but some other sort of strobe application.

I have attempted to power it and experiment with the unidentified wires attached to the IC. However, I wasn't able to determine anything conclusive. Pulling pin 6 to BATT+ through a current limiting resistor seemed to have something to do with turning the inverter on (thus the pin designation, IE-Inverter Enable) but I could never get a 120 uF photoflash capacitor to charge to any significant voltage, though a 0.22 uF cap would occasionally charge to 200 or 300 V very quickly. It wasn't consistent though. And then the IC let its smoke out so further experiments will have to wait until I have more confidence in what I'm doing. :(:)

If anyone can provide any information that would help resolve these mysteries, please contact me via the Sci.Electronics.Repair FAQ Email Links Page

Malcohm's Flashgun Charger

(From: Malcolm Watts (m.j.watts@massey.ac.nz).)

I built a 40 J flash and slave for my camera about 15 years ago using a variation of the basic inverter circuit which also delivers to the cap any energy left in the core at the end of the forward stroke. The transistors I used were BD438 and the supply was a 12 V 6 amp-hour Gel cell lead-acid battery. The circuit variation requires the inclusion of several extra diodes to steer what little core energy there is to the output capacitor (you end up with a bridge arrangement). All diodes I used are ultra-fast recovery types (UF4007). My units charge a 450 uF cap to 400+ volts in about 3 seconds from a good battery. The caps I used are low-ESR types designed for SMPS applications.

See Malcohm's Flashgun Charger.

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Schematics for Line Powered Flashes and Strobes

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General Description of Line Powered Flash Units

These units are usually (but not always) more powerful than those operating from small battery packs. Most use doubler or tripler attached directly to the AC line and are therefore NOT isolated - and even more DANGEROUS to troubleshoot than their smaller cousins! The first one is the only commercial unit in this category so far and does use a stepup transformer rather than a non-isolated voltage multiplier.

Honeywell Prox-O-Lite Flash Unit

This is a two piece AC line powered flash. It can power 1 or 2 flash heads at the same time (subject to certain energy restrictions on the Main and Aux jacks). The flash head I have uses a ring shaped flashlamp and mounts around the camera lens to provide shadow-free illumination.

- Get the schematic for HWPL1 in PDF format: [HWPL1-SCH].

The rectified output of a stepup transformer is applied to an SCR-based regulator which will maintain about 400 V on the energy storage capacitors. The regulator is somewhat peculiar and I'm not sure I copied the circuit correctly. :)

To provide Low (L), Medium (M), and High (H) energy levels, there are 3 energy storage capacitors of 56, 70, and 374 uF. These correspond to approximately 4.5, 5.5, and 30 w-s (Joules) at 400 V and are used in combination to provide 4.5 (L), 10 (M), or 40 (H) w-s to the Main flash head; or 30 (L), 30 (M), or 40 (H) w-s to the Aux flash head. (Yes, L and M are the same energy for the Aux jack.) Both flash heads can be used simultaneously as long as the energy isn't set for High. A single switch with high current contacts selects the L, M, or H energy levels (so must be the same setting for Main and Aux).

The ring flashlamp in the flash head is about 3-1/16" OD made of 4 mm tubing. However, the circuit should drive any common flashlamp that can handle the 40 w-s maximum energy.

Medium Power Photoflash Circuit

Here is a sample schematic for a typical line operated medium power electronic flash unit. Cycle time is under 1 second.

```
       S1      D1         R2                                           Flashlamp
  H o--/ --+---|>|---+--/\/\/--+---------+------+--------+-------------------+
     Power | 1N4005  |    250  |         |      |        |               FL1 |
           |        +|    10W  |         |      |        |                   |
           |        _|_ C1     |         \     +++       \                  +|
   AC Line |        ___ 25 uF  | Energy  / R6  |o| IL1   / R3               _|_
   115 VAC |         |  200 V  | Storage \ 91K |o| NE2   \ 1.5M*           | | |
           |        -|         |  400 uF /     +++       /       Trigger  ||   |
           |   R1    |        +|  450 V  |      | Ready  |          T2     ||   |
  N o------|--/\/\---+       __|__       |      |        |  C4         +--||   |
           |   27    |       _____ C3    +------+  +-----+--||--+   ::(    ||   |
           |   5W   +|         |         |         |     |.1 uF |   ::(    || _ |
           |        _|_ C2    -|         |         |     |      +-+ ::(    |_|_|
           |        ___ 25 uF  |         \         \     |         )::(      |
           |         |  200 V  |         / R7      / R4  | Shutter )::(      |
           |        -|         |         \ 180K    \ 3M   |-       )::(     -|
           |   D2    |         |         /         /     | S2   +-+    +-+   |
           +---|<|---+---------+         |         |     |      |        |   |
             1N4005            |         |   R5    |     |      |        |   |
                               +---------+--/\/\---+-----+------+--------+   |
             Doubler                     |  1.5M*                            |
                                         |                                   |
```

```
                                   +----------------------------------+
```

Medium Power Photoflash Operation

1. The doubler consisting of D1, D2, C1, and C2, boosts the AC line voltage to about 320 V. This charges the energy storage capacitor, C3 through R2. R1 limits inrush current to the doubler.

2. The trigger capacitor, C4, charges through R3, R5, and T2.

3. The neon bulb, IL1, signals ready by coming on when C3 is charged to about 270 V.

4. Pressing the shutter closes S2 which discharges C4 through T2 generating a high voltage pulse (4 to 5 kV) which ionizes the xenon gas in the flashlamp, FL1.

5. The energy storage capacitor discharges through the flashlamp. R2 limits current from doubler to allow flashlamp arc to quench.

Medium Power Photoflash Notes

1. CAUTION: Line operated power supply is not isolated - use with care. Fuse and power-on indicator not shown. * R3 and R5 provide protection from line for trigger circuit - do not remove!

2. Flash energy is about 20 W-s. Adjust component values for desired application.

3. For rapid cycle times, make sure flashlamp is rated for adequate average power dissipation (e.g., 25 W for 1 second repeat). Forced air cooling may be required for sustained operation at full power.

4. Trigger transformer, T2, available from places like Digikey and Mouser.

5. Shutter contacts, S2, may be replaced with SCR for electronic control of flash trigger.

6.
```
       |                          |           |
    ---+--- are connected;     ---|--- and ------- are NOT connected.
       |                          |           |
```

- Back to Schematics for Line Powered Flashes and Strobes Sub-Table of Contents.

Higher Power Photoflash with SCR Trigger

Here is a sample schematic for a typical line operated moderately high power electronic flash unit. The power supply uses a tripler to generate approximately 420 V for the energy storage capacitor.

An SCR allows a safely isolated logic or sensor signal to easily trigger the strobe.

Cycle time is under 2 seconds.

```
       C1 22 uF 450 V
      +------)|-------+
      |        +      |
      |  D1      D2   |  D3    R2                                      Flashlamp
  H o-+--|>|--+--|>|--+--|>|--/\/\--+----+------+--------+-------------------+
       1N4007 |1N4007  1N4007  270  |    |      |        |               FL1 |
              |                2W   |    \     +++       \                  +|
  AC Line     |                     |    / R5  |o| IL1   / R3               _|_
  115 VAC     |                  C3 |    \ 91K |o| NE2   \ 1.5M            | | |
          C2 _|_+            500 uF |    /     +++       /       Trigger  ||   |
       22 uF ---              450 V |    |      | Ready  |  C4      T2    ||   |
       450 V  |                  +__|__  +------+  +-----+--||--+      +--||   |
              |                   _____  |         |     |.1 uF |   ::(   ||   |
              |                     |    \         \   __|__    +-+ ::(   || _ |
              |                     |    / R6   R4 /   _\_/_ SCR1  )::(    |_|_|
              |                     |    \ 270K 1M \   / | TIC106D )::(      |
              |                     |    /         /  |  | 400V +-+    +-+  -|
         R1   |                     |    |         |  |  | 6A   |        |   |
  N o---/\/\--+---------------------+----+---------+--|--+--+---+--------+---+
         22                                           |     |
                                                 C5*  |     |
           Tripler                 Trigger + o---||---+     |
                                               .001 uF      |
                                                600 V       |
                                                            |
                                                 C6*        |
                                   Trigger - o---||---------+
                                               .001 uF
                                                600 V
```

Higher Power Photoflash with SCR Trigger Operation

1. The tripler consisting of D1, D2, D3, C1, and C2, boosts the AC line voltage to about 420 V. This charges the energy storage capacitor, C3 through R2. R1 limits inrush current to the tripler.

2. The trigger capacitor, C4, charges through R3 and T2.

3. The neon bulb, IL1, signals ready by coming on when C3 is charged to about 360 V.

4. Applying a positive edge between Trigger + and - turns on the SCR which discharges C4 through T2 generating a high voltage pulse (5 to 8 kV) which ionizes the xenon gas in the flashlamp, FL1.

5. The energy storage capacitor discharges through the flashlamp. R2 limits current from doubler to allow flashlamp arc to quench.

Higher Power Photoflash with SCR Trigger Notes

1. CAUTION: Line operated power supply is not isolated - use with care. Fuse and power-on indicator not shown. * C5 and C6 provides protection from the line for trigger circuit - do not remove! As an added safety

precaution, the use of an optoisolator or optoisolated SCR is recommended for the trigger circuit.

2. Flash energy is about 45 W-s. Adjust component values for desired application.
3. For rapid cycle times, make sure flashlamp is rated for adequate average power dissipation (e.g., 50 W for 1 second repeat). Forced air cooling may be required for sustained operation at full power.
4. Trigger transformer, T2, available from places like Digikey and Mouser.
5.
```
   |                         |           |
---+--- are connected;    ---|--- and ------- are NOT connected.
   |                         |           |
```

- Back to Schematics for Line Powered Flashes and Strobes Sub-Table of Contents.

Super High power (Laser Pump) Strobe Circuit

Here is a schematic for a high power xenon strobe unit suitable for pumping a medium to large ruby, Nd:YAG, or Nd:Glass laser rod. (However, this would still be considered small compared to those at the Laser Fusion Facilities of the Lawrence Livermore National Laboratory.)

WARNING: This is only an example. We take no responsibility for either the accuracy or functional correctness of the schematic or any consequences should you attempt to construct this circuit either in its original form or modified in any way.

```
                                                        L1
     Power         D1   R5                            ::::::
         +-----+--|>|--/\/\--+-----+------------------^^^^^^----------------+
      ||(      | 5 kV   5K   |     |                25 uH (est)             |
      ||(      |.5 A  25 W +_|_    /                                        |
H --+ ||(      |            ___ C1 \ R1  C1-C4: Energy storage              |
     )||( 600  |           - |     /     capacitor bank,          Flashlamp |
 115 )||( VRMS |             |     |     3600 uF, 450 V (each!)         FL1 |
 VAC )||( 200  |             +-----+                                       +|
 2A  )||( mA   |             |     |     R1-R4: Voltage drop               _|_
     )||(      |           +_|_    /     equalizing resistors,            | | |
N --+ ||(      |            ___ C2 \ R2  200K, 1 W               Trigger ||   |
      ||(      |           - |     /                              30 kV  ||   |
      ||(      |             |     |   R7               + C5 -        +--||   |
         +-------------------+-----+--/\/\--+-------+-----||---+   ::(   ||   |
      T1       |             |     |  1.8M  |       |   3.9 uF |   ::(   || _ |
               |           +_|_    /    1 W |       |   450 V  |   ::(    |_|_|
               |            ___ C3 \ R3     |       |          |   ::(      |
               |           - |     /        \       |          +-+ ::(     -|
               |             |     |        / R8  __|__ SCR1      )::(      |
               |             +-----+        \ 1M  _\_/_ C107D     )::(      |
               |             |     |        /     / |   400 V     )::(      |
               |           +_|_    /        |    |  |   4 A       )::(      |
```

```
|            ___ C4 \ R4     |    |  |          +-+    +-+   |
|           - |     /        |    |  |          |   T2   |   |
|  D2    R6   |     |        |    |  |          |        |   |
+--|<|--/\/\--+-----+--------+-------+-----+----+--------+---+
  5 kV   5K                  R9   |   R10  |
 .5 A   25 W        Fire o--/\/\--+--/\/\--+
                    (+5)     100      100
```

Super High Power (Laser Pump) Strobe Operation

1. Power transformer, T1, in conjunction with D1, D2, and C1-C4, provides 1.7 kV DC. The power supply doubler capacitors are also used as the energy storage capacitors. Resistors, R1-R4, equalize the voltage drops across the series capacitors to compensate for slight differences in leakage resistance. R5 and R6 limit inrush current and charge rate.

2. The trigger capacitor, C5, charges through T2 from the voltage divider formed by R7 and R8.

3. Ready light and capacitor bank voltage monitoring circuits are not shown.

4. Applying a 5 V signal to the Fire input turns on SCR1 dumping C5 into the primary of the trigger transformer, T2. This generates a 30 kV pulse which ionizes the xenon gas in the flashlamp, FL1.

5. The energy storage capacitor bank discharges through L1 and FL1.

Super High Power (Laser Pump) Strobe Notes

1. WARNING: If you thought line operated equipment was dangerous, this is much much worse. The power transformer output is enough to kill. Once doubled and stored in the capacitor bank, it is LETHAL. The total energy storage is about 1300 W-s (this is not a typo!). Based on one estimate, this is enough energy to KILL 20 adult humans simultaneously with the power supply unplugged from the AC line - and still have some juice left over. TAKE EXTREME CARE!

2. Fuse, power switch, power-on light, and all other absolutely essential safety interlocks and indicators are not shown. R1-R4 do act as bleeder resistors and will discharge the capacitor bank to safe levels in about 10 MINUTES. However, don't depend on these. Resistors can fail. Use the capacitor discharge tool and indicator.

3. The power transformer from a tube type (old) TV set would probably be suitable for T1. Microwave oven high voltage rectifiers may be used for D1 and D2. A high power xenon tube like this requires a 30+ kV trigger pulse. Those little tiny trigger transformers will NOT work. Capacitors, C1-C4, must be rated for photoflash rapid discharge.

4. High power strobes require special flashlamps - anything from a pocket camera or electronic flash will explode into a mass of molten bits of glass and metal. This design is derived from one using a tube from EG&G, Electro-Optics Division (Salem, Massachusetts, 35 Congress St., Salem, MA 01970, (508)745-3200. They produce a complete line of xenon strobe and continuous output lamps. Another division of EG&G produces most of the xenon flashtubes used in disposable cameras in the world.) Even a properly specified flashlamp may explode - operate only behind protective shielding. Flashlamp cooling must be adequate for desired cycle time.

5. L1 helps to shape the discharge current pulse. For some high power strobe designs, a series inductor is essential to optimize power output and prevent damage to the flashlamp due to excessively high current and negative voltage (undershoot resulting in reverse current). A damping factor of .8 is generally recommended. The 25 uH value is just an estimate - L1 must be calculated for each combination of energy storage capacitor value, voltage, and the impedance characteristics of the specific flashlamp to be used.

6. If you are serious about constructing a high energy strobe system (and your life and accident insurance is fully paid), consider some advanced reading first. The flashlamp manufacturer's datasheets and application notes will prove essential. The following is one example of possible sources of general design information:

   (From: Bill Reuber (breuber@mail.wcl.on.ca).)

   I have found this to be useful:

   > Solid State Laser Engineering (revised)
   > Springer-Verlag Heidelberg, New York
   > ISBN 3-540-18747-2 or 0-387-18747-2

   They have chapters on many aspects of laser system design including pulse forming networks for flashlamp systems.

7. Flash energy is about 1300 W-s. For a typical flash duration of 250 uS, this is an equivalent power input to the flashlamp of 5.2 MW! Adjust component values for the desired application.

8. DO NOT even think about staring at the flashlamp when fired. The peak light output is equivalent to at least 500,000 - 100 W light bulbs! Even when averaged over the 1/40th of a second typical response of the human eye, this is still more than 5,000 - 100 W light bulbs. (Note: this estimate takes into account the increased luminous efficiency of xenon flashlamps compared to incandescent light bulbs.)

9. Make sure all optical components - especially the flashlamp - are cleaned with isopropyl alcohol and a lint free cloth to remove all traces of contaminants.

10.
```
        |                         |           |
     ---+--- are connected;    ---|--- and ------- are NOT connected.
        |                         |           |
```

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Schematics for Miscellaneous Xenon Flash Devices

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Commercial Systems

Simple Commercial Timing Light

This schematic was taken from a cheap commercial automotive timing light.

```
         R1 150 ohms   D2 1N4007
H o--------/\/\/---+-----|>|------+------------+
        _   10 W   |              |            | FL1
       _|_         | D1 1N4007    |+         +-|-+
N o----   ----+    +--|<|--+     _|_ 16 uF   | | || HV Wire
      Power   |+           |  C2 ___ 420 V   |   ||--------o From #1 Spark Plug
             _|_ 16 uF     |      |-         | _ ||
          C1 ___ 420 V     |      |          +-|-+
              |-           |      |            | Flashlamp
              +------------+------+------------+
```

Timing Light Operation

1. D1 and C1 form a half wave doubler which produces a waveform across D1 which is approximately a sinusoid with a p-p voltage of 2*1.414*VRMS of the line or about 320 V. (The peaks will get squashed with a significant load).

2. C2 charges from this through D2 to about 300 V. The flashlamp fires when triggered by the HV pulse from the #1 spark plug connection. Note: this requires a direct connection, not an inductive pickup. CAUTION:

Excessive trigger voltage could puncture the glass of the flashlamp or cause other damage if the trigger electrode isn't formed in such a way that a discharge to ground will happen first! I don't recall how this device was configured - probably with a metal reflector.

3. I would think that there will be some beating of the charging and flash for high rpms but the timing will be accurate. In other words, it will not fire for every rotation of the crankshaft since C2 cannot recover quickly enough but will flash at the proper instant when C2 has charged to a sufficient voltage. (This is probably by design - otherwise, the flashlamp would overheat very quickly at high rpms.)

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Welch Scientific Model 2153C Stroboscope

Here is a schematic for a typical line operated variable rate stroboscope. This unit is from Welch Scientific - Model 2153C Stroboscope. These things typically gather dust in the dusty dark corners of high school physics labs. :-)

Its uses include the visualization of moving parts as well as rotation speed or frequency determination of rotating or vibrating machinery.

Specifications:

```
 Flash energy   - .1 W-s.
 Low range      - 1.6 to 20 pps (96 to 1200 rpm).
 High range     - 8 to 120 pps (480 to 6000 rpm).
 Flash duration - approximately 10 uS.

                D1   D2       L1 ======         R1              Flashlamp
             +--|>|--|>|--+------^^^^^^--------/\/\/-----------------+----+
             |  1kV  1kV  |       2.5H        25K 25W            FL1 |    |
             |            |                                          |    |
      Power  |            |  200K  2.5M                              |    |
             |        +---+--/\/\--/\/\--+--+-----+                 +|    |
       T1    |        |     R2 ^  R3 ^   |  |     |                _|_    |
          +--+        |   Trim |  Adj|   |  o     |                | | |  |
       ||(            |        /     +---+   | S2 |      Trigger  ||   |  |
H o--+ ||(            |     R4 \     |      o  X5 |         T2    ||   | _|_
      )||(            |   100K /     |      |     +--------+   +--||   | --- C3
 115  )||(            |        \     |      / R7           )::(   ||   |  | .5
 VAC  )||(            |   R5   |     |      \ 100    R8    )::(   || _ |  | uF
      )||(            +--/\/\--+  C4 |      /       220    )::(    |_|_|  |
N o--+ ||(            |  330K  | .05_|_     \    +--/\/\--+ ::(      |    |
       ||(       C1 __|__      /  uF---  C5 |    |          ::(      |    |
          +--+   16 _____   R6 \     | .20_|_  _|_ D3      ::(     -|    |
             |   uF   |   680K /     |   uF---  \/\ Diac       +-+   |    |
             |   700V |        \     |      |    |  175 V        |   |    |
             |        |        |     |      |    |               |   |    |
G o----------+--------+--------+-----+------+----+---------------+---+----+
```

Welch Scientific Model 2153C Stroboscope Operation

1. The power supply consisting of T1, D1, D2, C1, and L1, develops about 650 V. This charges the energy storage capacitor, C3 through R1.

   The trigger capacitor, C4 (X1 range) or C4||C5 (X5 range), charges through the frequency (speed) control network consisting of R2, R3, R4, R5, and R6. The main (user) control is R3 which provides roughly a 12:1 range.

2. When the voltage on the Diac, D3, exceeds about 175 V, D3 changes to the conductive state - it becomes a short circuit. This discharges the trigger capacitor(s) through T2 generating a high voltage pulse (4 to 5 kV) which ionizes the xenon gas in the flashlamp, FL1.

3. The energy storage capacitor discharges through the flashlamp.

4. The energy storage capacitor and trigger capacitor(s) recharge and the cycle repeats. The inductor, L1, prevents the voltage across the energy storage capacitor from increasing too quickly for a few critical milliseconds just after the tube fires to enable the arc to reliably extinguish at high repetition rates.

Welch Scientific Model 2153C Stroboscope Notes

1. Power switch, S1, and fuse, F1, not shown.

2. Flash duration is minimized by using the small (.5 uF) but high voltage energy storage capacitor.

3.
```
      |                          |           |
   ---+--- are connected;     ---|--- and ------- are NOT connected.
      |                          |           |
```

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High Speed Logic Triggered Strobe 1

Basic Description of HSS1

This is a short pulse strobe originally designed by Don Klipstein don@misty.com and myself (Sam) for a special application requiring a very short flash duration (under 50 microseconds), triggering from a logic level input, and portability. It will operate from a 12 to 18 VDC power supply with a cycle time of less than 3 seconds for the 36 uF energy storage capacitor charged to 900 V (15 J). The capacitor voltage is actively regulated with the inverter running as required to maintain full charge. Current consumption (at 12 VDC input) is around 1 A while charging and averages less than 50 mA (in periodic 1 A pulses) while idling. To reduce idle current consumption to near zero, the inverter may be controlled and monitored via the system logic.

The specified flashlamp (8538 from Mouser is a wide bore U-shaped unit suitable for medium power photographic applications. However, this same circuit can be used for a laser pump by replacing the inductor and flashlamp with PFN1/SSY1 or another suitable set of components.

The inverter section could also be used with minor modifications to charge the capacitor(s) for a normal photographic strobe operating at 300 to 500 V. Simply replace R15 with a jumper and modify R14 to produce the desired regulated voltage. Note that many not-quite-so-small flashtubes work best at a lot more than 300 volts. For example, the three largest Mouser tubes have nominal anode voltage of 400 to 450 volts and they will probably do well with even a little more, especially with flash energy well below the limit. Thus HSS1 would also be suitable for these or as an adjustable general purpose capacitor charger.

HSS1 Schematics

- Get the schematic for HSS1 in PDF format: HSS1-SCH.

HSS1 consists of the inverter, pulse forming network (energy storage capacitor, inductor, and flashlamp), and trigger circuit.

The inverter consists of a CMOS TLC555 timer and IGBT (Insulated Gate Bipolar Transistor). The IGBT is driven like a MOSFET but has output characteristics more like that of a bipolar transistor - the best of both worlds. The output voltage is monitored by one section of an LM339 quad voltage comparator and shuts off the oscillator once full charge is reached. With the components values for the voltage divider resistors (R14,R15,R17,R18) shown, this is approximately 900 V. The circuit should work for voltages up to 1 kV or more by changing the value of the parallel combination of R17||R18. As the voltage decays due to leakage through the trigger circuit and voltage monitor, the oscillator will come on briefly at periodic intervals to top off the charge. With some minor changes, the idling current could be substantially reduced.

The other sections of the LM339 are wired as buffers to accept an inverter ENABLE signal, provide a (low going) READY output signal, and drive a READY LED. The ENABLE input and READY output allow the control logic to turn on the inverter on demand (which is fine for the intended application). (But the internal voltage limiter cannot be overridden.) This reduces the idle current consumption substantially.

One beauty of this inverter design is the super simple transformer requiring a grand total of 32 turns of wire. Yes, you read correctly, not the hundreds or thousands of turns you might have expected! :) I didn't believe it the first time I saw the transformer description either. It takes advantage of the flyback pulse generated when the chopper IGBT turns off boosted by the 1:1 autotransformer.

The trigger circuit consists of an opto-triac driving a 10 A SCR which dumps a 0.082 uF capacitor charged to about 300 V through the trigger transformer. For manual triggering, these components could be replaced with a pushbutton switch.

The PFN (Pulse Forming Network) as shown was designed to optimally drive the 8358 flashlamp with a 15 J input at less than 50 us. The inverter itself really doesn't care what is used for the PFN except that as designed it charges to 900 V and how long it will take to charge the energy storage capacitor. This one was designed based on a Ko value for the flashlamp of around 12.

Note that the 36 uF, 1 kV energy storage capacitor (C1) is quite special - I call it the "magic yellow cap". It has a very low ESR (about 24 milliohms) and high peak current capability (at least 800 A). Substituting a series or series/parallel combination of photoflash (electrolytic) capacitors will not result in nearly as short a flash duration or peak light output. The flash will be 2 to 3 times as long and the total output light energy will also be much less because much of the electrical energy will be dissipated inside the much higher ESR capacitors. The typical ESR for a 120 uF, 330 V photoflash capacitor is 0.3 ohms - over 10 times that of the magic yellow cap. Of course, they are also about 25 times cheaper! The magic yellow cap appears physically identical to one found in the laser pump PFN1. It is a custom capacitor from Cornell-Dubilier but I don't think it is listed on their Web site.

The PFN inductor, L1, is just 7 turns of #14 AWG insulated stranded wire in a single layer on a 1.5" diameter form. A toilet paper roll works fine. :)

The diode across the flashlamp (D1) is just insurance. There really should be no reverse voltage across the flashlamp given the critically damped design of the PFN.

The HSS1 Inverter Transformer

The wonderfully simple transformer consists of two E cores of the "older" Ferroxcube part number E375-3C81 (or even previous to that E375-3C8) and the modern Philips Components part number E34/14/9-3C81. The half gap (paper thickness) is two pieces of regular copy paper which should be about 0.2 mm. The bobbin is old Ferroxcube part number E375pcB1-12 and Philips Components part number CPH-E34/14/9-1512. I got them from Eastern Components, 1-800-642-0518.

Gapped versions of this core may be available. If both halves are gapped, specify 0.2 mm. If you get a gapped piece paired with an ungapped piece then the gapped one should be 0.4 mm.

The primary and secondary are each 16 turns of insulated #20 AWG hookup wire, but wire size is not critical and the secondary could easily be #22. Magnet wire is fine with adequate insulation between layers and between the secondary and the core (3C8 and related ferrite materials are slightly conductive!), and as thick as #18 should easily fit.

- Back to Schematics for Miscellaneous Xenon Flash Devices Sub-Table of Contents.

Variable Intensity Variable Frequency Stroboscope

This circuit is designed to provide a variety of options in terms of repetition rate, flash intensity, and various repeat and triggering modes.

- Get the schematic for STROBEX in PDF format: STROBEX-SCH.

The design includes:

1. Line operated voltage doubler power supply. A low voltage inverter could be easily substituted if desired. See the sections starting with: Schematics for Pocket Camera and Externally Mounted Compact Flash Units as well as the document: Various Schematics and Diagrams for a variety of possibilities.

2. Power transformer operated low voltage logic supply.

3. Variable frequency repeat mode controlled by 555 timer.

4. Optoisolated external trigger input.

5. Selectable flash intensities of .2, 2, and 20 W-s.

6. Autorepeat speeds from .05 to 100 Hz (though obviously, the flashlamp will not operate at all intensities for these entire ranges.)

Parts of this circuit have been built and tested but the entire unit is not complete. Maybe someday.

- Back to Schematics for Miscellaneous Xenon Flash Devices Sub-Table of Contents.

Other Strobe Circuits

12 V Powered Ignition Timing Light

This schematic was provided by Jan Hamer.

Here is a timing light circuit that is powered from the 12 V battery in the car (or whatever) rather than the AC line. Ignition Timing Strobe uses a 2 transistor multivibrator with a pair of 2N3053 buffers driving a 240 V to 12 VCT transformer in reverse to charge a 0.1 uF (100 nF) energy storage capacitor. Triggering is via an external electrode connected to the #1 spark plug. CAUTION: Excessive voltage on the trigger electrode could conceivably puncture the glass of the flashlamp or do other damage. The trigger electrode must be arranged in such a way that a discharge will take place harmlessly to ground before this happens.

Flashing Alarm Beacon

This schematic was provided by Jan Hamer.

Flashing Alarm Beacon is a simple line powered fixed rate xenon flasher. It appears to be set for about 5 flashes/per second as drawn. Obviously, it would be easier to change this rate by selecting different values for the 750K resistor through which the trigger timing capacitor is charged.

Note that the 47 uF main energy storage capacitor may be too large for a typical small flashlamp resulting in relatively short life due to excessive power dissipation if nothing else. The flash energy is about 2 w-s so at 5 flashes/per second this becomes 10 W.

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-- end V2.53 --

Sam's Strobe FAQ Components

HTML, Diagrams, Photos, and Schematics

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

Introduction

This is a complete list of the files which constitute the Sam's Strobe FAQ (Official name: Notes on the Troubleshooting and Repair of Electronic Flash Units and Strobe Lights - and - Design Guidelines, Useful Circuits, and Schematics).

Note: There are *zillions* of additional diagrams and schematics included within the HTML files themselves. Those that are listed here are only the ones that are in .pdf, .gif, .jpg, or other graphics or compressed format.

Sam's Strobe FAQ Components

  - Photo of Flash Circuit Using IC 1 - Top View (flshic1t.jpg).
  - Photo of Flash Circuit Using IC 1 - Bottom View (flshic1b.jpg).
  - Flash Circuit Using IC 1 (flashic1.gif).
  - Malcohm's Flashgun Charger (mflinv1.gif).

- Honeywell Prox-O-Lite Flash Unit (hwpl1sch.pdf).

- Variable Intensity Variable Frequency Stroboscope (strobex.pdf).

- HSS1 - High Speed Logic Triggered Strobe 1 (hss1sch.pdf).

- Ignition Timing Strobe (timnglt1.gif).
- Flashing Alarm Beacon (beacon1.gif).

Warning Signs and Icons :-)

- Electrical Safety Warning Sign (Shock.gif).

- Sci.Electronics.Repair FAQ Icon (Browser, serfaq.gif).

- Laser (HeNe Tube) FAQ Icon (Browser, laserfaq.gif)

- Silicon Sam's Technology Resource Icon (Browser, sstr.gif).

- Go to Sam's Strobe FAQ.

Silicon Sam's Technology Resource

Local Installation

Version 1.53

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

Table of Contents

Introduction

This document outlines the installation procedure to create a local browser accssible copy of Silicon Sam's Technology Resource - the complete set of Repair and Information Guides that I have authored. It consists of a set of HTML files and associated schematics, diagrams, and photographs.

Note: Some of these documents (the large electronics and appliance repair guides) are not as nicely formatted as those at the Sci.Electronics.Repair FAQ sites - which you may prefer to view on-line. However, the ugly ones may be more recent versions.

Basic Installation

Important: all-faqs.zip does not include laserfaq.zip (Sam's Laser FAQ). This must be downloaded separately. The following assumes a first time install of SSTR.

- See Home and Mirror Site Locations to identify a site with a ZIPPED version of SSTR.

- Download all-faqs.zip into a new directory (or the same directory as Sam's Laser FAQ) and decompress it (unix unzip or DOS PKUNZIP):

    - Extract all files: unzip all-faqs
    - Extract selected files: unzip (or PKUNZIP) -x all-faqs file1 file2 ...
    - Directory of all-faqs: unzip (or PKUNZIP) -v all-faqs

  (Answer 'yes' or 'all' to any duplicate file queries.)

  The files "faqfil.htm", "cdfaqfil.htm", (and "laserfil.htm" if Sam's Laser FAQ was downloaded and decompressed) contain a summary of all the HTML, photos, diagrams, and schematics which constitute this release.

- When "sammenu.htm" is accessed using a Web browser, everything may be viewed directly. If you want the entry point to be to a short file located elsewhere, move "faqsam.htm" to the desired dirrectory and modify its links to point to the directory where you have put all the text and graphics files.

- Your browser needs to be configured properly to make sense of the many ASCII diagrams, schematics, and tables. See the document: Suggested Browser Settings for font and other related information.

- If you are not planning to have Sam's Laser FAQ loaded locally but would like the laser related links to be live, edit "sammenu.htm" and replace the text strings: "lasersam.htm", "laserfil.htm", and "laserpic/laesrpic.htm", with links to files of the same names in the SSTR directory at one of the sites found in "samsites.htm".

I routinely test all of this on both Unix (Sun OS/Solaris) and DOS under Win95/Win98. Please let me know if there are any problems.

Icons and Links

A set of icons are included for linking to Silicon Sam's Technology Resource or the full Sci.Electronics.Repair FAQ from you own Web pages (sstr.gif or serfaq.gif, 64 x 64 pixels) and from Windows (sstr.ico or serfaq.ico, 32 x 32 pixels). For example:

- To create a link to SSTR from an existing Web page, use a text or HTML editor to add the following lines to it:

  ```
  <li><a href="sammenu.htm">SSTR Main ToC</a>  <a href="sammenu.htm">
    <img WIDTH=64 HEIGHT=64 src="sstr.gif" alt="SSTR" align=middle
    border=0></a> - Comprehensive Repair Guides, FAQs, Testing Info,
    Assorted Schematics, etc.
  ```

  This will add the SSTR icon and create hot links to the SSTR Main Table of Contents as long as it is in the same directory with an appearance similar to this:

  - SSTR Main ToC - Comprehensive Repair Guides, FAQs, Testing Info, Assorted Schematics, etc.

  Edit as appropriate for your complete path if located elsewhere or to link to the S.E.R FAQ.

- If you are running Win95 or Win98 (I don't know if this works for Win3.1x), the .ico format icon files can be used when accessing SSTR or the full S.E.R FAQ from a folder or the desktop.

  To add a link from the Win95 desktop directly to the Silicon Sam's Technology Resource main menu, via Netscape, surf over to your copy of "sammenu.htm" and press and hold the left mouse button while dragging the local "Main Menu" or its icon hot link to the desktop. Create a shortcut there and then edit its properties to use the icon of your choice! (You can do the same thing with any of the other hot links instead if you do not intend to maintain a local copy of these documents.)

- Back to SSTR Install Table of Contents.
- Go (back) to Home and Mirror Site Locations.

-- end V1.53 --

Sam's Gadget FAQ

Salvaging Interesting Gadgets, Components, and Subsystems

Version 1.53

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

Table of Contents

PART I - Household (Well, Sort of) Sources of Useful Gadgets

PART II - What Common Consumer Electronic Equipment and Appliance Contain

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* Back to Sam's Gadget FAQ Table of Contents.

Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

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* Back to Sam's Gadget FAQ Table of Contents.

Introduction

Reducing the Clutter in Land Fills

The purpose of this document is to prevent land fills from becoming filled. :-)

Many dead appliances, and consumer electronic and computer equipment contain parts and subassemblies which are not only neat and interesting, but useful for various experiments and projects.

- I bet you tossed that big heavy slow 5-1/4" hard drive in the garbage when you upgraded, didn't you? Admit it! Did you know that if it was a high performance drive, it contained several of the most powerful permanent magnets you would ever be likely to find anywhere? And, they would have been free!
- That big old microwave oven? Too bad. More magnets, nice high voltage power transformer, rectifier, capacitor. Electronic or mechanical timer, fans, other motors, etc.
- What about that dot matrix printer? Too bad - at least two stepper motors, a nice power supply, and various other electronic and mechanical components.
- More steppers in floppy drives. Also, probably a regulated speed pancake motor.
- Old TV or monitor? Another mistake. The high voltage power supply was probably good for 12 to 30 kVDC at 1 or 2 mA. This is useful for many high voltage experiments, plasma globes, negative ion and ozone generators, bug disintegrators, starters for really LARGE HeNe lasers, etc.

There will be several types of information:

1. Where to obtain a particular type of part like a powerful magnet.
2. What dead consumer electronics, computer equipment, and appliances yield in the way of useful parts.
3. Unconventional uses for subsystems or common replacement parts or modules from such equipment.

Safety Considerations

The devices, equipment, circuits, and other gadgets described in this document may be dangerous. Much of it deals with potentially lethal voltages. Getting electrocuted could ruin your whole day.

Before thinking about experimenting with anything using or producing high voltages or connected to the AC line - even opening up a disposable camera that may have been laying around gathering dust (the capacitor can still be charged - arggh!), see the document: Safety Guidelines for High Voltage and/or

Line Powered Equipment. A large percentage of equipment that is perfectly safe from the outside has dangers lurking inside. In addition to electrical dangers, there might be sharp sheet metal, wound up springs, powerful magnets, and other potential risks to your outer surface integrity like CRT implosion - just to name a few. Something that looks innocent can really ruin your entire day!

For really high voltage equipment, also see: Tesla Coils Safety Information.

Places to Obtain Sacrificial Equipment

So, where do you find the equipment from which to remove parts other than your basement, your attic, or those of your relatives or friends? Consider garage, yard, tag, estate, and other sales; thrift stores (which may even have a 'free' table); junk, salvage, and surplus yards (including those run by the Department of Defense!), the town dump and other landfills if they let you take things away, trash rooms of high rise apartment complexes, the curb on pickup day, college campuses around the end of the Spring term, and any other place where perfectly good equipment gets tossed in this throw-away society!

Of course, don't overlook high tech flea markets as well as ham and computer fests. Regular flea markets are usually overpriced (where do you think they get the stuff??) but sometimes you will be able to negotiate a great price because they have no idea of what they are selling!

Yes, we are a strange bunch. :-)

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Neat Magnets

Sources of Extremely Powerful Magnets

Two excellent sources of magnets are described below. These are at least as strong as the more well known speaker types, possibly much stronger, and generally easier to remove:

- Microwave oven magnetron tubes. Go to your local appliance repair shop and ask - they just toss bad ones. Each one has two ring shaped ferrite magnets about 2-1/4" in diameter with a 7/8" hole, magnetized N-S on the faces.

  Surplus places typically charge $3 to $6 each for one of these magnets.

  Note: A few older magnetrons used AlNiCo magnet assemblies or even possibly electromagnets which are not nearly as interesting. However, you probably won't see any of these.

- Large hard disk drives - especially full height 5-1/4" high performance types - e.g., Seagate

WREN series or Micropolous boat anchors (the rare earth magnets in these are wicked). The magnets in small drives are even stronger but are, well, much smaller. :-) A typical size for a large drive is about 1" x 1-1/4" by 1/2". Since almost no one wants such large slow drives anymore, they are often found at swap meets or yard sales for next to nothing. These magnets are a few thousand Gauss compared to 10 to 15 K Gauss (1 to 1.5 Tesla) for a medical MRI scanner (of course, the field of the MRI scanner's superconducting magnet is uniform over a volume of several cubic FEET! The disk drive magnet's field decays quickly as you move away from it.)

Surplus places may charge $12 or more for ONE of the magnets from a large disk drive (there are typically 2 to 6 such magnets in a disk drive)!

I have a monolithic clump of 40 or 50 of the magnets from full height 5-1/4" SCSI drives. I figure there is a black hole growing inside but haven't dared to look. :) The only way I was able put the clump together with minimal damage to flesh was by using a hard wood ramp to gently guide each new magnet into place. I haven't figured out how I'll ever get them apart though!

Here is a quick easy experiment to try with these powerful magnets: Slide one such magnet over a thick aluminum plate. What do you feel? Or, let a 1/8" x 2" x 12" aluminum plate drop through the intact yoke from a Seagate WREN series 5-1/4" full height hard drive positioner. What happens? Why? What material might produce an even more pronounced effect? Why?

For more things to do with these neat magnets, see: Neodymiumarium.

CAUTION: Both these types are powerful and will squash flesh as they suck all the bits off of your magnetic media! I am not kidding about the part about squashed flesh - with some you actually need a small crowbar to pry the assembly apart!

You will find that some of these magnets are painted. This provides some resistance to chipping though this material may be on the verge of flaking off or has already done so in spots. In any case, I further recommend that you add additional layers of a tough enamel (e.g., Rustoleum) or the plastic/rubber dip used to coat tool handles. Otherwise, chipping damage (at least) will result all too easily and the chips are just as powerful as the rest of the magnet.

Additional Disclaimer: I will not be responsible when your spouse or parents come home to find the microwave or PC missing some key components and as dead as a brick!

(From: Terry Sanford (tsanford@nf.sympatico.ca).)

Magnets salvaged from scrapped computer drives are strong!

- We use them to hold old blankets that cover a vintage car stored in garage.
- Useful for finding nail locations in plasterboard walls. Strong magnet will 'stick' to wall at the nail location. better than those weak magnet 'dippy indicator' things! You can leave magnet parked on

the nearest nail head after each use!

- Use magnet to pick up wrench/spanner dropped off boat wharf into ten feet of sea water! Also fished wrench out from under patio deck other day; main problem was finagling wrench through the gap between the deck boards. Used bent coat hangar which kept sticking to the magnet; darn!

- Also you can 'feel' if current is actually flowing to an electrical appliance by holding a strong magnet next to the wiring! It detects 'flow' not the presence of voltage.

PS: After WWII, strong horseshoe ex radar magnetron magnets were sold surplus for about two and sixpence each. Someone took his into a pub on way home and everyone had a great time with it until people starting checking their (then magnetic) watches. He wasn't too popular after that I can tell you!

Other Sources of Fairly Powerful Magnets

The following are other possibilities. However, they are not likely to be nearly as strong!

- Spent laser printer toner cartridges where the entire developer assembly is part of the cartridge (e.g., EPS-2 for Canon engines). These include a page-width ferrite magnet. However, expect to make a mess disassembling the cartridge as there will still be considerable toner remaining inside.

  WARNING: The toner is a possible health hazard. A good dust mask should be used while working on these. Also, do not vacuum what remains - static can set off a dust explosion - use wet rags or paper towels to clean up the mess! The coating on the photosensitive drum may also be a hazardous material.

- Loudspeakers.

  - Smaller or older speakers use AlNiCo type magnets which are usually in the form of a cylinder (about as tall as it is wide). AlNiCo is an extremely hard metal alloy.

    AlNiCo magnets are not as powerful as ferrite or rare earth types and are easily demagnetized (but just as easily remagnetized). Passing a stack of these through the center hole of a strong ferrite magnet will increase their strength dramatically - until they are separated from each other!

  - Modern loudspeakers use ring shaped ceramic ferrite magnets (similar to those in a microwave oven magnetron - see the section: Neat Magnets) glued to the pole piece (yoke) assembly within which the voice coil moves. The ferrite is extremely hard but very brittle so care must be used to extract these from the yoke assembly - see the section: Disassembling Loudspeakers to Get at the Magnets.

- Permanent magnet stepper and servo motors. These will use ferrite or rare earth magnets usually in strange shapes. Note: Removing the magnets may result in partial demagnetization (reduction in magnetic strength) as the rotor is part of the magnetic circuit. Therefore, I do not recommend this source. There is generally no practical way of remagnetizing the strange shapes involved.

- Optical (laser) pickups from CD players, CDROM drives, and other optical data storage devices. These may have some very tiny, but strong, rare earth magnets in the focus and tracking actuator. However, it seems a shame to sacrifice the beautiful mechanics in such a device just to get the magnets! CAUTION: Tiny magnets even more fragile than bigger ones!

Disassembling Loudspeakers to Get at the Magnets

For small speakers with AlNiCo type magnets (the magnets usually look like metal cylinders), careful prying with a sturdy screwdriver will usually break the adhesive bond and/or free them from the yoke assembly. Note: Use the proper tool for the job - not your dad's prized screwdrivers!) Unlike the ceramic magnets described below, AlNiCo types are metal and quite sturdy.

(From: Arie de Muynck (ademu@pi.net).)

For the normal black ceramic ring shaped magnets (and likely for some Ticonal 'iron colored') the trick is: heat the complete assembly slowly using a paint-stripper gun, or in an oven (thermal, not microwave!). The glue will weaken and with a screwdriver you can SLOWLY work them loose. Protect your fingers with an old cloth. Never apply too much force, the ceramic would chip or break.

Do not overheat them above the so-called Curie temperature or the magnet will loose it's power irreversibly. That temp depends on the material but should be way above the 120 C or so to soften the glue. If you want to experiment with this effect: use a piece of iron attracted towards a magnet, heat the iron with a flame and above a rather sharply defined temperature it will not be attracted anymore. The effect is used in some Weller soldering irons to stabilize the temp.

Note that the force of a bare ceramic magnet is not as strong as you might expect, the magnetic lines of the large area of the ring have to be bundled and guided though iron to a narrow gap to provide a proper magnetic field.

How do I Make a Harddrive Motor Spin?

You are tempted - those spindle motors that are part of the same large old clunky harddrives that yield really powerful magnets look like they would be perfect in that next robotics project if only you could figure out what all those darn wires were for!

(From: Bob Weiss (bweiss@carroll.com).)

These motors are usually brushless DC, and can be a pain to figure out. Windings are usually 3-phase wye. DC power applied to center tap of wye, and ends of windings go to output transistors/fets in the driver. Driven by 3 pulse trains 120 degrees apart. Other leads are for hall effect sensors that measure rotor position and time the drive pulses to the relative positions of the rotor magnets and stator coils. Not an easy driver to build from discretes! Some motors contain all the driver electronics, and only require +12VDC and a TTL enable signal to run. The Disc drive you took them out of will contain appropriate parts to build a controller, probably a driver chip from SGS or Sprague UCN series. Look up the chip in a databook for suggested circuitry. Best way to learn this field is reverse engineering!

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High Voltage Power Supplies from Dead Equipment

You are Surrounded by HV Equipment!

There are a surprisingly large number of types of common consumer electronics equipment and appliances which employ high voltage in one form or another:

- TVs, monitors, and computer terminals all contain a source of high voltage for the CRT. Depending on the particular model, up to 30 kVDC or more at 1 to 2 mA will be available assuming the deflection/HV subsystem of your sacrificial equipment is in operating condition. However, you cannot (or at least should not) just string HV wires from the back of the family's 35 inch TV to your lab. :-)

    - How much circuitry you actually need (and what you will have to add) depends on design but figure on the mainboard with the deflection drive and flyback, and probably the yoke (to keep the system properly tuned though this may not be essential).

      Some capacitance on the HV output may be needed as well (though the ones I have tried were happy enough with just the stray capacitance of the wiring). Originally, the CRT envelope provided this capacitance.

      See the section: Why the Yoke is Needed to Keep the Horizontal Deflection System Happy.

    - Power will either be the AC line (WARNING: Very dangerous) or a DC supply (typically 12 to 24 VDC). They will usually operate on somewhat lower input voltages with correspondingly reduced output.

    - A 555 timer based oscillator or other horizontal sync source may be needed as well if the system doesn't free-run at close to the normal horizontal scan rate. This is probably easier where the guts came from a monitor or terminal (since a separate TTL compatible horizontal drive input is likely to be available) but it should be possible to fake out a TV as well.

    - Depending on design, these may require signals like 'HV Enable' and/or a feedback or reference voltage to operate properly.

    - Small B/W TVs, mono computer monitors, and computer terminals will provide about 12 to 15 kV.

    - Large B/W TVs and Color TVs and monitors will provide 15 to 30 kV. Even more from projection sets!

    - Some larger high performance color monitors may have a separate self contained HV module. One particular type (found in a 19 inch workstation monitor) is rated at 25 kV, 1.1 mA (and produces several other voltages) from a 26 VDC, 2.5 A power supply. However, by tweaking some internal pots, over 30 kV is available. See the section: High Voltage Power Supply Module from Monitronix EZ Series Monitors for one example.

  One key advantage of using predesigned circuitry is that you are less likely to destroy power transistors and other expensive parts - and I have blown my unfair share. :-(

  See the section: Sam's Super-Starter(tm) for a specific example of this kludge, um, err, approach for starting large HeNe laser tubes. :-)

- The high voltage power supplies from plasma globes, electrostatic dust precipitators, photocopiers and laser printers, bug zappers, negative ion and ozone generators, electric fences, cattle prods, electric chairs, and other 'common' equipment may be pressed into service for your applications.

  Since these HV generators are not combined with anything else, they are likely to be self contained modules and very easily used by themselves.

  However, available current from some of these sources is generally less than from TVs or monitors. Details are left to the highly motivated student. :-)

    - Plasma globes: Pulsed (not rectified or filtered) 10 to 15 kV.

    - Electrostatic dust precipitators: 5 to 10 kVDC.

    - Photocopiers and laser printers: Two outputs at 5 or 6 kVDC.

    - Bug zappers: 10 kV???.

CAUTION: Since these power supplies were designed for a specific purpose under specific operating conditions, their behavior when confronted with overloads or short circuits on the output will depend on their design. It may not be pretty - as in they may blow up! Take care to avoid such events and/or add suitable protection in the form of fast acting fuses and current limiting to the switching transistor.

Note about X-rays: Improper use of these sorts of devices may result in shock or electrocution, but at least you will not be irradiated at the same time unless you connect them to a something which includes a vacuum. In order to produce measurable X-ray radiation, electrons must be accelerated to high velocity and strike a heavy metal target. A high vacuum such as in a CRT or other vacuum tube (valve) is best but there may be some X-ray production from a low pressure gas filled tube. There is virtually none in sparks or arcs at normal atmospheric pressure. However, there will be UV and ozone which are both hazardous.

Sam's Super-Starter(tm)

This would be called a kludge by some, a Rube Goldberg by others. But, hey, as still others would say: "If it works, use it!". The original application was for starting LARGE HeNe laser tubes but there can be many other uses.

The entire horizontal deflection and high voltage sections of a long obsolete and lonely ASCII video display terminal were pressed into service for starting larger HeNe tubes. A source of about 12 VDC at 1.5 A is needed for power and a 555 timer based oscillator is needed to provide the fake horizontal sync:

- The deflection circuitry was all on one corner of relatively small board (about 3 x 6 inches). The flyback transformer is a plug-in unit. I left the other circuitry (vertical, video) in place since it is not powered by the same supply and therefore is pretty inert. However, if you want to recycle the parts.....

- The horizontal deflection yoke is needed to 'tune' the system - performance is much better with it installed. This wart looks a bit strange but is the easiest way to avoid modifying the design. See the section: Why the Yoke is Needed to Keep the Horizontal Deflection System Happy for more info.

- Horizontal drive is provided by a 555 timer in astable mode running at about 16 kHz (the original horizontal deflection rate of the terminal). A 10K ohm pot allows me to fine tune this for maximum HV output.

  Well, it turns out there was an unused spot on the board ready made for this circuit (well almost, at least there was a pattern for a spare 8 pin DIP! So, once the thing was basically working, I built the oscillator onto the board to reduce the clutter!

- Power requirements are modest - 10 to 15 VDC at just over 1 A. Over this range, the output varies between about 10 and 15 kV (what a coincidence!). Input down to about 5 VDC produces correspondingly reduced output but the circuit is not particularly stable over this lower range of voltages.)

I guarantee that "Sam's super-starter(tm)" - or its big brother, "Sam's hyper-starter(tm)" using parts from a color TV or monitor - will start ANY HeNe tube that can possibly be started! These also make nice self contained HV sources for other experiments. :-)

Why the Yoke is Needed to Keep the Horizontal Deflection System Happy

If you unplug the yoke (even if there is no interlock), while the system may still work to some extent but performance will be poor. High voltage will be reduced and parts may overheat (and possibly blow up).

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

Of course that doesn't work. The flyback capacitor is tuned for the presence of both inductances: line transformer and deflection coil. If you remove the deflection coil then the remaining primary transformer inductance is about 5 times as large. So, rule-of-thumb, you would have to decrease the flyback capacitor by a factor of approximate 5. But that's not all:

Without the deflection coil, a lot less current runs through the horizontal output transistor. So, in all likelihood, it will now be overdriven. So you need to reduce the base drive. But that's not all:

If you remove the picture tube capacitance and the deflection coil then all peak energy demand must be delivered from the primary winding of the line transformer. Even the shortest peak load will cause saturation. The parallel deflection coil will at least lend some temporary energy, and the picture tube capacitance does an even better job. A good high-voltage source without the benefit of a deflection coil is more expensive...

If you *must* get rid of the 'ugly' deflection coil, then you may want to replace it with an equivalent 'pretty' coil. But:

- It must be able to carry the peak current without saturation (a deflection coil has such a huge air gap that it can not possibly ever saturate, but a smaller coil can).
- It must have a low enough dissipation so you might have to wind it with litz-like wire (multi-stranded isolated), do not underestimate the losses in high-frequency coils, mostly due to skin- and proximity-effect.
- Yes, it can be done, good luck.

And you might want to add a discrete high-voltage capacitor. How to isolate the wiring (corona discharge!) is left as an exercise to the reader... (We pot them in convenient blocks).

High Voltage Power Supply Module from Monitronix EZ Series Monitors

This is a self contained module (separate from the deflection circuitry) which makes it very convenient for your HV projects.

It is fully enclosed in an aluminum case about 1-7/8" x 6" x 5" with a 9 pin connector for the low voltage wiring and thick red wires with HV connectors - suction cup and Alden type - for the CRT 2nd anode and focus voltage respectively.

- Manufacturer: Toyo, Corp., Japan
- Model: HVP-1208A1-26L.
- Input: 26 V, 2.5 A max.
- Outputs:
  - High Voltage: 25 kVDC, 1.1 mA
  - Focus: 4.5 to 7.65 kVDC, 15 uA
  - G2: 200 to 1000 VDC, 5 uA
  - AUX: -200 VDC, .5 mA

There are 8 pins installed on the 9 pin connector of which 6 were used. I wonder if the other 2 have any function other than spacing off the G2 voltage.

```
   ___________
  /           \
 (  o3  o6  o9 |
  >            |  View of connector on case.
 (  o2  o5  o8 |
  >            |
 (  o1  o4  o7 |
  \___________/
```

- Pin 1 - G1: -200 VDC (-184 VDC measured), white or yellow.
- Pin 2 - DC+ in: 26 VDC, 2.5 A max, green or brown.
- Pin 3 - Power Gnd, black.
- Pin 4 - Shield Gnd, bare or black.
- Pin 5 - NC.
- Pin 6 - NC.
- Pin 7 - Enable (low) TTL, orange.
- Pin 8 - NC.
- Pin 9 - G2 (+200 to +1000 VDC), red.

I assume the NCs are truly not connected to anything and simply serve as clearance for the up to 1000 V G2.

In addition to the Focus and G2 pots, there is an unmarked adjustment accessible via a hole in the case. At first, this appeared to have no effect on any output.

When I opened the case, 2 additional pots come into view. While I do not really know their exact function, by advancing them clockwise, the HV could be boosted significantly. With both fully clockwise, the externally accessible control will vary the HV between about 27 and 32 kVDC regulated (only HV probe meter load).

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High Voltage Transformers

Types of HV Transformers and Where to Get Them

There are many types of transformers capable of generating high voltages for hobbyist type projects. Some operate from the AC line directly while others require an interrupter or solid state high frequency driver.

- Neon sign or luminous tube transformers (same thing): 10 to 15 kV at 15 to 60 mA, current limited. Some may be higher. There are also smaller ones.

  Current limited means that the transformer will deliver the rated current (Io) into a short circuit and produce the rated voltage (Vo) with no load. In between, it is designed to produce a somewhat constant current up to a substantial fraction of its no-load output voltage. This is somewhat similar to being in series with a resistor equal to n*Vo/Io (where n may be 2 or 3 or more) over this range but implemented without silicon as the magnetic design of the core and windings with no extra power dissipation. (It isn't really this straightforward but will serve as a first approximation.) Therefore, a short circuit on the output will not blow a fuse or trip a breaker (though the transformer will overheat if left this way for too long).

  Sources: Your local sign shop, demolition company, or salvage yard. New: $100 or more. Used: $5 to $50 or free.

  Both iron (an actual transformer) and electronic (high frequency inverter) types are available. The iron types are more robust and will survive repeated abuse that may destroy the others but they are heavy.

  WARNING: Though current limited, the available current from neon sign transformers - especially the larger ones - is far into the range where lethal consequences are likely under the wrong circumstances.

  (From: Jason Freeburg (egraffiti@iname.com).)

  > "A used neon sign transformer should not cost more than $20 or so. Find a neon shop in your area. They usually have the used ones stacked up somewhere and will sell cheap. The 60 mA models are usually somewhat cheaper than the 30 mA type if

you buy them used from a neon shop because they are really too hot (e.g., provide too much current) for running neon and they cause staining and premature burnouts. It all depends on the particular shop you go to. I don't suggest buying new for something like this, the performance will be the same but the price much higher. A new 15 kV, 60 mA transformer lists for about $80.

BTW, the best name to look for in neon sign transformers is France. These things are ruggedly built like and will take a lot of abuse without dying. The name to avoid is Actown - their transformers are wimpy and usually don't deliver the rated current."

- Oil burner ignition transformers: 8 to 10 kV at 10 to 25 mA, current limited. (See description for neon sign transformers, above.)

  Sources: Your local HVAC contractor probably for the asking as the ignition transformers are thrown out along with old oil burners when they are replaced. Of course, you will probably have to take the entire icky smelling disgusting burner assembly as part of the deal. :-) However, there is will be a nice motor and small oil pump in there as well. ;-)

  WARNING: Though current limited, the available current from oil burner ignition transformers is still more than enough to kill under the wrong circumstances.

Both neon sign and oil burner ignition transformer generally have centertapped secondaries connected to the case - which MUST be grounded (via a three wire cord and properly wired outlet) for SAFETY. Therefore, it is generally not possible to construct a totally isolated HV power supplie with these devices.

- Microwave oven high voltage transformers: 1.5 to 3 kV at 0.25 to 0.5 AMPS.

  Sources: Dead microwave ovens (the transformer is rarely the problem). Try your local appliance repair shop. However, you will probably have to cart away the entire oven - but other useful parts inside. :-) See the section: Dangerous (or Useful) Parts in a Dead Microwave Oven.

  WARNING: The electrocution danger from microwave oven transformers cannot be overemphasized. They are not current limited, and even if they were, could be instantly lethal given the least excuse for a suitable path through your body since the rated current is a substantial fraction of an AMP at several thousand volts. Normally, one end of the high voltage secondary is bonded to the core - which must be grounded for safety. However, it may be possible to disconnect this and construct an isolated HV power supply (which will be only marginally less dangerous).

- Automotive ignition coils: 25 to 75 kV (depending on model) at low current.

  Sources: Your 1997 Honda. Just kidding. :-) Auto repair shops or parts stores, salvage yards.

WARNING: While unlikely to be lethal, the HV output of an ignition coil can still result in a seriously unpleasant shock and possible collateral damage.

- Flyback transformers from TVs, monitors, computer terminals, or other HV power supplies. Little teeny ones in CRT based camcorder viewfinders and older Watchman TVs. Output from less than 3 kV to over 30 kV at 1 to 2 mA depending on model. Most include a high voltage rectifier though some may use an external one or voltage multiplier (also a useful and neat device).

  For many hobbyist uses, the only portion of the flyback that is important will be the high voltage winding (and rectifier, if present). It is a simple matter to add your own drive and feedback windings on the flyback core. This eliminates the uncertainty of determining the number of turns and wire size for the existing windings.

  Sources: CRT based equipment tossed for failures NOT caused by a defective flyback. However, sometimes even a bad flyback can be used for HV projects. This will be the case if the problem is:

  - Shorted primary windings. With some flybacks, the primary windings are on a separate bobbin and can be removed. Even when buried, they can sometimes be extracted without affecting the HV winding (just don't lose the HV return!).

  - External arcing due to cracks or pin-holes. Try coating with RTV silicone or HV sealer (allow ample time to dry completely). Plastic electrical tape may work temporarily at least. Note: Try to get the type of RTV that is non-acidic. The normal kind (that smells like viniger when curing) may be corrosive to the wiring. However, I haven't seen problems with this.

  - Breakdown in focus/screen network. This section may be removable with a hacksaw or small chisel! Then, insulate the exposed HV terminals as above.

  - Shorted HV rectifier (rare). Just add an external HV rectifier if needed.

    If you really want AC, this is an advantage! In fact, it might be possible to deliberately short the HV rectifier where you want an AC source by passing excessive (DC) current through it and/or violating its PIV rating (but that may be tough as other parts are likely to fail first!).

  - Broken or cracked core. Substitute the core from another flyback or glue or clamp the pieces together (broken edges in close contact). Don't lose the mylar/plastic spacers and replace them (if needed) when the repair is complete!

  No one actually buys flyback transformers for experimentation!

  WARNING: Flyback transformers are capable of producing shocking experiences. However, when run at high frequencies, your first hint of bodily damage may be via your sense of smell -

from burning flesh. Keep clear!

Note: Ignition coils and flyback transformers can generate very high voltages but must be driven by a pulsed or high frequency drive circuit. These cannot be plugged into the wall socket directly!

Also see the section: Driving Automotive Ignition Coils and Similar Devices.

Basic Ignition Coil Circuit

For a description of how an ignition coil generates high voltage and some math, see the section: Driving Automotive Ignition Coils and Similar Devices. The circuit below is about the simplest possible and easily generates 25 kV using the 12 VDC output of a surplus PC power supply:

```
                           T1 +-------o HV Out
              Rb       Bat ||(
+12 o--------/\/\--------+ ||(
                          )||( Ignition Coil
                          )||(
             Cp           )||(
        +----||---+----+-+    +-+
        |         |    |        |
        | S1 _|_  |    +--------+
Gnd o---+----o o--+
           Points
```

- T1 is one of those round metal can ignition coils widely used in automobiles when there were actual points. If you have a modern one, that should work also as long as there isn't other 'stuff' inside.

- Rb is a current limiting ballast resistor. I used the nichrome element from a defunct waffle baker but an auto headlight or any other high power resistor will work just as well. The nice thing about the heating element is that it is easily adjustable by just moving a crocodile clip lead.

- Cp is essential - not just to protect the switch contacts ('points') but to provide a buffer so that current flow isn't interrupted so suddenly that a low voltage arc forms across the switch contacts. Without Cp, there will be next to no HV output. Think of it this way: without Cp, as the points open, the inductive kick-back from T1 results in an arc forming across the switch contacts. This is relatively low voltage and essentially kills any output from the coil. With Cp present, current continues to flow into Cp until the contacts have opened wide enough that they no longer arc and a high voltage can build up (probably a couple hundred volts). The accompanying field collapse results in a nice juicy spark from the ignition coil! See additional comments below.

  I used a .1 uF, 400 V capacitor for Cp. You can try smaller capacitors (but at least the same voltage). Too small, however, and that annoying arcing will return and you will barely be able to light a tiny neon indicator lamp!

- S1, the switch ('points') should be a 'fast break' variety - not a knife switch. The faster the contacts move apart (and the better the insulating medium is if it isn't air), the smaller Cp can be and still result in reliable operation. Smaller Cp should result in higher output voltage. Just touching some wires was erratic - a large pushbutton 'micro-switch' was much better. Of course, using a power transistor and 555 timer to drive it would be even more way cool. :) See the "Adjustable High Voltage Power Supply" in the document: Various Schematics and Diagrams. It can easily be adapted to use an ignition coil instead of its flyback transformer.

- The power supply was a no-name far-East 200 W unit for a PC clone. You will likely need a load on the +5 to keep it happy - an automotive headlight works well. The second half of a dual-beam headlight can be used for Rb (though you may want to go to a lower value and it isn't adjustable like the heating element, above).

I was able to obtain a 1 inch spark from each button release using about 2 ohms for Rb. If you build an interrupter/buzzer or a mechanical doohickey (technical term) to operate the points, you will get a nice steady stream of fat juicy sparks. Just take care - contact with one isn't going to be an experience you will want to repeat.

(From: Jonathan Bromley (jsebromley@brookes.ac.uk).)

The voltage across the coil is L*dI/dt. Voltage across the coil HT winding is the same, but larger by a factor of (turns ratio) which is typically 50 to 100 in ordinary car coils.

When the points are closed, the coil current will progressively increase because the full battery supply appears across the primary. This will incidentally put around 1kV across the secondary, not enough to jump the gaps in spark plug and distributor. The points dwell time (or the behaviour of the electronic points-substitute controller) will be such as to allow the coil current to reach some sensible value.

When the points open, if no capacitor then current would instantaneously collapse to zero giving a very high coil voltage (huge dI/dt). But this happens JUST AT THE MOMENT THE POINTS OPEN, when the points gap is tiny. So the high coil voltage will immediately strike an arc at the points as they open. This provides a fairly low-resistance path which will be sustained as the points open further. dI/dt is therefore not so big after all, just enough to maintain the few tens of volts across the points arc. Therefore, not enough voltage on the HT winding to fire the proper spark, and all the stored energy in the coil goes into the arc at the points.

So, the (rather small) capacitor is there to allow the coil current to continue to flow, without a big voltage appearing across the points initially. Basically this C is there to give the points time to open before the coil primary voltage reaches its peak value of a few hundred volts. The C is chosen to resonate with the L of the primary so that the peak voltage is delayed just long enough so that the points are open wide enough that the 500V primary voltage DOESN'T arc across them, but the 50*500V = 25kV secondary voltage DOES jump the plug/distributor gaps. It's therefore the breakdown voltage of the plug/distributor gap that controls the highest voltage reached across the points. Typically this will not be high enough to allow much of the coil's energy to be transferred into the capacitor. Any energy that _is_ stored in the capacitor will eventually find its way into the spark by the reverse- current mechanism that you describe - the spark current will oscillate for a while. But the oscillations are fairly heavily damped by the loss of energy into the spark.

The story is slightly more complex in reality because of finite resistance of the coil windings and their distributed capacitance, but this simplified account is not too far from the truth.

(From: George Nole (gnole@brisbane.dialix.com.au).)

In the operation of the Kettering ignition system three clearly defined stages or phases can be identified.

1. Points closed.
2. Points open, but no gas discharge or spark has been initiated.
3. As per (2) but discharge has occurred.

Before proceeding with an analysis, a few notes on the ignition coil. The ignition coil is a transformer with very high leakage inductance. This because the core of the coil is not a closed magnetic circuit, but a straight piece with both ends open. The turns ratio is of the order of 100 or so. Recent measurements on a 6V coil revealed primary inductance with secondary open -no discharge- of 4mH, and with the secondary loaded -gas discharge- of 1mH. These values vary considerably from coil to coil.

Now the analysis which you can do yourself. Don't take my word.

1. With the points closed a current flows and energy is stored in the inductor (primary inductance).

2. When the points open, the circuit consists of a capacitor or condenser in series with the inductor. The other terminal of the capacitor is connected to chassis, and so is the other terminal of inductor via the ignition switch and the car battery.

   This forms a series resonant circuit of finite Q with energy stored in the inductor, and will start to oscillate. The voltage across the inductor -and the capacitor- will be much higher than the voltage across the series resonant circuit and in practice it is of the order of a few hundred volts. This is important because, with a transformer ratio of -say- 100 and a secondary requirement of 20kV, the primary voltage has to be 200V.

3. Before the oscillation can reach the first peak the gas discharge commences and the inductance changes to that of the leakage value, with a quenched oscillation continuing at a higher frequency than the frequency before the spark.

End of analysis.

What would happen if you tried to start the car without a condenser? If you do the experiment, please let me know the result.

Driving Automotive Ignition Coils and Similar Devices

From a posting on one of the sci.electronics newsgroups:

> "I have some questions about automotive ignition coils. I'm referring to the cylindrical "universal" type which has two 12 V terminals and one HV terminal in the center of the cap.
>
> What is the typical peak output voltage and current?
>
> What is the maximum average power input that such a coil can tolerate? I'm aware that the cross-sectional area of a transformer core dictates power handling capability. Judging from the skinny core in a spark coil, I'd place the maximum continuous duty input at around 50 watts. Am I in the ball park on this?
>
> Is there an optimum pulse rate?
>
> Do ignition coils employ any sort of current limiting?
>
> Do "high-performance" coils with 45-75kv outputs offer significant increases in output power, or just higher voltage?"

(From: jfreitag@gsosun1.gso.uri.edu (John Freitag).)

First, be aware that the coil does not act as a transformer as such, even so called "Hot Coils" have only a 1:100 turns ratio which would give only 1,200 volts from a transformer. If you were to energize the coil with an AC voltage like you would with a transformer this is what you would get. An automobile ignition is more properly referred to as an "induction coil" Its output voltage is defined, not by the turns ratio but rather by the differential equation:

```
V = L di/dt
```

Where:

- V is the output voltage
- L is the inductance in Henrys
- di/dt is the rate of change of current flow as the field collapses in the coil.

V into an open circuit, will essentially rise until a spark jumps. When the air ionizes and the spark occurs the remaining energy in the coil sustains the spark.

Hot coils have a heavier primary so that they can pass more current, hence a higher di/dt.

The maximum pulse rate is determined by the time taken for the current to build when the points close (due to L it rises slowly until it reaches a steady state) and the time for the field to collapse when the points open. (the voltage to generate the spark occurs only after the points open and the field is collapsing)

I have never thought about the power in the spark but I suppose it would be:

P = (L di/dt)^2 / R where P is the power in watts and R is the total resistance of the coil secondary, the plug wire and the ionized spark gap. (Some Professor of EE is welcome to comment here).

As for current limiting, many coils employ a series resistor in the primary which limits current and is shorted out during starting.

(From: Mark Kinsler (kinsler@froggy.frognet.net).)

I use a 12 volt battery and it works pretty well. Probably the best high voltage power supply for careless amateurs is the one I designed, which could be found on my Web page if I knew how to do schematics but I don't. But it's simple enough.

I've been driving my old 12 V coil (bought as a replacement for the one in my Econoline but never used) through a buzzer-type interrupter made from an old relay. I put a capacitor across the contacts for good luck, and for the most part it works pretty well. It'll give me about a 1/2" spark, which is all I need for my illegal spark transmitter and the spark plug in my famous "One Stroke Engine" demonstration. However, it yields some amusing effects, to wit: blue sparks dancing around on the battery lead and the battery itself, extremely strange noises, copious production of ozone, and the occasional puff of smoke. I have the whole mess mounted inside a plastic 2-liter cola bottle. On the advice of my friend Dewey King, who restores old gas engines from oil rigs, I've purchased a Chrysler ballast resistor to put in series with the battery and thus keep the coil healthy.

All you need to do is make a trip to the local auto junkyard:

Buy a used but fairly viable car battery, an old-fashioned ignition coil (i.e., before electronic ignition came out in the '70's), an ignition condenser (capacitor) from out of a dead distributor, and the heaviest 12 volt spdt relay you can get from Radio Shack. DPDT is okay, too.

1. Figure out how to connect the relay so it buzzes.

2. Connect the capacitor across the contacts

3. Connect the primary winding of the ignition coil in parallel with the relay coil.

If you do this right, the relay contacts will give a pulsating current through the ignition coil primary.

You'll get a several hundred Hz, 12,000 V between the secondary (the central tower of the coil) and ground. It'll give you a big surprise but it won't kill you unless you're pretty determined to do yourself in.

I've found that only a car battery has sufficiently low internal resistance to run the thing: my big old bench power supply won't do it. So keep a trickle charger on the battery. It seems capable of giving a 3 cm or so arc depending on conditions.

(From: Pamela Hughes (phughes@omnilinx.net).)

I did something like that only it plugged into the wall. Don't remember the circuit but it was a 33 uF, 630 VAC mercury vapor ballast cap connected to a rectifier in a linear fashion (much like using a cap for an AC resistor only the rectifier prevented bidirectional current flow...). This was connected to an 800 V, 6 A SCR and a neon lamp for a diac in a trigger circuit. Adjusted the trigger point so the scr would fire at a certain point in the AC cycle and discharge the cap through the primary of an ignition coil. If you adjusted the trigger point right, you could get about 3" to 4" sparks. Connected that to a 40 kV TV rectifier and a cap made from a window and some aluminum foil and to a 2" spark gap. Wouldn't fire unless something was placed in the spark gap, but then it went off with a bang that would put any bug zapper to shame.

BTW, I took the ignition coil apart, disconnected the common lead connecting the primary and secondary and then used the secondary and core for a giant sense coil for monitoring changes in magnetic fields... thing would make the volt meter jump if you brought a magnet anywhere close to it, but mostly it just fluctuated with atmospheric effects like lightning.

(From: Pierre Joubert joubertp@icon.co.za).)

1. Use a monostable-based circuit which gives the maximum 'on' time for current in the coil. As revs go up, many older systems produce reduced spark energy simply because the rate of rise of current in the coil prevents full current from being reached before the current has to be switched off.

2. Use one of the coils which is designed to operate normally with a series resistance, which is conventionally bypassed during cranking to help get a better spark on the reduced battery voltage. But instead, limit the current in the coil to a safe value by setting a current limit around the switch transistor. This prevents the coil overheating (which it would if you used it without the resistor in a conventional system.

3. Look around for the 'best' coil you can find; you might find a better match to your needs by using a coil from a different model or even make of car. If you know the R and approximate L you can model the current buildup and estimate the energy available. Generally the more energy the better, assuming that the transformation ratios of most coils are roughly the same, which was true way back when.

(From: Scott Stephens (Scott2@mediaone.net).)

I have characterized a 'typical' car coil, and found it rings best around 1 kHz with the steel core in, and around 8 kHz with it out (no capacitive load on secondary). As you can imagine, leakage (coupling) get worse without the core out, but Q is a little better. Q is under 10, more like around 4. The secondary is around 20 Henries (core in) and 4 H with it out, and primary is around 5 mH. Step up ratio is around 60. My thermal guestimate said continuous power should be under 300 watts in oil. Disappointing.

Mark's Comments on High Voltage Lab Conditions

(From: Mark Kinsler (kinsler@frognet.net).)

So how do you make your high-voltage laboratory safe? Well, you just assume that anything you build is likely to catch fire and/or arc over, and design your lab space accordingly. Stay out of the way of capacitor strings, though when these blow up the shrapnel is generally pretty harmless. I've gotten stung by exploding carbon resistors, but again, it's no big deal if you're well away from them. In general, take the same precautions with high-voltage or high-current components that you would with small fireworks: avoid flammable environments and stay well away from them. If all else fails, take the stuff outside.

My advisor at Mississippi State University observed that if you never damage any equipment and you don't have fairly catastrophic failures, you're probably not doing any research. That helped justify the 6" crater I blew in the concrete lab floor (a record that still stands--his crater was only 4", though there were several of them produced at once.)

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Discharge Display Gizmos

Plasma Globes

A 'plasma globe' is one of those things sold at Radio Shack and gift shops which have a glass sphere containing a partial vacuum sitting on a power supply base which is a high frequency inverter. The pressure is such that the discharge tends to take place in streamers rather than as a diffuse glow. The resulting display is supposed to be neat, nifty, interesting, etc. When you place your hand(s) on the globe, the patterns of the discharge inside change.

Recent Sci-Fi movies and TV series seem to have latched onto plasma globes as high-tech replacements for the old-fashioned Jacobs Ladder. :-) (E.g., certain episodes of "Star Trek the Next Generation" and "Star Trek Voyager".)

One such product is called "Eye of the Storm".

It should be possible to construct these gadgets with salvaged flyback transformers, power transistors, and a few other miscellaneous parts using a large clear light bulb - good or bad, doesn't matter - for the discharge globe (However, I don't know how good these actually are for this purpose).

Of course, purists will insist on fabricating their own globe (and official ones can also be purchased at exorbitant prices as well).

As far as I know, these will work with just regular air (though the expensive ones no doubt have fancy and very noble gasses!) and the vacuum is not that high so a refrigeration compressor should be fine.

See The Electronic Bell Jar vacuum technology articles for info on using refrigeration compressors as vacuum pumps.

However, since large clear light bulbs may also be satisfactory (though I don't which ones to recommend), there is may be no need to mess with a vacuum equipment. :-) And, of course, you have a wide selection of inexpensive types to use for experiments, and dropping one or blowing it up isn't a disaster!

Excitation is usually from a high frequency flyback transformer based inverter producing 12 to 15 kV AC at around 10 kHz. Its HV terminal attaches to the internal (center) electrode of the globe or light bulb. The HV return is grounded. Ionization of the gas mixture results from the current flowing due to capacitive coupling through the glass.

For a power source, either the "Simple High Voltage Generator" or "Adjustable High Voltage Power Supply" would be suitable. See the document: Sam's Schematic Collection - Various Schematics and Diagrams for circuit ideas.

However, note that its output must be AC so there must not be any internal HV rectifier in the flyback transformer (which may be hard to find these days since most flybacks have internal rectifiers). (If a flyback with an internal rectifier is used, the globe will just charge up like a capacitor which is pretty boring after a few milliseconds!)

(From: Don Klipstein (don@misty.com).)

As for common gas fills, Radio Shack's "Illuma Storm" sure looks like neon and xenon. I have seen others that had neon-krypton or neon-xenon-krypton. I have seen one in a science museum that looked like plain argon. Other lightning display type things with brighter basically white sparks have xenon.

(Portions from: Steve Quest (Squest@mariner.cris.com).)

A $20 air conditioner repair hand-pump is fine. If the colors of plain air are not 'pretty' enough, let me recommend what is used in commercial units: a mixture of low pressure argon and neon. If you want to be extra fancy, try all the inert gasses, or a mixture of them all, helium, neon, argon, krypton, xenon, radon. :) Of course, radon may not be safe/legal, or even available. You could just toss a chunk of radium into the globe, it will generate the daughter isotope Rn(222) thus slowly, over time, enhance the color of the gas mixture. Just a thought.

The power supply needs to be dielectrically isolated (using the glass as the dielectric), otherwise you'd have direct emission from the metal, and it would be more of a light bulb than streaks of color. Plus, people touching it would feel a tingle while the dielectrically isolated is less likely to shock. What this means is that a direct connection to the filament lead wires is not that great as you really want glass in between the driving source the center as well as the outside globe.

- If you are making your own 'globe', one way to do this is to fuse a glass test tube into the center and coat its interior with conductive paint. This then becomes the center electrode.

- For a light bulb (which isn't really recommended anyhow), you can try to use the filament directly or cut the lead wires as close to the glass as possible and insulate them with RTV or HV putty. Then coat the remainder of the interior of the glass filament support structure with conductive paint to use as the center electrode.

If you cannot locate a suitable flyback, wind your own. Tesla-style air core transformers work. :)

However, I would highly recommend using a commercial flyback! You just need to find one without an internal rectifier. To wind your own flyback requires several thousand turns of super fine wire in 50 to 100 nicely formed layers with the whole thing potted in Epoxy for insulation. Not a fun project.

(From: John Drake (jdrake_deja@deja.com).)

Here is a simple trick:

1. Find some clear light bulbs. Burnt out ones are fine. Any size will do, from a small turn signal light for a car, to a head lamp for a car, to whatever.

2. Attach any Tesla coil output or other low current high voltage source in the 10 to 100 kV range to one of the filament leads. Leave the other lead alone.

3. Turn on the power and watch. Touch with your hand, if you dare. Plenty of lightning in a jar. Eventually, the lightning will poke a hole in the glass, and let the air in. Game over. Get another bulb.

The guy who patented the plasma globe, William Parker (aka Sparks), primarily concentrated on using really interesting blends of gasses and certain frequencies of AC voltage to produce really unusual discharges. For example, it was common to see a kind where an orange lightning bolt had a white tip on it, and a control would let you change the length of the white tip. Other mixes of gasses produced lightning that had a "kinkyness" control -- you could make a bolt very twisty or very straight with a slider control. Check out **U.S. Patent #4754199: Self Contained Gas Discharge Device.** Suitably obscure, huh? :) (The US Patent & Trademark Office currently has a search facility with free access to complete text and graphics.)

Sparks patented his device, and overseas companies literally ripped off the patent wholesale. (Most of the $49 plasma globes you see use his exact circuit from the patent, including a couple of unnecessary parts, etc.) He was trying to get some money out of the whole thing, but I don't know if he ever did or will. Alas.

Of course, if you are just going to make plasma globes and not sell them, you aren't necessarily violating the patents. The underlying idea was well known for a long time before Sparks patented his "globe with controls".

If you want to make your own globes, you can make them lightning compatible by either just sucking the air out, or sucking the air out then adding gas in. Common gasses to use are argon, neon, and krypton. Helium might work (haven't tried), and it's easy to get and use; you can replace the air in the bulb with helium since it's lighter than air.

Lum(n)glass Lightning Plates

There are the disk shaped displays that have random electrical discharges radiating from center to edge and are sold in science/novelty stores in various styles and sizes. Unfortunately, Star Trek Voyager has latched onto these 20th century gizmos as somehow being beneficial to the Borg regeneration cycle - or perhaps they just got a good deal from some antique dealer or on the 24th century equivalent of eBay! :)

A basic description can be found in **U.S. Patent #5383295: Luminous Display Device.** The abstract reads:

> "A luminous display device which includes a fused assembly of three flat members, behind the first of which a chamber partly defined by an opening in the second of said members is formed, a quantity of beads and an ionizable gas being disposed in said chamber, a source of high frequency voltage being connected to an electrode through an opening in the third of said members to form myriad discharge paths throughout said chamber."

For the diagrams, you have to view the patent on-line. In non-patentspeak, the device consists of a sandwich of two glass plates and a spacer ring. It appears as though constructing one of these at home might be possible. A neon sign type electrode in the center of the bottom disk is fed from an RF source probably similar to the high frequency flyback based power supply used for a plasma globe. This will typically be several kV at a couple of mA, at frequency of 20 to 50 kHz or higher. There is no return electrode - the capacitance between the ionized gas and ground provides the return path. However, the physical discharge chamber will certainly more difficult to fabricate. A fairly decent vacuum is also required - the patent claims 15 microns. This requires at least a two stage mechanical pump.

By adjusting the voltage and frequency, using gasses (other than air), phosphor type materials on the beads, colored beads and/or glass, higher or lower pressure, and other changes in drive or construction, the size, color, character, and dynamics of the resulting display to be varied over a wide range.

I would suggest making the assembly out of a pair of pieces of plate glass (though even Lucite/Plexiglas might work - it shouldn't get hot during operation). The plates don't even need to be circular though this isn't really difficult with a glass cutter and template. The outer ring which serves to space the glass plates and also to seal the chamber may be the greatest challenge if made of glass. The space is filled with glass beads, or frit, which, in conjunction with the outer ring, also prevents the thing from imploding. Drilling the hole in the center of the bottom plate for the electrode can be done with some abrasive and a tile or glass bit.

The patent describes a construction method that fuses the entire assembly together at high temperature. This may not be needed unless you intend to seal the device permanently (and even then, a good two-part Epoxy will likely be adequate).

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Cheap Sources of Magnet Wire

It has been suggested that transformers, inductors, and TV/monitor deflection coils are inexpensive or free sources of magnet wire. This may be OK for antennas or similar applications where the insulation isn't critical. However, unwinding those coils may result in damaged insulation as the wire is peeled apart since they tend to be impregnated with varnish. This makes the wire unsuitable for winding new coils. Unless, you have a way of dissolving the varnish without destroying the insulation, the risk of a random shorted turn or two (or many) buried beneath several thousand nice separate ones isn't worth it!

However, a nice source of fine magnet wire is relays and solenoids - many have very fine wire - #40 for example - and miles of it (well thousands of feet at lest). These are very often not varnished so they unwind easily (just don't let them unwind all over your junk drawer!).

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Ideas for Things to do with High Voltage

(From: Robert Michaels (rrr@crush.wwnet.net).)

- Jacobs Ladder, Tesla Coil, CO2 and other home-built lasers, ersatz plasma globe(s) from clear light bulbs; investigate (or at least observe) spark and spark-gap behavior between electrodes made of various materials; Use of spark as an ignition source - for igniting paper, black powder, flash powder, firecrackers. combustible liquids, gases and mixtures of gases; with a rectifier (few bucks from surplus places) - DC phenomena, electrostatic precipitator

- If you have a vacuum pump in that "well-stocked workbench" collection, and you get hold of a rectifier, you are set to investigate all sorts of high-voltage discharge phenomena in partial vacuum and/or reduced pressure - that could keep me amused for weeks.

- Spark travel and propagation over surfaces (kind of a sub-set of my earlier suggestion about spark phenomena in general).

- Flame phenomena: Flames are highly ionized (hence, charged) and react in various ways to high voltages applied to them in one way or another.

- Spark-gap transmitter: Revisit the very earliest days of of radio by duplicating on a small scale the work of Hertz, Marconi, Fessenden, et. al. (Note that the operation of a spark-gap transmitter is unlawful in most jurisdictions - but - if you keep the power way down; use a small antenna; work in the dead of night; and keep transmissions *very* brief -

- High-voltage and photography: Great opportunity to combine two hobbies. Lictenberg Figures and Kirlian photography. There are also Kerr cell shutters, and microflash - both for ultra- brief bullet-stopping photographic exposures. There is also X-ray flash and microflash (for a photo of a bullet actually entering and traveling inside of - whatever - a block of wood -- a side of beef).

- I guess I may as well mentioned X-rays. Of course you need a small X-ray tube. Some of us have been successful in finding, begging, borrowing, such. They can of course be bought - but usually we claim to have no money. :) 10 kV (actually 14.14-kV peak) gives rather soft (but still usable) X-rays, which brings me to:

- Voltage multipliers, impulse generators (a la Marx, Cockcroft-Walton, and many others). You need rectifiers and (homemade perhaps) capacitors. Multiplications of 3X and 4X are attainable without too much effort, 6x, 7x maybe achievable.

- Kissing-cousin to spark-gap radio transmitters is the singing-arc. Although it is an arc phenomena rather than a spark phenomena, you can use your transformer all the same to good advantage. A singing- arc circuit is essentially the same as that for a spark-gap radio transmitter except it is tuned for audio frequencies. (You can imagine the rest).

- There's always Van DeGraaff Generators - the kind charged by an external high voltage power supply. Of course you need a rectifier to get the DC required.

- Crystal phenomena: Certain crystals, such as those of Potassium Chloride, develop what are called color centers when exposed to prolonged, intense, high-voltage fields (and for that matter to strong x-rays as well).

- There is also X-ray crystallography to be investigated when you get that X-ray tube. Fortunately it does not require much power or hardness from the X-rays/tubes. Investigators have spent an entire career in this field alone - it ought to keep you occupied for at least a couple of weekends.

- Plant growth: Are you any kind of a gardener, whether inside or out? Plants are greatly influenced by the presense of an electric field - AC, DC, positive polarity, negative polarity - hey each have their effects. (Watch your fingers as you do the watering!)

- Ozone generation. Be careful. Ozone is considerably more toxic than many realize. It's approximately the same as hydrogen cyanide (HCN). Fortunately Ozone has a much stronger aroma in small concentrations.

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Dangerous (or Useful) Parts in a Dead Microwave Oven

A microwave oven with its power cord cut or removed AND its high voltage capacitor safely discharged is an inanimate object. There are no particularly hazardous parts inside. Of course, heavy transformers can smash your feet and sharp sheet metal can cut flesh. And, the magnets in the magnetron may erase your diskettes or mess up the colors on your TV.

Some may feel there is nothing of interest inside a microwave oven. I would counter that anything unfamiliar can be of immense educational value to children of all ages. With appropriate supervision, an investigation of the inside of a deceased microwave oven can be very interesting.

However, before you cannibalize your old oven, consider that many of the parts are interchangeable and may be useful should your *new* oven ever need repair!

For the hobbiest, there are, in fact, some useful devices inside:

- Motors - cooling fan and turntable (if used). These usually operate on 115 VAC but some may use low voltage DC. They can easily be adapted to other uses.

- Controller and touchpad - digital timer, relay and/or triac control of the AC power. See the section: Using the Control Panel from Defunct Microwave Oven as an Electronic Timer.

- Interlock switches - 3 or more high current microswitches.

- Heavy duty power cord, fuse holder, thermal protector, other miscellaneous parts.

- High voltage components (VERY DANGEROUS if powered) - Typical HV transformer (1,500 to 2,500 VRMS, 0.5 A - see the section: Microwave Oven Transformers), HV rectifier (12 to 15 kV PRV, 0.5 A), and HV capacitor (approximately 1 uF, up to 1,500 to 2,500 VAC (4,200 to 7,000

VDC).

- Magnetron - there are some nifty powerful magnets as part of the assembly. Take appropriate precautions to protect your credit cards, diskettes, and mechanical wristwatches. See the section: Neat Magnets and the document: Notes on the Troubleshooting and Repair of Microwave Ovens for more info.

DOUBLE WARNING: Do not even think about powering the magnetron once you have removed any parts or altered anything mechanical in the oven. Dangerous microwave leakage is possible.

Microwave Oven Transformers

The high voltage transformers from discarded microwave ovens can be put to many useful purposes. Ther are LARGE and can easily handle a kW or more, And due to their construction with separate and distinct windings for the 115 VAC primary, filament, and HV, are much more easily modified compared to typical power transformers with all the windings on top of one-another.

However, these transformers are designed with the bare minimum of copper so without a load, they still draw several amps from the power line. Therefore, they are most suitable for applications where a heavy sustained load is involved - not for that isolation transformer used mostly for testing (20 W) laptop switchmode power supplies! Figure things like arc or spot welding, battery charging, shaker table drivers, aluminum ring levitation (remember that science museum demo?), and other low voltage high current experiments. I am not recommending these for your 1 kW class A audio amp because of they are not generally rated for continuous duty and tend to hum - but you could try especially if you add some cooling.

Note that very few microwave oven failures are due to transformer problems. And, even those that are, likely mean that the HV or filament windings are to blame - neither of which you will likely be using (unless you want the 1.5 to 2.5 kVRMS at 0.5 A or so they put out).

Aside from the dead microwave oven(s) you may have around the house and your friends' and relatives' houses, try the local dump and repair shops - but you may have to convince them that you know what you are doing and of course be willing to haul away the entire carcass, not just the transformer!

WARNING: The intact microwave oven transformer is extremely dangerous when powered. (When not powered, about all it can do is smash your foot.) That 1.5 to 2.5 kVRMS at 0.5 A or more is an instantly deadly combination. Take extreme care if you have any idea about using the transformer without modifications. In addition, since it is so LARGE, any windings you add are also going to be capable of high current and could quite easily end up arc welding or burning things you didn't intend!

Assuming you are not using the HV or filament windings, the first step is to remove them. The filament winding is only 2 to 3 turns of heavy wire and easily extracted. However, the HV winding is likely to require the services of one or more of the following: a chisel, hacksaw, ax, blowtorch, heavy cutters, drill. (And, make sure your accident insurance is paid up for the required trip to the ER to stitch up your hand afterwards.)

Once these windings are gone, there is plenty of core area to wind your own new ones.

- Confirm that the primary is good. Power the transformer at normal line voltage and make sure it doesn't draw excessive current. As noted above, with no load, a few amps due to magnetizing current and core saturation is normal. However, it shouldn't trip your 15 A line fuse!

- Determine the V/turn rating. This is likely to be around 1 V/turn for the typical design which uses just enough copper to prevent excessive overhating. Just wrap 10 turns of insulated wire on the core, power up the primary at normal line voltage, and measure the voltage across your 10 turn secondary with a multimeter. Divide this by 10 to determine the V/turn rating.

- For each secondary, determine the wire size you will need based on your current requirements. A rough guideline would be to keep the total heat dissipation for the secondary to under 25 W. As an example, suppose you want 25 VRMS at 40 A. Then, R needs to be less than .015 ohms. Assuming a 1 V/turn transformer with an average turn length of 10 inches (36 feet of wire), this results in a wire size of at least #6 AWG (or 4 'strands' of #12 AWG wire). Fatter wire won't hurt if it will fit.

- Wrap the core with insulating tape. For light duty use, this can simply be plastic electrical tape. However, proper transformer insulating material should be used for serious applications.

- Wind your secondary or secondaries. For maximum fill, the use of proper magnet wire - even special square wire - is desirable. However, for a couple of turns here and there, any insulated wire of suitable size will do. For extended operation, make sure the insulation is rated for high temperature use.

Using the Control Panel from Defunct Microwave Oven as an Electronic Timer

It is usually possible to remove just the touchpad and controller board to use as a stand-alone timer with a switched output. Be careful when disconnecting the touchpanel as the printed flex cable is fragile. With many models, the touchpanel (membrane touchpad) needs to be peeled off of the front plastic panel or the entire assembly can be removed intact.

The output will control a 10 to 15 A AC load using its built in relay or triac (though these may be mounted separately in the oven). Note that power on a microwave oven is regulated by slow pulse width modulation - order of a 30 second cycle if this matters. If it uses a triac, the triac is NOT phase angle controlled - just switched on or off.

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The Zap in Scripto Lighters and Gas Grill Ignitors

Some types of disposable lighters contain a piezo electric element (instead of a flint and wheel) which generates a spark to ignite the butane gas. Pressing down on the activator drives an escapement which results in a bar hitting the piezo element.

The result is several thousand volts on demand with its output available at a couple of terminals. This can be used to trigger xenon tubes or even to start helium neon lasers (with the addition of a pair of high voltage diodes to form a charge pump). Or as a prod for small cattle, but I didn't say that. :-) For a discussion of the HeNe laser application, see the document: Sam's Laser FAQ.

Detaching the piezo assembly only requires bending back and removing the sheet metal shroud at the top of the lighter. The entire piezo unit then just pops out.

Gas grill ignitors are similar - and even more powerful. These are available as replacement parts at your local home center or appliance store. (Don't steal the one from the family gas grill - your dad won't be happy.) Ditto for piezo matches. Once the gas is used up in these, you're the only one who will want them anyhow. :)

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Useful Parts in a Battery Powered Electronic Flash

These units are found in both pocket cameras (regular 35 mm, older 110 or 126, as well as disposable 'single use' types), and external flash units. Larger, more sophisticated models will have proportionately larger components but the basic circuits are very similar.

For information on how these things work, see the document: Sam's Strobe FAQ - Notes on the Troubleshooting and Repair of Electronic Flash Units and Strobe Lights which also includes many many sample circuits. Two popular designs from Kodak disposable camera flashes are:

- Kodak Funsaver with Flash Schematic.
- Kodak MAX Flash Schematic and Photo. Many newer Kodak disposable cameras including the "Funsaver Sure Flash" appear to use a similar if not identical circuit though some parts may be surface mount. I've heard that some APS (Advanced Photo System) "ADVANTIX" are powered by a pair of AAA cells instead of the single AA used in most other units, so their design may differ somewhat but I haven't disassembled one of those as yet.

For detailed instructions on disassembling the Kodak MAX camera to safely remove the flash unit and some simple modifications, see Don's Hack Kodak MAX to Strobe Page. Details on other cameras will differ but this information should alert you as to what to avoid touching.

WARNING: The energy storage capacitor in even the tiny flash from a disposable camera may hold a painful, if not lethal, charge for days or longer. Always remove the battery first and then make sure to check and, if necessary, safely discharge this large capacitor before touching anything!

The major parts present in all units include:

- Chopper transistor - high gain power transistor to drive the inverter. For pocket cameras, typical part numbers are: 2SD965, 2SD879, 2SD1960, etc. These are low voltage (20 to 40 V) NPN (though some may use PNP), high current (e.g., 5 A), with Hfes in the 400 to 600 range.

- Inverter transformer - Generates the 300+ VDC to charge the energy storage capacitor. Includes a primary drive winding of 5 to 15 turns, similar feedback winding (maybe), and 1,000 to 2,000 turn high voltage secondary.

- Energy storage capacitor - 120 to 500 uF or more, 330 to 400 V, photoflash rated (rapid discharge) electrolytic. Note: These usually do not have a high temperature rating - 55 DegreesC typical. WARNING: Can be lethal if even partially charged!

- Neon (normal or 200 V breakdown) or other ready indicator.

- Trigger transformer - generates a 4 to 8 kV pulse to fire the xenon tube from a small 150 to 300 V capacitor discharge. Includes a primary of about 12 turns, secondary of 350 to 450 turns.

- Xenon flashtube - usually between 1 and 2 inches in length. These require a 300 to 400 V energy storage capacitor, 4 to 8 kV trigger, and can handle 10 to 30 W-s flash energy.

And, in the disposable cameras, there is likely to be a very nearly fresh Alkaline cell unless the place you obtained them from knew this and beat you to it! :)

Automatic types will have additional components including the following:

- Quenchtube - looks like an oversize neon light bulb but filled with xenon and triggered in a similar way to the main flashtube.

- Trigger transformer for the quenchtube - similar to the main trigger transformer.

- Thyristor (SCR) - in series with the flashtube used in energy conserving automatic flash unitsx.

- Photosensor - used to read light reflected from scene to set exposure.

There will also be a variety of other small electronic components possibly including fancy microchips in TTL (Through The Lens) programmable units.

Note: To remove individual components without destroying either the PCB or the component, you must use a proper desoldering technique. If too much heat is used for too long, I've heard that the HV winding inside the transformer may become detached which renders it useless. And, the PCB will certainly be damaged. I generally use a desoldering pump like Solda-Pullet(tm), (not the cheap short one) but this can still damage the fine PCB traces. The use of copper braid with rosin like Solder Wick(tm) may be gentler.

Also see the document: Sam's Schematic Collection - Various Schematics and Diagrams for possible useful modifications to inverters like the one from the Kodak MAX Flash.

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Useful Parts in a Non-Working VCR

- Motors: 1 to 6 motors of various types. Mostly these are cheap DC permanent magnet motors but the main capstan motor may be a high quality brushless type with electronic control on-board. The video drum motor is likely three phase with its own controller.

- Power supply: Outputs various voltages and may be used intact but will always contain useful components like transistors and diodes, transformer(s), and large capacitors.

- Tuner. Whether you can make this work without the rest of the VCR is problematic but worth a try.

- RF modulator. This usually accepts a DC voltage for power, a control voltage to select TV/VCR, and will output on channel 3 or 4.

- IR receiver module (for remote control). It is usually possible to power this from a DC supply (5 or 12 VDC typical) to convert the IR signal from remote controls (probably not just the one that came with the VCR) to a logic level output.

- Miscellaneous electronic components including crystals, delay lines, video and audio ICs, pots, connectors, etc.

What can you build with it? One can never tell! :-)

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Useful Parts in a CD, DVD, LaserDisc, or Other Optical Disc/k Device

All of these devices are basically need to perform similar functions though the specific implementation can differ considerably. Usually, the older the equipment, the more good stuff it yields. Modern CD and DVD drives have almost everything laser and optics related in a little tiny optical pickup block which may not be easy to disassemble. However, 20 year old CD players have much larger optical assemblies with larger numbers of distinct parts. All CD players, CDROM drives, and other common optical storage devices use infra-red laser diodes usually around 780 nm. For all intents and purposes, this is invisible and they make truly lousy laser pointers. DVD players are so new that few cast-offs are available but they, at least, use visible red (635 to 650 nm) laser diodes. Really old LaserDisc players use red helium-neon lasers (actually appears orange-red, 632.8 nm) with possibly even separate focus and tracking mirrors on galvo-like devices which can be easily converted into a simple laser show.

* The laser itself - For really old LaserDisc players, this is a helium-neon gas laser tube (probably linearly polarized) and high voltage power supply. All the others use diode lasers which require current limited drivers to prevent instant destruction. The output power of these lasers is usually less than 5 mW except for writeable optical drives which may go up to 30 mW (but IR) or more.

* Optics - May include lenses, mirrors, beam splitters, 1/4 wave plates, diffraction gratings, and other unidentified optical elements. Depending on the application, these may be optimized for the laser's wavelength. Thus, an IR mirror may actually look more or less transparent. The objective lens and/or other mirrors may be on electromagnetic positioning devices.

* Motors - For spindle, sled movement, drawer open/close, etc. Some are common DC permanent magnet types while the spindle motor may be a brushless DC type. Some CDROM and other use storage drives linear motors to directly position the optical pickup sled.

* Mechanical parts - Gears, racks, rails, pulleys, belts, etc.

* Power supply components - Transformer, regulator(s), transistors, capacitors, etc.

* Other electronic components - Microswitches, opto-interrupters, solenoids, etc. Ironically, the high-tech chips are probably not work unsoldering. :(

See the documents: "Notes on the Troubleshooting and Repair of CD Players and CDROM Drives" and "Notes on the Troubleshooting and Repair of Optical Disc Players and Optical Data Storage Drives" for information on how this equipment works.

WARNING: In addition to electrical and mechanical dangers, the laser may emit levels of visible or invisible radiation that is potentially harmful to vision.

There is much more info on their laser and optics [Sam's Laser FAQ].

Wayne's Notes on Salvaging Parts from Pioneer LaserDisc Players (From: Equinox (eso@pacific.com).)

I have taken apart several of Pioneers old video disc units, I cannot remember the model #'s right now.

The units I had contained the following items that I found of value and kept. Yours should be the same or similar, as all units that I took apart, internally were very similar.

- The laser - A bare HeNe laser tube producing a red beam rated at 1 mW or less, about 8 "long.
- The laser power supply - A small circuit board with a flyback transformer with obvious high voltage white rubbery wires going to the laser tube.
- Large transformer - The laser power supply gets it's input voltage from the main stepdown/up transformer of the entire system. it put out around 700 VAC to work the laser power supply, as well as the analog and digital DC voltages for the rest of the player. Keep it! Your laser power supply board may be useless without it.
- Small X-Y galvo - Dual voice coil assembly to deflect the beam. (In some models, this may be similar/identical to Meredith's GAL-2.)
- Small diffraction grating in round brass housing producing 3 beams if I remember correctly.
- Beam splitter, 2 adjustable mirrors, photo detector and preamp, other optics.
- Voice coil actuated focusing assembly - This looks like a speaker magnet with a hollow center with a lens. It sort of looks like a mechanical eyeball from the top - Used to focus the beam on the disc.
- DC motor with analog tach output - drove the disc Small geared down DC motor - found near and controls the assembly that houses the optics controlling the translation of the beam/optics across the disc.

Disassemble the unit with care. Be careful if you start cutting wires, as the laser power supply has DC control voltages used to enable/disable high voltage output of the laser supply. It may also have other DC voltages used to assist in HV generation. Count the wires coming off of the board and follow and note where they go. You need to know the DC voltages on these wires.

With care and the forethought that you are working with 110 VAC, 700 VAC and more than a kV for the laser, you can measure the voltages in, and enable/disable the safety interlock and see which line it triggers. The interlock switches (2?) were a metal tab activated switch in the back of the lid, and I think part of the latch gizmo near the front of the system had one.

(From: Chris Hoaglin (choaglin@aol.com).)

Inside Maxoptix magneto-optical drives, there are quite a few small mirrors, lenses, beam splitters, etc. The models I've taken apart have been the Tahiti II model. These drives also have a very nice actuator. The laser diode isn't even on the part which emits the beam against the disc, it's mounted on the frame of the drive and reflected against the disc by a mirror mounted on the bottom of the part that moves back and forth. The actuator assembly might be useful for experimentation as well, since It's very sturdy (It rides on two metal shafts and has small metal wheels which keep in contact with the shafts). It has a coil and magnet arrangement on each side. All the optics are on small removable mounts as well, so they'd be easy to put to other uses. I believe the wavelength being used is IR, but they might work for visible stuff as well.

How and where to find them: The drive is a full height 5.25" drive. Looks a bit like an ESDI drive, except for the slot on the front to insert the MO disk, of course. A good place to look for them might be places which do data storage, or use workstations (DEC, Sun, etc.) I don't think they're used much on the PC platform.

Also, I noticed today while reading Lasers and Optronics that several outfits are offering OEM modules which incorporate 400 nm diodes. Sooner or later people will start scrapping equipment that uses them, although probably not for a few years.

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Useful Parts in a Laser Printer or Laser Fax

All modern laser printers use IR diode lasers of 5 to 30 mW maximum output. Very old laser printers used helium-neon lasers but these are even rarer than HeNe laser based LaserDisc players. However, if you do find one, there will likely also be an Acousto-Optic Modulator (AOM) and driver since directly controlling HeNe lasers at high speed isn't feasible - don't neglect these very desirable components!

- Laser - Usually semiconductor laser diode mounted in assembly with collimating lens and other optics. Its output is a nearly parallel beam 1 or 2 mm in diameter.

- Laser diode driver - Usually a circuit board in close proximity to the laser diode which provides power and modulation capability. Reverse engineering and luck may be required to figure out how to use it.

- Thermo-electric cooler - I don't know how common this is but some laser printers have/had a nice little Peltier device to maintain the laser diode at a constant temperature. There would be an electronics board associated with the actual device.

- Multifaceted scanner - A polygonal mirror (usually metal coated) on a high quality brushless DC motor. The constant speed controller may be a part of the motor assembly with only a few interface signals to power and run it.

- Objective lenses - 2 or 3 lenses that look cylindrical may actually be just relatively thin sections of normal lenses or anamorphic with different focal lengths in the two axis. Due to their shape, they may be of questionable utility for other purposes.

- Mirrors - 1 or 2 long strip mirrors that may be metal coated (with a copper tinge for IR laser printers) or dichroic coated. Note that while these appear to be planar, they may in fact have a slight curvature along the narrow axis. The dichroic types may be of very high (laser resonator) quality but if frosted on the opposite surface, of limited utility since any transmitted beam is dispersed.

- Fiber optic sensor - Canon engines have this situated at the one end of the scan line to detect the beam and provide a time reference.

- Motors - In addition to the scanner, there will be a main AC line driven for paper movement. There will also be 1 or 2 fans.

- Mechanical parts - rollers, gears, pulleys, clutches, bearings, you name it - lot's of useful stuff.

- HV power supply - Usually a self-contained module which generates the corona voltages. Up to 6 kV or more but microamps of current.

- LV power supply components - Depending on whether a switchmode or linear power supply is used, there could be a variety of useful parts and possibly the complete power supply as a separate unit.

- Toner/Developer - There will be a long, moderately powerful magnet associated with the toner distribution system, probably inside an aluminum cylinder. The toner cartridge or built-in mechanism will also include other useful parts but is extremely icky and messy to disassemble.

- Fuser lamp and power supply - Quartz halogen lamp and triac controlled power supply with temperature sensor.

- Other electronic components - Again, the high-tech parts may be less useful than the simple things. :)

- Fax machine components (where applicable) - Include a cold cathode fluorescent lamp for the light source and linear CCD image sensor with associated electronics.

I'm sure I've missed some major parts.

See the document: "Notes on the Troubleshooting and Repair of Printers and Photocopiers" for information on how this equipment works as well as warnings and precautions with respect to the hazards of toner dust.

WARNING: In addition to electrical and mechanical dangers, the laser may emit levels of visible or invisible radiation that is potentially harmful to vision.

There is much more info on their laser and optics Sam's Laser FAQ.

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Useful Parts in a Photocopier

There are mostly similar to laser printers, above. However, instead of a laser, the light source is usually a halogen or high intensity fluorescent lamp. Most other parts are similar and similar precautions with respect to toner apply. Copiers are likely to use toner cartridges having the various components such as the photosensitive drum, toner reservoir, and developer as separate units. Thus, they are more likely to have gobs of messy toner all over the interior when you finally get your hands on them!

Items in place of the laser of a laser printer include:

- Light source - a linear quartz halogen lamp is most likely. Some may use a special fluorescent lamp instead. In either case, the needed power supply or ballast will be included - don't miss it!
- Optics - Several mirrors and a high quality objective lens. The large tempered glass plate on which the material to be copied sits is also useful.
- Additional mechanical parts - Include those for paper selection and sorting, two sided copying, and so forth.

See the section: Useful Parts in a Laser Printer or Laser FAX for more information.

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Useful Parts in a Barcode Scanner

The types mostly likely to show up surplus are helium-neon laser based supermarket checkout scanners that have been replaced by more modern diode laser based equipment but are probably still operational.

Looking through the glass of the scanner, it may appear that all sorts of stuff is arranged at random. However, this is not the case. :) For more information on how barcode scanners operate, see the chapter: "Laser Instruments and Applications" in Sam's Laser FAQ.

- Laser - The source of the beam is either a low power helium-neon (HeNe) or diode laser. Older (and larger) scanners tended to use HeNe lasers. However, size alone is no sure indication until you get to very small (6 inch cubes or hand-held wands) which are almost always based on diode lasers (if they use a laser at all). A better test is to check the color of the beam - the light from HeNe laser based scanners appears orange-red (632.8 nm) while that from diode laser based scanners tends to be a deep red from the 670 nm wavelength which is less expensive (but just as effective). Just explain that you are doing scientific research when the people in the white coats come to take you away for staring into the scanner! :)

    - HeNe lasers are typically 1 to 3 mW (mostly near 1 mW) using tubes between 5 and 10 inches in length. The tube will probably be mounted on brackets and will be easily replaceable. Some scanners use HeNe tubes with larger than diffraction limited divergence to simplify the optical system down the line. Where an external lens is actually glued to the output mirror of the HeNe tube, it can probably be removed with a suitable solvent or heat leaving a low divergence tube. See the chapter: "The Home-Built Laser Assembly and Power Supply" chapter of Sam's Laser FAQ for more details. Or, simply locate the collimating lens that is present in the scanner or one of your own and use that to adjust the divergence as desired.

      The HeNe laser power supply may be a self-contained 'brick' or built onto the mainboard.

    - Diode lasers are typically 670 nm (deep red) with 5 mW maximum output. A collimating lens and possibly some other optics will be part of the diode laser assembly.

      The laser diode driver circuit will be in close proximity to the laser diode itself and may be on a separate board. However, it is most likely part of the mainboard. and difficult to determine correct use without a schematic.

- Variable attenuator - A graded density filter may be present immediately following the laser's output to adjust the beam intensity to compensate for variations in laser power (mostly for HeNe lasers - diode lasers will have a pot for this purpose).

- Turning mirror(s) - There may be one or more high quality planar first surface or dichroic mirrors to direct the beam. Their mount will probably be adjustable in X and Y to some extent.

- Main objective combo - This consists of a large (probably plastic molded) convex lens with a hole in its center in which a prism, mirror, and/or lens may be inset.

  The components of the this part can generally be separated to use individually using a combination of brute force and solvents. For example, to remove the lens and prism from the combo in the Orien 300, a pad of tissue paper is inserted in the hole followed by a wooden dowel that just fits. A couple of whacks to the dowel with a small hammer while holding the assembly should result in the prism/lens popping free. They can then be separated by soaking in acetone.

WARNING: Acetone and its vapors are flammable and toxic.

CAUTION: Acetone will also damage many plastics including most likely, the large plastic lens, so don't let it contact that or other plastic optical components.

- Multifaceted rotating mirror - The collimated outgoing is deflected by a 3 to 6 facet polygonal mirror directly driven by a speed regulated brushless DC motor. The motor/scanner assembly is generally a separate module in older equipment requiring only DC power and an enable signal to run. However, newer ones may be mounted directly on the mainboard.

  Unlike those in a laser printer, the mirror facets are large since they have to reflect the diffuse return beam as well as the tiny spot of the outgoing beam. They are fabricated as individual mirrors glued to a cast metal wheel type affair and are all set at slightly different angles so that each rotation of the mirror wheel results in scan lines at 3 to 6 slightly different locations depending on the number of facets.

- Multiple planar mirrors - These are usually decent quality aluminized first surface mirrors and could find all sorts of other uses. Although generally shaped as strange 4 sided polygons, they can be subdivided into more useful sizes using a glass cutter from the rear or a water-cooled diamond cutoff wheel.

- Photodetector - A silicon photodiode, often of moderate area (typically 2x2 mm, good for a laser power meter) There may be an additional focusing lens and/or red ambient light blocking filter associated with the photodetector.

- Electronic components - Include a microprocessor, RS232 or other interface, etc. However, these may not be very useful for other purposes.

- Power supply - Depending on the model, these may plug directly into the AC line or be powered from a wall adapter.

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Notes on the Troubleshooting and Repair of Microwave Ovens

Version 3.42

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

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For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Careless troubleshooting of a microwave oven can result in death or worse. Experienced technicians have met their maker as a result of a momentary lapse of judgement while testing an oven with the cover removed. Microwave ovens are without a doubt, the most deadly type of consumer electronic equipment in wide spread use.

The power supplies for even the smallest microwave ovens operate at extremely lethal voltage and current levels. Do not attempt to troubleshoot, repair, or modify such equipment without understanding and following ALL of the relevant safety guidelines for high voltage and/or line connected electrical and electronic systems.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Introduction

Radar Range anyone?

Remember when you actually had to use the real oven to defrost a TV dinner? Think back - way back - before VCRs, before PCs (and yes, before Apple computers as well), almost before dinosaurs, it would seem. There was a time when the term 'nuke' was not used for anything other than bombs and power reactors.

For a long time, there was controversy as to whether microwave ovens were safe - in terms of microwave emissions and molecular damage to the food. Whether these issues have been resolved or just brushed aside is not totally clear. Nonetheless, the microwave oven has taken its place in virtually every kitchen on the planet. Connoisseurs of fine dining will turn up their collective noses at the thought of using a microwave oven for much beyond boiling water - if that. However, it is difficult to deny the convenience and cooking speed that is provided by this relatively simple appliance.

Microwave ovens are extremely reliable devices. There is a good chance that your oven will operate for 10 years or more without requiring repairs of any kind - and at performance levels indistinguishable from when it was first taken out of the box. Unlike other consumer electronics where a new model is introduced every 20 minutes - some even have useful improvements - the microwave oven has not changed substantially in the last 20 years. Cooking is cooking. Touchpads are now nearly universal because they are cheaper to manufacture than mechanical timers (and also more convenient). However, an old microwave oven will heat foods just as well as a brand new one.

This document provides maintenance and repair information applicable to most of the microwave ovens in existence. It will enable you to quickly determine the likely cause and estimate the cost of parts. You will be able to make an informed decision as to whether a new oven is the better alternative. With minor exceptions, specific manufacturers and models will not be covered as there are so many variations that such a treatment would require a huge and very detailed text. Rather, the most common problems will be addressed and enough basic principles of operation will be provided to enable you to narrow the problem down and likely determine a course of action for repair. In many cases, you will be able to do what is required for a fraction of the cost that would be charged by a repair center - or - be able to revive something that would otherwise have gone into the dumpster or continued in its present occupation as a door stop or foot rest.

Should you still not be able to find a solution, you will have learned a great deal and be able to ask appropriate questions and supply relevant information if you decide to post to sci.electronics.repair. In any case, you will have the satisfaction of knowing you did as much as you could before taking it in for professional repair. You will be able to decide if it is worth the cost of a repair as well. With your new-found knowledge, you will have the upper hand and will not easily be snowed by a dishonest or incompetent technician.

On-line microwave oven repair database

Microtech maintains a web site with a large amount of information on microwave oven repair including an on-line Tech Tips Database with hundreds of solutions to common problem for many models of microwave ovens. There are also an extensive list of microwave oven related links to other interesting sites (including this document!). The comprehensive Safety Info is a must read as well. Not entirely coincidentally, I assume, some of its wording appears remarkably familiar! Microtech also offers instructional videos and books on microwave oven and VCR repair.

It is quite possible your problem is already covered at the Microtech site. In that case, you can greatly simplify your troubleshooting or at least confirm a diagnosis before ordering parts. My only reservation with respect to tech tips databases in general - this has nothing to do with Microtech in particular - is that symptoms can sometimes be deceiving and a solution that works in one instance may not apply to your specific problem. Therefore, an understanding of the hows and whys of the equipment along with some good old fashioned testing is highly desirable to minimize the risk of replacing parts that turn out not to be bad.

Jim Bryant's Microwave Ovens page is another site worth visiting. While he deals mostly with models in the UK, he will answer questions via email and includes links to many USA microwave oven manufacturers and parts suppliers.

Expert system for microwave oven fault diagnosis

The MIDES (Microwave Oven Diagnosis Expert System) site represents an interesting and possibly useful approach for isolating the cause of many common failures. It will take you through a customized step-by-step procedure based on your symptoms (and specific microwave oven model in some cases) and the results of its suggested tests. For the novice, this may be an effective way of obtaining a solution quickly as long as you follow the extremely important safety information provided by MIDES (or this document). You will not be forced to acknowledge that you have read, understood, and followed their safety precautions and warnings before performing each test.

The simplest problems

- Bad interlocks switches or door misalignment causing fuses to blow or no operation when the start button is pressed. Locate and replace defective switches and/or realign door.

- Arcing in oven chamber: clean oven chamber and waveguide thoroughly. Replace carbonized or damaged waveguide cover. Smooth rough metal edges. Touch up the interior paint.

- Blown fuse due to power surge or old age: Replace fuse. On rare occasions, the main fuse may even be intermittent causing very strange symptoms.

- An MOV, probably on the controller, may have shorted due to a power surge blowing the controller fuse. Remove remains of MOV, replace fuse and test, replace MOV for future surge protection.

- Erratic touchpad operation due to spill - let touchpad dry out for a week.

- Bugs in the works - the controller circuit board is a nice warm safe cozy place to raise a family.....

More detailed explanations are provided elsewhere in this document.

Repair or replace?

With small to medium size microwave ovens going for $60-100 it hardly makes sense to spend $60 to have one repaired. Even full size microwave ovens with full featured touchpanel can be had for under $200. Thus, replacement should be considered seriously before sinking a large investment into an older oven.

However, if you can do the repair yourself, the equation changes dramatically as your parts costs will be 1/2 to 1/4 of what a professional will charge and of course your time is free. The educational aspects may also be appealing. You will learn a lot in the process. Many problems can be solved quickly and inexpensively. Fixing an old microwave for the dorm room may just make sense after all.

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Installation and Preventive Maintenance

Microwave oven installation and use

To assure safety and convenient, follow these recommendations:

- Read your users manual from cover to cover especially if this is your first microwave. What a concept! If nothing else, you may discover that your oven has features you were not aware were even possible. In any case, there may be requirements or suggestions that are specific to your model and will enable you to get the most performance from your new microwave.

- Select a stand-alone unit rather than a built-in if possible. It will be cheaper to buy, cheaper and easier to service, and possibly more reliable since ventilation and adjacent heat producing appliances will not be as much of a factor.

- Select a convenient location - easy access and not too high or too low. This is particularly important if the door of the oven opens down instead of to the left side (only a few models are built this way, however).

- Put the microwave oven on its own dedicated 3 wire grounded circuit. Temporary use of a 3 to 2 prong adapter is acceptable only if the outlet box is properly grounded to begin with (BX, Romex, or conduit with ground) AND the adapter's ground wire or terminal is securely attached to the outlet box ground screw.

  Make sure the outlet is in good condition in either case. Check that the plug (or adapter) fits tightly and that there is no appreciable heating of the outlet during use of the microwave oven. If there is, spread the metal strips of each of the prongs apart if possible and/or replace the outlet.

  A grounded outlet is essential for safety. Microwave ovens are high power devices and a separate circuit will eliminate nuisance fuse blowing or circuit breaker tripping when multiple appliances are being used at the same time. It will also minimize the possibility of Radio Frequency Interference (RFI) between it and any electronic equipment which might be on the same circuit. A GFCI is not needed as long as the outlet is properly grounded and may result in nuisance tripping with some microwave ovens.

  Inexpensice outlet testers are available at hardware stores, home centers, and electrical parts distributors, to confirm that the outlet is properly wired and grounded.

- Allow adequate ventilation - do not push it up against the wall or wedge it under a tight fitting wall cabinet (or inside one for that matter!). Leave at least 2 inches on all sides and top if possible.

- Do not let children use the microwave oven unless properly supervised. It is very easy to cause a fire through the use of excessive times or power settings. Even something as simple as microwave popcorn can explode and/or catch fire if heated for too long - e.g., 5 minutes instead of my precisely determined 3:41 on high :-).

Microwave oven maintenance

Most people do not do anything to maintain a microwave oven. While not much is needed, regular cleaning at least will avoid potentially expensive repairs in the future:

- Clean the interior of the oven chamber after use with a damp cloth and some detergent if necessary. Built up food deposits can eventually carbonize resulting in sparks, arcs, heating, and damage to the mica waveguide cover and interior paint - as well as potentially more serious damage to the magnetron. If there is any chance of food deposits having made their way above the waveguide cover in the roof of the chamber, remove the waveguide cover and thoroughly clean inside the waveguide as well.

- Clean the exterior of the cabinet and touchpad in a similar manner. DO NOT use a spray where any can find its way inside through the door latch or ventilation holes, or a dripping wet cloth. Be especially careful around the area of the touchpad since liquid can seep underneath resulting in unresponsive or stuck buttons or erratic operation. Do not use strong solvents (though a bit of isopropyl alcohol is fine if needed to remove sticky residue from unwanted labels, for example).

- Inspect the cord and plug for physical damage and to make sure the plug is secure and tight in the outlet - particularly if the unit is installed inside a cabinet (yes, I know it is difficult to get at but I warned you about that!). Heat, especially from a combination microwave/convection oven or from other heat producing appliances can damage the plug and/or cord. If there is evidence of overheating at the outlet itself, the outlet (and possibly the plug as well) should be replaced.

- Periodically check for built up dust and dirt around the ventilation holes or grills. Clean them up and use a vacuum cleaner to suck up loose dust. Keeping the ventilation free will minimize the chance of overheating.

- Listen for any unusual sounds coming from inside the oven. While these appliances are not exactly quiet, grinding, squealing, scraping, or other noises - especially if they were not there when the oven was new - may indicate the need for some more extensive maintenance like belt replacement or motor lubrication. Attending to these minor problems now may prevent major repairs in the future.

- Keep your kitchen clean. Yes, I know, this isn't exactly microwave specific but cockroaches and other uninvited guests might just like to take up residence inside the electronics bay of the oven on the nice warm controller circuit board or its neighborhood and they aren't generally the tidiest folks in the world.

  If it is too late and you have a recurring problem of cockroaches getting inside the electronics bay, tell them to get lost and then put window screen over the vents (or wherever they are entering). Such an open mesh should not affect the cooling of the electronic components significantly. However, the mesh will likely clog up more quickly than the original louvers so make sure it is cleaned regularly. If possible, clean up whatever is attracting the unwanted tenants (and anything they may have left behind including their eggs!!). WARNING: See the section: SAFETY before going inside.

CAUTION: Do not spray anything into the holes where the door latch is inserted or anywhere around the touchpad as this can result in internal short circuits and costly damage - or anywhere else inside, for that matter. If you do this by accident, immediately unplug the oven and let it dry out for a day or two.

How long does microwave energy hang around?

You have probably been warned by your mother: "Wait a few seconds (or minutes) after the beep for all the microwaves to disappear". There is no scientific basis for such a recommendation. Once the beep has sounded (or the door has opened), it is safe. This is because:

1. There is no such thing as residual microwave radiation from a microwave oven - it is either being produced or is non-existent.

2. There is little energy storage in the microwave generator compared to the amount being used. The typical high voltage capacitor - the only component that can store energy - has a capacity of less than 15 W-s (Watt-seconds) even for the largest ovens. Power consumption is typically 800 to 1500 W depending on oven size. Therefore, the capacitor will be fully drained in much less than .1 second - long before the beep has ended or the door has cleared the front panel. (Based on the numbers, above, for a 1500 W oven with a capacitor storing 15 W-s, it is more like .01 seconds!)

   WARNING: This only applies to a *working* microwave oven! If there is no heat, the magnetron may not be drawing any current from the HV power supply and the HV capacitor can remain charged for a long time. In this case, there is a very real risk of potentially lethal electrical shock even after several minutes or more of being unplugged! See the section: SAFETY if you will be troubleshooting a microwave oven.

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Microwave Oven Troubleshooting

SAFETY

The following applies to microwave oven troubleshooting - once the cabinet cover is removed. There is also safety information on proper use of the oven in subsequent sections, below.

Please see Typical Microwave Oven Electronics Bay for parts identification.

WARNING! WARNING! WARNING! WARNING! WARNING! WARNING! WARNING! WARNING!

Microwave ovens are probably the most dangerous of consumer appliances to service. Very high voltages (up to 5000 V) at potentially very high currents (AMPs) are present when operating - deadly combination. These dangers do not go away even when unplugged as there is an energy storage device - a high voltage capacitor - that can retain a dangerous charge for a long time. If you have the slightest doubts about your knowledge and abilities to deal with these hazards, replace the oven or have it professionally repaired.

Careless troubleshooting of a microwave oven can not only can fry you from high voltages at relatively high currents but can microwave irradiate you as well. When you remove the metal cover of the microwave oven you expose yourself to dangerous - potentially lethal - electrical connections. You may also be exposed to potentially harmful levels of microwave emissions if you run the oven with the cover off and there is damage or misalignment to the waveguide to the oven chamber.

There is a high voltage capacitor in the microwave generator. Always ensure that it is totally discharged before even thinking about touching or probing anything in the high voltage power circuits. See the troubleshooting sections later in this document.

To prevent the possibility of extremely dangerous electric shock, unplug the oven from the AC outlet before removing the cover and do not plug it in to operate it with the cover off if at all possible. If you must probe live, remove the connections to the magnetron (see below) to prevent the inadvertent generation of microwaves except when this is absolutely needed during troubleshooting. Discharge the high voltage capacitor (with the oven unplugged) and then use clip leads to make any connections before you plug it in and apply power. Then after removing power and unplugging the oven discharge the HV capacitor once again.

WARNING: Experienced technicians have been electrocuted deader than a brick from even careful probing of the HV circuits of a powered microwave oven. Therefore, I highly recommend avoiding any probing of the HV circuits - nearly everything can be determined by inspection and component tests with the oven unplugged.

The microwave oven circuitry is especially hazardous because the return for the high voltage is the chassis - it is not isolated. In addition, the HV may exceed 5000 V peak with a continuous current rating of over .25 AMP at 50/60 Hz - the continuous power rating of the HV transformer may exceed 1500 W with short term availability of much greater power. Always observe high voltage protocol.

Safety guidelines

These guidelines are to protect you from potentially deadly electrical shock hazards as well as the equipment from accidental damage.

Note that the danger to you is not only in your body providing a conducting path, particularly through your heart. Any involuntary muscle contractions caused by a shock, while perhaps harmless in themselves, may cause collateral damage - there are many sharp edges inside this type of equipment as well as other electrically live parts you may contact accidentally.

The purpose of this set of guidelines is not to frighten you but rather to make you aware of the appropriate precautions. Repair of TVs, monitors, microwave ovens, and other consumer and industrial equipment can be both rewarding and economical. Just be sure that it is also safe!

- Don't work alone - in the event of an emergency another person's presence may be essential.

- Always keep one hand in your pocket when anywhere around a powered line-connected or high voltage system.

- Wear rubber bottom shoes or sneakers.

- Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current, or get caught in moving parts.

- Set up your work area away from possible grounds that you may accidentally contact.

- Know your equipment: TVs and monitors may use parts of the metal chassis as ground return yet the chassis may be electrically live with respect to the earth ground of the AC line. Microwave ovens use the chassis as ground return for the high voltage. In addition, do not assume that the chassis is a suitable ground for your test equipment!

- If circuit boards need to be removed from their mountings, put insulating material between the boards and anything they may short to. Hold them in place with string or electrical tape. Prop them up with insulation sticks - plastic or wood.

- If you need to probe, solder, or otherwise touch circuits with power off, discharge (across) large power supply filter capacitors with a 25 W or greater resistor of 5 to 50 ohms/V approximate value.

  For the microwave oven in particular, use a 25K to 100K 25 W resistor with a secure clip lead to the chassis. Mount the resistor on the end of a well insulated stick. Touch each of the capacitor terminals to the non-grounded end of the resistor for several seconds. Then, to be doubly sure that the capacitor if fully discharged, short across its terminals with the blade of a well insulated screwdriver. I also recommend leaving a clip lead shorting across the capacitor terminals while working as added insurance. At most, you will blow a fuse if you should forget to remove it when powering up the microwave.

- Connect/disconnect any test leads with the equipment unpowered and unplugged. Use clip leads or solder temporary wires to reach cramped locations or difficult to access locations.

- If you must probe live, put electrical tape over all but the last 1/16" of the test probes to avoid the possibility of an accidental short which could cause damage to various components. Clip the reference end of the meter or scope to the appropriate ground return so that you need to only probe with one hand.

- Perform as many tests as possible with power off and the equipment unplugged. For example, the semiconductors in the power supply section of a TV or monitor can be tested for short circuits with an ohmmeter.

- Use an isolation transformer if there is any chance of contacting line connected circuits. A Variac(tm) is not an isolation transformer! (See the next section with regards to isolation transformers and microwave ovens.) The use of a GFCI (Ground Fault Circuit Interrupter) protected outlet is a good idea but will not protect you from shock from many points in a line connected TV or monitor, or the high voltage side of a microwave oven, for example. A circuit breaker is too slow and insensitive to provide any protection for you or in many cases, your equipment. A GFCI may, however, prevent your scope probe ground from smoking should you accidentally connect an earth grounded scope to a live chassis.

- Don't attempt repair work when you are tired. Not only will you be more careless, but your primary diagnostic tool - deductive reasoning - will not be operating at full capacity.

- Finally, never assume anything without checking it out for yourself! Don't take shortcuts!

As noted, a GFCI (Ground Fault Circuit Interrupter) will NOT protect you from the high voltage since the secondary of the HV transformer is providing this current and any current drawn off of the secondary to ground will not be detected by the GFCI. However, use of a GFCI is desirable to minimize the risk of a shock from the line portions of the circuitry if you don't have an isolation transformer.

An isolation transformer is even limited value as well since the chassis IS the HV return and is a large very tempting place to touch, lean on, or brush up against.

And, of course, none of these devices will protect fools from themselves!

Take extreme care whenever working with the cover off of a microwave oven.

Isolation transformers and microwave ovens

There's little point to using an isolation transformer with a microwave for testing the high voltage circuitry. It would have to be HUGE due to the high power nature of a microwave oven and since the high voltage return is the chassis which is grounded, it won't be terribly useful as noted above. However, an isolation transformer can and should be used to test the primary side circuitry if necessary including interlocks, motors, triac/relay, etc. Disconnect the HV transformer to eliminate the possibility of high voltage shock and to reduce the load.

Actually, the best policy is to NEVER EVER attempt to measure anything in the HV section while the oven is powered - it's almost never needed in any case. Failures are usually easily found by performing test with the oven unplugged. If you insist on making live measurements, connect the meter before power is applied and disconnect or move its probes only after power is removed AND the HV cap has been discharged (even if the meter catches fire or explodes!). Qualified service people have been electrocuted using proper test equipment on microwave ovens!

Troubleshooting tips

Many problems have simple solutions. Don't immediately assume that your problem is some combination of esoteric complex convoluted failures. For a microwave oven, there may be a defective door interlock switch or just a tired fuse.

If you get stuck, sleep on it. Sometimes, just letting the problem bounce around in your head will lead to a different more successful approach or solution. Don't work when you are really tired - it is both dangerous (particularly with microwave ovens) and mostly non-productive (or possibly destructive - very destructive).

If you need to remove the cover or other disassembly, make notes of which screw went where - they may not all be identical. More notes is better than less.

Pill bottles, film canisters, and plastic ice cube trays come in handy for sorting and storing screws and other small parts after disassembly.

Select a work area which is well lighted and where dropped parts can be located - not on a deep pile shag rug. Something like a large plastic tray with a slight lip may come in handy as it prevents small parts from rolling off of the work table. The best location will also be relatively dust free and allow you to suspend your troubleshooting to eat or sleep or think without having to pile everything into a cardboard box for storage.

A basic set of high quality hand tools will be all you need to work on a microwave oven. These do not need to be really expensive but poor quality tools are worse than useless and can cause damage. Stanley or Craftsman are fine. Needed tools include a selection of Philips and straight blade screwdrivers, needlenose pliers, wire cutters and wire strippers.

A medium power soldering iron and rosin core solder (never never use acid core solder or the stuff for sweating copper pipes on electronic equipment) will be needed if you should need to disconnect any soldered wires (on purpose or by accident) or replace soldered components.

However, most of the power components in microwave ovens use solderless connectors (lugs) and replacements usually come with these as well.

See the document: Troubleshooting and Repair of Consumer Electronics Equipment for additional info on soldering and rework techniques and other general information.

An assortment of solderless connectors (lugs and wirenuts) is handy when repairing the internal wiring. A crimping tool will be needed as well but the $4 variety is fine for occasional use.

Old dead microwaves can often be valuable source of hardware and sometimes even components like interlock switches and magnetrons as these components are often interchangeable. While not advocating being a pack rat, this does have its advantages at times.

Test equipment

Don't start with the electronic test equipment, start with some analytical thinking. Many problems associated with consumer electronic equipment do not require a schematic (though one may be useful). The majority of microwave oven problems are easily solved with at most a multimeter (DMM or VOM). You do not need an oscilloscope for microwave oven repair unless you end up trying to fix the logic in the controller - extremely unlikely.

A DMM or VOM is necessary for checking of power supply voltages (NOT the high voltage, however) and testing of interlock switches, fuses, wiring, and most of the components of the microwave generator. This does not need to be expensive but since you will be depending on its readings, reliability is important. Even a relatively inexpensive DMM from Radio Shack will be fine for most repair work. You will wonder how you ever lived without one! Cost: $25-50.

Other useful pieces of 'test equipment':

- A microwave leakage detector. Inexpensive types are readily available at home centers or by mail order. These are not super accurate or sensitive but are better than nothing. Also see the sections: "Microwave leakage meters" and "Simple microwave leak detectors".

- A microwave power detector. These can be purchased or you can make one from a small neon (NE2) or incandescent bulb with its lead wires twisted together. Sometimes these homemade solutions do not survive for long but will definitely confirm that microwave power is present inside the oven chamber. Note: always have a load inside the oven when testing - a cup of water is adequate.

- A thermometer (glass not metal) to monitor water temperature during power tests.

- High voltage probe (professional, not homemade!). However, this is only rarely actually required. Low voltage, resistance, or continuity checks will identify most problems. WARNING: the high voltage in a microwave oven is NEGATIVE (-) with respect to the chassis. Should you accidentally use the wrong test probe polarity with your meter, don't just interchange the probes = it may be last thing you ever do. Unplug the oven, discharge the HV capacitor, and only then change the connections.

There are special magnetron and microwave test instruments but unless you are in the business, these are unnecessary extravagances.

Safe discharging of the high voltage capacitor

It is essential - for your safety and to prevent damage to the device under test as well as your test equipment - that the large high voltage capacitor in the microwave generator be fully discharged before touching anything or making measurements. While these are supposed to include internal bleeder resistors, these can fail. In any case, several minutes may be required for the voltage to drop to negligible levels.

The technique I recommend is to use a high wattage resistor of about 5 to 50 ohms/V of the working voltage of the capacitor. This will prevent the arc-welding associated with screwdriver discharge but will have a short enough time constant so that the capacitor will drop to a low voltage in at most a few seconds (dependent of course on the RC time constant and its original voltage).

- For the high voltage capacitor in a microwave oven, use a 25 W or larger 100 K ohm resistor for your discharge widget with a clip lead to the chassis. The reason to use a large (high wattage) resistor is again not so much power dissipation as voltage holdoff. You don't want the HV zapping across the terminals of the resistor. Even better is to use a proper high voltage resistor rated for at least 5 kV. A series string of 10 to 20 1/2 W normal resistors in series can also be used.

- Clip the ground wire to an unpainted spot on the chassis. Use the discharge probe on each side of the capacitor in turn for a second or two. Since the time constant RC is about .1 second, this should drain the charge quickly and safely.

- Then, confirm with a WELL INSULATED screwdriver across the capacitor terminals. If there is a big spark, you will know that somehow, your original attempt was less than entirely successful. There is a very slight chance the capacitor could be damaged by the uncontrolled discharge but at least there will be no danger.

- Finally, it is a good idea to put a clip lead across the capacitor terminals just to be sure it stays fully discharged while you are working in the area. Yes, capacitors have been known to spontaneously regain some charge. At worst, you will blow the fuse upon powering up if you forget to remove it.

WARNING: DO NOT use a DMM for checking voltage on the capacitor unless you have a proper high voltage probe. If your discharging did not work, you may blow everything - including yourself.

A suitable discharge tool can be made as follows:

- Solder one end of the appropriate size resistor (100K ohms, 25W in this case) to a well insulated clip lead about 2 to 3 feet long. Don't just wrap it around - this connection must be secure for safety reasons.

- Solder the other end of the resistor to a well insulated contact point such as a 2 inch length of bare #14 copper wire mounted on the end of a 2 foot piece of PVC or Plexiglas rod which will act as an extension handle.

- Secure the resistor to the insulating rod with some plastic electrical tape.

This discharge tool will keep you safely clear of the danger area. The capacitor discharge indicator circuit described in the document: Capacitor Testing, Safe Discharging and Other Related Information can be built into the discharge tool if desired.

Again, always double check with a reliable high voltage meter or by shorting with an insulated screwdriver!

Reasons to use a resistor and not a screwdriver to discharge capacitors:

1. It will not destroy screwdrivers and capacitor terminals.

2. It will not damage the capacitor (due to the current pulse).

3. It will reduce your spouse's stress level in not having to hear those scary snaps and crackles.

Getting inside a microwave oven

You will void the warranty - at least in principle. There are usually no warranty seals on a microwave so unless you cause visible damage or mangle the screws or plastic, it is unlikely that this would be detected. You need to decide. A microwave still under warranty should probably be returned for warranty service for any covered problems except those with the most obvious and easy solutions.

Unplug the unit! Usually, the sheet metal cover over the top and sides is easily removed after unscrewing 8-16 philips head sheet metal screws. Most of these are on the back but a few may screw into the sides. They are not usually all the same! At least one of these includes a lockwasher to securely ground the cover to the case. Make note of any differences in screw types so they can be put back in the same place. The cover will then lift up and off. Note how fingers on the cover interlock with the main cabinet - these are critical to ensure prevention of microwave leakage after reassembly.

Please see Typical Microwave Oven Electronics Bay for parts identification. Not all ovens are this wide open. If yours is a compact unit, everything may be really squeezed together. :) Details will vary depending on manufacturer and model but most of the major components will look fairly similar to those depicted in the photo. Note that for this model, the oven lamp is actually inside the electronics bay right next to the high voltage on the magnetron filament - light bulb changing here is really best left to a professional if you would otherwise not go inside!

Discharge the high voltage capacitor as described in the section: Safe discharging of the high voltage capacitor before even thinking about touching anything.

A schematic showing all of the power generation components is usually glued to the inside of the cover. How much of the controller is included varies but is usually minimal.

Fortunately, all the parts in a microwave can be easily replaced and most of the parts for the microwave generator are readily available from places like MCM Electronics, Dalbani, and Premium Parts.

Reassemble in reverse order. Take particular care to avoid pinching any wires when reinstalling the cover. Fortunately, the inside of a microwave is wide open and this is not difficult. Make sure ALL of the metal fingers around the front edge engage properly with the front panel lip. This is critical to avoid microwave emissions should the waveguide or magnetron become physically damaged in any way. Confirm that the screws you removed go back in the proper locations, particularly the one that grounds the cover to the chassis.

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Principles of Operation

Instant (2 minutes on HIGH) microwave oven theory

Please see Typical Microwave Oven Electronics Bay for parts identification.

A typical microwave oven uses between 500 and 1000 W of microwave energy at 2.45 GHz to heat the food. This heating is caused mainly by the vibration of the water molecules. Thus plastic, glass, or even paper containers will heat only through conduction from the hot food. There is little transfer of energy directly to these materials. This also means that the food does not need to be a conductor of electricity (try heating a cup of distilled water) and that electromagnetic induction (used elsewhere for high frequency non-contact heating) is not involved.

What is significant about 2.45 GHz? Not that much. Water molecules are not resonant at this frequency. A wide range of frequencies will work to heat water efficiently. 2.45 GHz was probably chosen for a number of other reasons including not interfering with existing EM spectrum assignments and convenience in implementation. In addition, the wavelength (about 5 inches) results in reasonable penetration of the microwave energy into the food. The 3 dB (half power) point is about 1 inch for liquid water - half the power is absorbed in the outer 1 inch of depth, another 1/4 of the power in the next inch, and so forth.

From: Barry L. Ornitz (ornitz@tricon.net).)

> "Industrial ovens still often operate at 915 MHz and other frequencies near 6 GHz are also used.
>
> Water has numerous resonances over the entire spectra range, but the lowest frequency resonance is the rotational resonance is around 24 GHz. Other resonances occur in the millimeter wave range through the infrared.

> For references, check books on microwave spectroscopy by Townes and Gordy."

Since the oven chamber cavity is a good reflector of microwaves, nearly all the energy generated by the oven is available to heat the food and heating speed is thus only dependent on the available power and how much food is being cooked. Ignoring losses through convection, the time to heat food is roughly proportional to its weight. Thus two cups of water will take around twice as long to bring to a boil as one.

Heating is not (as popularly assumed) from the inside out. The penetration depth of the microwave energy is a few cm so that the outside is cooked faster than the inside. However, unlike a conventional oven, the microwave energy does penetrate these few cm rather than being totally applied to the exterior of the food. The misconception may arise when sampling something like a pie filling just out of the microwave (or conventional oven for that matter). Since the pie can only cool from the outside, the interior filling will appear to be much hotter than the crust and will remain that way for a long time.

One very real effect that may occur with liquids is superheating. It is possible to heat a pure liquid like water to above its boiling point if there are no centers for bubbles to form such as dust specks or container imperfections. Such a superheated liquid may boil suddenly and violently upon removal from the oven with dangerous consequences. This can take place in a microwave since the heating is relatively uniform throughout the liquid. With a stovetop, heating is via conduction from the burner or coil and there will be ample opportunity for small bubbles to form on the bottom long before the entire volume has reached the boiling point.

Most metal objects should be excluded from a microwave oven as any sharp edges (areas of high electric field gradient) may create sparking or arcing which at the very least is a fire hazard. Microwave safe metal shelves will have nicely rounded corners.

A microwave oven should never be operated without anything inside as the microwave generator then has no load - all the energy bounces around inside an a great deal is reflected back to the source. This may cause expensive damage to the magnetron and other components.

Why don't microwaves leak out from through the glass?

> "I am trying to find out what the glass on a microwave consists of exactly. i have not been able to get a better answer than 'a wire mesh'. if you can help, i would greatly appreciate it."

There *is* a wire mesh embedded in the glass panel. Since the holes in the mesh are much much smaller than the wavelength of the 2.45 GHz microwaves (about 5 inches or 12.5 cm), it is essentially opaque to microwaves and essentially all the energy is reflected back into the oven cavity.

(From: Filip (I'll buy a vowel) Gieszczykiewicz (filipg@repairfaq.org).)

Greetings. Did you ever see a "mesh" satellite disk up close? You will note that it looks much like it's made out of simple wire mesh that you can get in a hardware store (in the USA, it's called "chicken fence" :-). The reason this works is that the wave that the dish picks up is longer than the hole in the mesh. Consider bouncing a tennis ball on the "wire mesh" in the microwave - it WOULD work because the ball is bigger than the holes. The wave in the microwave is about 2.5cm "long" ... as long as the holes are smaller than that (actually, you want them as small as possible - without affecting the "watching the food" - to minimize any stray and harmonic waves from escaping... like bouncing tennis and golf and ping-pong balls and marbles off the mesh - you want to catch all the possible sizes - yet still be able to see through it) they will not let anything out of the oven.

BTW, it's not really "glass" but rather a 'sandwich' of glass, from the outside, wire mesh (usually a sheet of metal which is either stamped or drilled with a hole pattern - like a color TV CRT mask!), and followed by a sheet of glass or plastic to make sure that food splatters and vapor condensation are easy to clean - imagine scraping the mesh!

How a microwave oven works

The operation of a microwave oven is really very simple. It consists of two parts: the controller and the microwave generator.

A schematic diagram of the microwave generating circuitry and portions of the controller is usually glued to the inside of the cover.

The controller is what times the cooking by turning the microwave energy on and off. Power level is determined by the ratio of on time to off time in a 10-30 second cycle.

The microwave generator takes AC line power. steps it up to a high voltage, and applies this to a special type of vacuum tube called a magnetron - little changed from its invention during World War II (for Radar).

Controller

The controller usually includes a microcomputer, though very inexpensive units may simply have a mechanical timer (which ironically, is probably more expensive to manufacture!). The controller runs the digital clock and cook timer; sets microwave power levels; runs the display; and in high performance ovens, monitors the moisture or temperature sensors.

Power level is set by pulse width control of the microwave generator usually with a cycle that lasts 10-30 seconds. For example, HIGH will be continuous on, MEDIUM may be 10 seconds on, 10 seconds off, and LOW may be 5 seconds on, 15 seconds off. The power ratios are not quite linear as there is a 1 to 3 second warmup period after microwave power is switched on.

The operating voltages for the controller usually are derived from a stepdown transformer. The controller activates the microwave generating circuitry using either a relay or triac.

Sensors

More sophisticated ovens may include various sensors. Most common are probes for temperature and moisture. A convection oven will include a temperature sensor above the oven chamber.

Since these sensors are exposed to the food or its vapors, failures of the sensor probes themselves are common.

Cooling fans

Since 30 to 50 percent of the power into a microwave oven is dissipated as heat in the Magnetron, cooling is extremely important. Always inspect the cooling fan/motor for dust and dirt and lubricate if necessary. A couple of drops of electric motor oil or 3-in-One will go a long way. If there are any belts, inspect for deterioration and replace if necessary.

An oven that shuts off after a few minutes of operation could have a cooling problem, a defective overtemperature thermostat, a bad magnetron, or is being operated from very high AC line voltage increasing power to the oven.

One interesting note: Since 30 to 50 percent of the power goes out the vents in the back as heat, a microwave oven is really only more efficient than conventional means such as a stovetop or gas or electric oven for heating small quantities of anything. With a normal oven or stovetop, wasted energy goes into heating the pot or oven, the air, and so on. However, this is relatively independent of the quantity of food and may be considered to be a fixed overhead. Therefore, there is a crossover point beyond which it is more efficient to use conventional heat than high tech microwaves.

Microwave generator

This is the subsystem that converts AC line power into microwave energy. It consists of 5 parts: high voltage transformer, rectifier diode, capacitor, magnetron, waveguide to oven chamber.

- High Voltage Transformer. Typically has a secondary of around 2,000 VRMS at 0.25 amp - more or less depending on the power rating of the oven. There will also be a low voltage winding for the Magnetron filament (3.3 V at 10 A is typical).

  You cannot miss this as it is the largest and heaviest component visible once the cover is removed. There will be a pair of quick-connect terminals for the AC input, a pair of leads for the Magnetron filament. and a single connection for the HV output. The HV return will be fastened directly to the transformer frame and thus the chassis.

  These transformers are designed with as little copper as possible. The primary for 115 VAC is typically only 120 turns of thick wire - thus about 1 turn per volt input and output (this is about 1/4th as many turns as in a "normal" power transformer. (It's usually possible to count the primary turns by examining how it is wound - no disassembly required!) So there would about 3 turns for the magnetron filament and 2080 turns for the high voltage winding for the transformer mentioned above. The reason they can get away with so few turns is that it operates fully loaded about 90 percent of the time but is still on the hairy edge of core saturation.

  There is also generally a "magnetic shunt" in the core of the transformer. This provides some current limiting, possibly to compensate for various magnetron load conditions. However, it's not enough to provide any reduction in the likelihood of electrocution should you come in contact with the HV winding!

- Rectifier - usually rated 12,000 to 15,000 PRV at around .5 amp. Most commonly, this will be rectangular or cylindrical, about .5 inch long with wire leads. Sometimes, it is a box bolted to the chassis. One end will be electrically connected to the chassis.

- Capacitor - .65 to 1.2 uF at a working voltage of around 2,000 VAC. Note that this use of 'working voltage' may be deceiving as the actual voltage on the capacitor may exceed this value during operation. The capacitor is metal cased with quick-connect terminals on top (one end). Always discharge the capacitor as described below before touching anything inside once the cover is removed.

- Magnetron - the microwave producing tube includes a heated filament cathode, multiple resonant cavities with a pair of permanent ceramic ring magnets to force the electron beams into helical orbits, and output antenna. The magnetron is most often box shaped with cooling fins in its midsection, the filament/HV connections on the bottom section, and the antenna (hidden by the waveguide) on top. Sometimes, it is cylindrical in shape but this is less common. The frequency of the microwaves is usually 2.45 GHz.

Magnetron construction and operation

The cavity magnetron was invented by the British before World War II. It is considered by many to be the invention most critical to the Allied victory in Europe.

The story goes that shortly after the War, a researcher at the Raytheon Corporation, Dr. Percy Spencer, was standing near one of the high power radar units and noticed that a candy bar in his shirt pocket had softened. In the typical 'I have to know why this happened' mentality of a true scientist, he decided to investigate further. The Amana Radarange and the entire future microwave oven industry were the result.

Here are two descriptions of magnetron construction. The first is what you will likely find if you go to a library and read about radar. (Some really old microwave ovens may use the classic design as well.) This is followed by my autopsy of a dead magnetron of the type that is probably in the microwave oven in your kitchen. (Items (1) to (6) in the following sections apply to each type while items (7) to (9) apply to both types.)

For more detailed information with some nice diagrams, see the articles at the Microtech Web Site. Topics include basic microwave theory as well as a complete discussion of microwave oven magnetron construction and principles of operation.

Magnetron construction - basic textbook description

This is the description you will find in any textbook on radar or microwave engineering. The original Amana Radarange and other early microwave ovens likely used this design as well.

1. A centrally located cylindrical electron emitting cathode. This is supplied with pulsed or continuous power of many thousands of volts (negative with respect to the anode.

2. A cylindrical anode block surrounding but separate and well insulated from the cathode.

3. Multiple cylindrical resonator cavities at a fixed radius from the cathode bored in the anode block. Channels link the cavities to the central area in which the cathode is located.

   The wavelength of the microwave energy is approximately 7.94 times the diameter of the cavities. (For the frequency of 2.45 GHz (12.4 cm) used in a microwave oven this would result in a cavity diameter of approximately .62" (15.7 mm).

4. An antenna pickup in one of the cylindrical cavities which couples the microwave energy to the waveguide.

5. The entire assembly is placed in a powerful magnetic field (several thousand Gauss compared to the Earth's magnetic field of about .5 Gauss). This is usually supplied by a permanent magnet though electromagnets have been also used. The original designs used huge somewhat horseshoe shaped permanent magnets which were among the most powerful of the day.

6. Cooling of the anode block must be provided by forced air, water, or oil since the microwave generation process is only about 60 to 75 percent efficient and these are often high power tubes (many kilowatts).

Magnetron construction - modern microwave oven

This description is specifically for the 2M214 (which I disassembled) or similar types used in the majority of medium-to-high power units. However, nearly all other magnetrons used in modern domestic microwave ovens should be very similar.

The item numbers are referenced to the diagram in the section: Cross section diagram of typical magnetron.

Also see this photo of the Typical Magnetron Anode and Resonant Structure. This is a view looking up through the anode cylinder from the filament end of the tube. See the text below for parts names and dimensions.

1. The filament and cathode are one in the same and made of solid tungsten wire, about .020" (.5 mm) diameter, formed in a helix with about 8 to 12 turns, 5/32" (4 mm) diameter and just over 3/8" (9.5 mm) in length. The cathode is coated with a material which is good for electron emission.

   Note: this coating is the only material contained in the microwave oven magnetron that might be at all hazardous. Beryllium, a toxic metal, may be used in large radar magnetrons but should not be present in the types found in domestic microwave ovens.

   The filament gets its power via a pair of high current RF chokes - a dozen or so turns of heavy wire on a ferrite core - to prevent microwave leakage back into the filament circuit and electronics bay of the oven. Typical filament power is 3.3 VAC at 10 A.

   The cathode is supplied with a pulsating negative voltage with a peak value of up to 5,000 V.

2. The anode is a cylinder made from .062" (1.5 mm) thick copper with an inside diameter of 1-3/8" (35 mm) and a length of about 1" (25.4 mm).

   Steel plates (which probably help to shape the magnetic field, see below) and thin steel covers (to which the filament and antenna insulators are sealed) are welded to the ends of the cylinder.

   The filament leads/supports enter through a cylindrical ceramic insulator sealed to the bottom cover and then pass through a hole in the bottom end plate.

3. Rather than cylindrical cavities (as you would find in most descriptions of radar magnetrons), there are a set of 10 copper vanes .062" (1.5 mm) thick and approximately 1/2" (12.7 mm) long by 3/8" (9.5 mm) wide. These are brazed or silver soldered to the inside wall of the cylinder facing inward leaving a 5/16" (8 mm) central area clear for the filament/cathode.

   Surrounding this space are the .062" (1.5 mm) thick edges of the 10 vanes with gaps of approximately .04" (1 mm) between them.

   Copper shorting rings at both ends near the center join alternating vanes. Thus, all the even numbered vanes are shorted to each other and all the odd numbered vanes are shorted to each other. Of course, all the rings are also all shorted at the outside where they are joined to the inner wall of the cylinder.

   This structure results in multiple resonant cavities which behave like sets of very high quality low loss L-C tuned circuits with a sharp peak at 2.45 GHz. At this high frequency, individual inductors and capacitors are not used. The inductance and capacitance are provided by the precise configuration and spacing of the copper vanes, shorting rings, and anode cylinder.

4. A connection is made near the middle of a single vane to act as the output power takeoff. It passes through a hole in the top end plate, exits the tube via a cylindrical ceramic insulator sealed to the top cover, and attaches to the pressed-on bu?ll-nose antenna cap.

5. The entire assembly is placed in a powerful magnetic field (several thousand Gauss compared to the Earth's magnetic field of about .5 Gauss). This is provided by a pair of ceramic ring magnets placed against the top and bottom covers of the anode cylinder. For the 2M214, these are about 2-1/8" (54 mm) OD, 1-13/16" (46 mm) ID, 1/2" (12.7 mm) thick.

6. A set of thin aluminum fins act as a heat sink for removing the significant amount of wasted heat produced by the microwave generation process since it is only about 60 to 75 percent efficient. These are press fit on the magnetron anode and also in contact with the magnetron case. There will always be a cooling fan to blow air through this assembly.

   The anode and magnetron case are at ground potential and connected to the chassis.

Magnetron construction - common features

The following items apply to all types of magnetrons.

7. The gap between the cathode and anode, and the resonant cavities, are all in a vacuum.

8. When powered, electrons stream from the cathode to the anode. The magnetic field forces them to travel in curved paths in bunches like the spokes of a wheel. The simplest way to describe what happens is that the electron bunches brush against the openings of the resonating cavities in the anode and excite microwave production in a way analogous to what happens when you blow across the top of a Coke bottle or through a whistle.

9. The frequency/wavelength of the microwaves is mostly determined by the size and shape of the resonating cavities - not by the magnetic field as is popularly thought. However, the strength of the magnetic field does affect the threshold voltage (the minimum anode voltage required for the magnetron to generate any microwaves), power output, and efficiency.

Cross section diagram of typical magnetron

The really extraordinary ASCII art below represents (or is supposed to represent) a cross section of the 2M214 type magnetron (not to scale) through the center as viewed from the side.

```
                       ________
                      |  ____  |
                      |_|    |_|  Antenna cap
                      / |____| \
                     |  | || |  | Antenna insulator
                     |  | || |  |
             xxxxxxxx|__| || |__|xxxxxxxx RF sealing gasket
 ____________________|    ||    |____________________
|        |       (5)||    ||    ||       (5)|        |
```

```
|        |   Top    ||    ||    ||   Top    |        |
|        |  Magnet  ||    ||    ||  Magnet  |        | Outer case
|        |__________||    ||    ||__________|        |
|              ______|     \\   |______              |
|             /____    (7)   \\    ____\             |
|____________||    \__  ______ \\ /    ||____________|
|            ||_______ |__  __| _\\ ___||            |
|____________||       | o || o |  ||(4)||____________|
|            ||       | o || o |       ||        (6) | Heat sink fins
|____________|| Vane  | o || o |  Vane ||____________|
|            || (3)   | o || o |  (3)  ||            |
|____________||       | o || o |       ||____________| o: Filament
|            ||_______|(1)|| o |_______||            |    helix
|____________||     __ |_||||_| __     ||____________|
|            ||____/   || ||      \____||<-- (2)     |
|             \_______  \\ \\    _______/             |
|         __________ |  ||  ||  | __________         |
|        |      (5)||  ||  ||  ||      (5)|        |
|        |  Bottom  ||  ||  ||  ||  Bottom  |        |
|        |  Magnet  ||  ||  ||  ||  Magnet  |        |
|________|__________||  ||  ||  ||__________|________|
    |                |__||__||__|                |
    |                 | ||  || |  Filament       |
    |                 | ||  || |  insulator      |
    |   (RF chokes    |_||__||_|                 |
    |    not shown)      ||  ||  Filament/cathode |
    |                    ||  ||  connections      |
    |____________________________________________|
```

Microwave generator circuit diagram

Nearly all microwave ovens use basically the same design for the microwave generator. This has resulted in a relatively simple system manufactured at low cost.

The typical circuit is shown below. This is the sort of diagram you are likely to find pasted inside the metal cover. Only the power circuits are likely included (not the controller unless it is a simple motor driven timer) but since most problems will be in the microwave generator, this schematic may be all you need.

```
                                       || +------------------------+
                                       ||( 3.3 VAC, 10 A, typical  |
                         TP  Relay or  || +------------+------+FA F| Magnetron
            _ Fuse   I   __    Triac   ||              |    +-|----|-+
    o------- _---+---/ --  ----/ ----+ || +------||----+    | |_  _| |
                 |                    )||( HV Cap      |    |   \/   |
   AC           I \ I=Interlock       )||(           __|__  |   ___  |
  Line           |  TP=Thermal Prot.  )||( 2,000 VAC _\_/_  +----|:--+
    o------------+-------------------+ ||( .25 A       | HV      |'--> Micro-
                                       ||( typical     | Diode   |      waves
```

```
       (Controller not shown)         || +-----------+--------+
                                                    _|_
                                                     -  Chassis ground
```

Note the unusual circuit configuration - the magnetron is across the diode, not the capacitor as in a 'normal' power supply. What this means is that the peak voltage across the magnetron is the transformer secondary + the voltage across the capacitor, so the peaks will approach the peak-peak value of the transformer or nearly 5000 V in the example above. This is a half wave voltage doubler. The output waveform looks like a sinusoid with a p-p voltage equal to the p-p voltage of the transformer secondary with its positive peaks at chassis ground (no load). The peaks are negative with respect to the chassis. The negative peaks will get squashed somewhat under load. Take extreme care - up to 5000 V at AMPs available! WARNING: Never attempt to view this waveform on an oscilloscope unless you have a commercial high voltage probe and know how to use it safely!

The easiest way to analyze the half wave doubler operation is with the magnetron (temporarily) removed from the circuit. Then, it becomes a simple half wave rectifier/filter so far as the voltage acrtoss the capacitor is concerned - which will be approximately V(peak) = V(RMS) * 1.414 where V(RMS) is the output of the high voltage transformer. The voltage across the HV rectifier will then be: V(peak) + V where V is the waveform out of the transformer. The magnetron load, being across the HV diode, reduces the peak value of this somewhat - where most of its conduction takes place.

Note that there is a difference in the labels on the filament connections of the magnetron. Functionally, it probably doesn't matter which way they are connected. However, the typical schematic (as above) shows FA going to the node attached to the Anode of the HV diode, while F goes to the lone Filament terminal on the HV transformer.

WARNING: What this implies is that if the magnetron is not present or is not drawing power for some reason - like an open filament - up to V(peak) will still be present across the capacitor when power is removed. At the end of normal operation, some of this will likely be discharged immediately but will not likely go below about 2,000 V due to the load since the magnetron does not conduct at low voltages.

Other types of power supplies have been used in a few models - including high frequency inverters - but it is hard to beat the simplicity, low cost, and reliability of the half wave doubler configuration. See the section: High frequency inverter type HV power supplies.

There is also usually a bleeder resistor as part of the capacitor, not shown. HOWEVER: DO NOT ASSUME THAT THIS IS SUFFICIENT TO DISCHARGE THE CAPACITOR - ALWAYS DO THIS IF YOU NEED TO TOUCH ANYTHING IN THE MICROWAVE GENERATOR AFTER THE OVEN HAS BEEN POWERED. The bleeder may be defective and open as this does not effect operation of oven and/or the time constant may be long - minutes. Some ovens may not have a bleeder at all.

In addition, there will likely be an over-temperature thermostat - thermal protector - somewhere in the primary circuit, often bolted to the magnetron case. There may also be a thermal fuse or other protector physically elsewhere but in series with the primary to the high voltage transformer.

Other parts of the switched primary circuit include the oven interlock switches, cooling fan, turntable motor (if any), oven light, etc.

Interlock switches

Various door interlock switches prevent inadvertent generation of microwaves unless the door is closed completely. At least one of these will be directly in series with the transformer primary so that a short in the relay or triac cannot accidentally turn on the microwaves with the door open. The interlocks must be activated in the correct sequence when the door is closed or opened.

Interestingly, another interlock is set up to directly short the power line if it is activated in an incorrect sequence. The interlocks are designed so that if the door is correctly aligned, they will sequence correctly. Otherwise, a short will be put across the power line causing the fuse to blow forcing the oven to be serviced. This makes it more difficult for an ignorant consumer to just bypass the door interlocks should they fail or to run the oven with an open door as a room heater - and protects the manufacturer from lawsuits. (That interlock may be known as a "dummy switch" for obvious reasons and is often not even mentioned in the schematic/parts manifest.) Of course, should that switch ever actually be used, not only will the fuse blow, but the switch contacts will likely be damaged by the high initial current! This also means it probably wouldn't be a bad idea to replace the interlock switch which might have been affected if your oven fails with a blown fuse due to a door problem.

Failed door interlocks account for the majority of microwave oven problems - perhaps as high as 75 percent. This is not surprising considering that two of the three switches carry the full oven current - any deterioration of the contacts results in increased resistance leading to their heating and further deterioration. And, opening the door to interrupt a cook cycle results in arcing at the contacts. Complete meltdowns are not unusual! If any defective door switches are found, it is probably a good idea to replace all of them as long as the oven is already apart.

The typical door switches and their function:

- **Door Sensing**: Input to the microcontroller to indicate the state of the door.

- **Interlock Monitor**: Shorts out the AC line (and blows the main fuse) should the Primary Interlock not open due to incorrect sequencing of the door switches or a failed switch.

- **Primary Interlock**: In series with the high voltage (magnetron) power supply so cuts power when the door is open.

Note that if the Door Sensing switch should malfunction, peculiar behavior may occur (like the fan or turntable operating at the wrong time) but should never result in microwaves being generated with the door open.

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Troubleshooting Guide

Instant troubleshooting chart - most common problems and possible causes

The following chart lists a variety of common problems and nearly all possible causes. Diagnostic procedures will then be needed to determine which actually apply. The 'possible causes' are listed in *approximate* order of likelihood. Most of these problems are covered in more detail elsewhere in this document.

While this chart lists many problems, it is does not cover everything that can go wrong. However, it can be a starting point for guiding your thinking in the proper direction. Even if not listed here, your particular problem may still be dealt with elsewhere in this document.

- Problem: Totally dead oven.
  Possible causes:

  1. No power to outlet (blown fuse or tripped breaker or GFCI).
  2. Blown main fuse - likely due to other problems.
  3. Open thermal protector or thermal fuse.
  4. Defective controller or its power supply.
  5. Clock needs to be set before other functions will operate (some models).

- Problem: No response to any buttons on touchpad.
  Possible causes:

  1. Door is not closed (some models).
  2. You waited to long (open and close door to wake it up).
  3. Controller is confused (pull plug for a minute or two to reset).
  4. Defective interlock switches.
  5. Faulty controller or its power supply.
  6. Touchpad or controller board contaminated by overenthusiastic cleaning.
  7. Defective/damaged touchpad.

- Problem: Oven runs when door is still open.
  Possible causes:

  1. Damaged interlock assembly.
  2. Cooling fans (only) running due to bad sensor or still warm.

- Problem: Oven starts on its own as soon as door is closed.
  Possible causes:

  1. Defective triac or relay.
  2. Controller is confused (pull plug for a minute or two to reset).
  3. Defective controller or its power supply.
  4. Touchpad or controller board contaminated by overenthusiastic cleaning.
  5. Defective/damaged touchpad.

- Problem: Oven works but display is blank.
  Possible causes:

  1. Defective controller or its power supply.
  2. Broken display panel.
  3. Oven needs to be reset (pull plug for a minute or two to reset).

- Problem: Whacked out controller or incorrect operation.
  Possible causes:

  1. Previous or multipart cook cycle not complete.

2. Controller is confused (pull plug for a minute or two to reset).
3. Defective controller or its power supply.
4. Touchpad or controller board contaminated by overenthusiastic cleaning.
5. Defective/damaged touchpad.
6. Defective sensor (particulalry covection/mirowave combos).

- Problem: Erratic behavior.
  Possible causes:

  1. Previous or multipart cook cycle not complete.
  2. Bad connections in controller or microwave generator.
  3. Faulty relay - primary (or HV side, much less commonly used).
  4. Defective controller or its power supply.
  5. Bad contacts/connections on mechanical timers. Intermittent fuse.
  6. Power surge at start of cook cycle confusing controller.
  7. Microwave (RF) leakage into electronics bay.

- Problem: Some keys on the touchpad do not function or perform the wrong action.
  Possible causes:

  1. Touchpad or controller board contaminated by overenthusiastic cleaning.
  2. Defective/damaged touchpad.
  3. Controller is confused (pull plug for a minute or two to reset).
  4. Faulty controller.

- Problem: Microwave oven does not respond to START button.
  Possible causes:

  1. Defective START button.
  2. Faulty interlock switches.
  3. Door is not securely closed.
  4. Faulty controller.
  5. You waited too long - open and close door to wake it up!

- Problem: No heat but otherwise normal operation.
  Possible causes:

  1. Blown fuse in HV transformer primary circuit or HV fuse (if used).
  2. Bad connections (particularly to magnetron filament).
  3. Open thermal protector or thermal fuse.
  4. Open HV capacitor, HV diode, HV transformer, or magnetron filament.
  5. Shorted HV diode, HV capacitor (will blow a fuse), or magnetron.
  6. Defective HV relay (not commonly used).

- Problem: Timer and light work but no heat, cooling fan, or turntable rotation.
  Possible causes:

  1. Defective (lower) door interlock switch or door not closing fully.
  2. Faulty relay or triac.

- Problem: Fuse blows when closing or opening door:
  Possible causes:

  1. Defective door interlock switchs.
  2. Misaligned door.

- Problem: Loud hum and/or burning smell when attempting to cook.
  Possible causes:

  1. Shorted HV diode, magnetron.
  2. Burnt carbonized food in or above oven chamber.
  3. Shorted winding in HV transformer.
  4. Frayed insulation on HV wiring.

- Problem: Arcing in or above oven chamber.
  Possible causes:

  1. Burnt carbonized food deposits.
  2. Exposed sharp metal edges.

- Problem: Fuse blows when initiating cook cycle.
  Possible causes:

  1. Defective interlock switches or misaligned door.
  2. Shorted HV capacitor.
  3. Shorted HV diode.
  4. Shorted magnetron (probably won't blow main fuse but HV fuse if used).
  5. Defective triac.
  6. Old age or power surges.
  7. Defective HV transformer.
  8. Short in wiring due to vibration or poor manufacturing.

- Problem: Fuse blows when microwave shuts off (during or at end of cook cycle).
  Possible causes:

  1. Defective triac (doesn't turn off properly).
  2. Defective relay.
  3. Shorting wires.

- Problem: Oven heats on high setting regardless of power setting.
  Possible causes:

  1. Faulty primary relay or triac or HV relay (not commonly used).
  2. Faulty controller.

- Problem: Oven immediately starts to cook when door is closed.
  Possible causes:

1. Shorted relay or triac.
2. Faulty controller.

- Problem: Oven heats but power seems low or erratic.
  Possible causes:

  1. Low line voltage.
  2. Magnetron with low emission.
  3. Faulty controller or set for wrong mode.
  4. Stirrer (or turntable) not working.
  5. Intermittent connections to magnetron filament or elsewhere.
  6. Faulty primary relay or triac or HV relay (not commonly used).

- Problem: Oven heats but shuts off randomly.
  Possible causes:

  1. Overheating due to blocked air vents or inoperative cooling fan.
  2. Overheating due to bad magnetron.
  3. Bad connections in controller or microwave generator.
  4. Faulty interlock switch or marginal door alignment.
  5. Faulty controller.
  6. Overheating due to extremely high line voltage.
  7. Stuck stirrer fan resulting hot spots detected by sensors.

- Problem: Oven makes (possibly erratic) buzzing noise when heating.
  Possible causes:

  1. Fan blades hitting support or shroud.
  2. Vibrating sheet metal.
  3. Vibrating transformer laminations.
  4. Turntable or stirrer hitting some debris.

- Problem: Oven light does not work.
  Possible causes:

  1. Burnt out bulb :-).
  2. Bad connections.

- Problem: Fans or turntables that do not work.
  Possible causes:

  1. Gummed up lubrication or bad motor bearing(s).
  2. Loose or broken belt.
  3. Bad motor.
  4. Bad thermostat.
  5. Bad connections.

What can go wrong

The most common problems occur in the microwave generating portion of the system, though the controller can be blown by a lightning strike or other power surge. Bad interlock switches probably account for the majority of microwave oven problems. Also, since the touchpad is exposed, there is a chance that it can get wet or damaged. If wet, a week or so of non-use may cure keys that don't work. If damaged, it will probably need to be replaced - this is straightforward if the part can be obtained, usually direct from the manufacturer. Unfortunately, it is an expensive part ($20-50 typical).

The interlock switches, being electromechanical can fail to complete the primary circuit on an oven which appears to operate normally with no blown fuses but no heat as well. Faulty interlocks or a misaligned door may result in the fuse blowing as described above due to the incorrect sequencing of the door interlock switches. Failed interlocks are considered to be the most common problems with microwave ovens, perhaps as high as 75% of all failures. See the section: Testing and replacing of interlock switches.

No adjustments should ever be required for a microwave oven and there are no screws to turn so don't look for any!

General system problems

The following problems are likely power or controller related and not in the microwave generator unless due to a blown fuse or bad/intermittent connections:

- Totally dead oven.
- No response to any buttons on touchpad
- Oven runs when door is still open.
- Oven starts on its own as soon as door is closed.
- Oven works but display is blank.
- Whacked out controller or incorrect operation.
- Erratic behavior.
- Some keys on the touchpad do not function or perform the wrong action.
- Microwave oven does not respond to START button.

First, unplug the microwave oven for a couple of minutes. Sometimes, the microcontroller will get into a whacko mode for some unknown reason - perhaps a power surge - and simply needs to be reset. The problem may never reoccur.

Note: when working on controller related problems, unplug the connection to the microwave generator (HV transformer primary) from the power relay or triac - it is often a separate connector. This will prevent any possible accidental generation of microwave energy as well as eliminating the high voltage (but not the AC line) shock hazard during servicing.

If this does not help, there is likely a problem with the controller circuitry or its power and you will have to get inside the oven.

Uninvited guests

Some cockroaches (or other lower life forms) may have taken up residence on the controller circuit board. It is warm, cozy, safe, and from their point of view makes an ideal habitat. If you got the microwave oven from a flea market, garage sale, the curb, a relative, or friend, or if your kitchen isn't the cleanest in the world, such visitors are quite possible. Creatures with six or more legs (well, some two legged varieties as well) are not known for their skills in the areas of housekeeping and personal hygiene.

Clean the circuit board and connectors thoroughly with water and then isopropyl alcohol. Dry completely. Inspect the circuit traces for corrosion or other damage. If there are any actual breaks, these will have be be jumpered with fine wire and then soldered. Hopefully, no electronic components were affected though there is always a slight possibility of other problems.

Totally dead oven

First, check power to the outlet using a lamp or radio you know works. The fuse or circuit breaker at your service panel may have blown/tripped due to an overload or fault in the microwave oven or some other appliance. You may just have too many appliances plugged into this circuit - microwave ovens are high current appliances and should be on a dedicated circuit if possible. If you attempt to run a heating appliance like a toaster or fryer at the same time, you *will* blow the fuse or trip the circuit breaker. A refrigerator should never be plugged into the same circuit for this reason as well - you really don't want it to be without power because of your popcorn!

If you find the fuse blown or circuit breaker tripped, unplug everything from the circuit to which the microwave is connected (keep in mind that other outlets may be fed from the same circuit). Replace the fuse or reset the circuit breaker. If the same thing happens again, you have a problem with the outlet or other wiring on the same branch circuit. If plugging in the microwave causes the fuse to blow or circuit breaker to trip immediately, there is a short circuit in the power cord or elsewhere.

The microwave oven may be powered from a GFCI outlet or downstream of one and the GFCI may have tripped. (Removing a broken oven lamp has been known to happen.) The GFCI outlet may not be in an obvious location but first check the countertop outlets. The tripped GFCI could be in the garage or almost anywhere else! Pushing the RESET button may be all that's needed.

Next, try to set the clock. With some ovens the screen will be totally blank following a power outage - there may be nothing wrong with it. Furthermore, some ovens will not allow you perform any cooking related actions until the clock is set to a valid time.

Assuming these are not your problems, a fuse has probably blown although a dead controller is a possibility.

If the main fuse is upstream of the controller, then any short circuit in the microwave generator will also disable the controller and display. If this is the case, then putting in a new fuse will enable the touchpad/display to function but may blow again as soon as a cook cycle is initiated if there is an actual fault in the microwave circuits.

Therefore, try a new fuse. If this blows immediately, there may be a short very near the line cord, in the controller, or a defective triac (if your oven uses a triac). Or, even a shorted oven lamp - remove and inspect the light bulb and socket.

If it does not blow, initiate a cook cycle (with a cup of water inside). If the oven now works, the fuse may simply have been tired of living. This is common.

If the fuse still blows immediately, confirm that the controller is operational by unplugging the microwave generator, power relay, and/or triac from the controller. If a new fuse does not now blow when a cook cycle is initiated - and it appears to operate normally - then one of the components in the microwave generator is defective (shorted). See the section: Microwave generator problems.

Some models have a thermal fuse as well and this may have failed for no reason or a cooling fan may not be working and the oven overheated (in which case it probably would have died while you were cooking something for an important guest - assuming you would use a microwave oven for such a thing!).

Other possible causes: bad controller power supply or bad controller chip.

Dead controller

The most common way that the controller circuitry can be harmed is by a power surge such as from a lightning strike. Hopefully, only components on the primary side of the power transformer will be affected.

- Check the primary of the power transformer - if it is open, there may be a fuse/thermal fuse underits outer insulation. If not, the transformer will need to be replaced. There is a good chance that the surge didn't propagate beyond the transformer and thus the rest of the controlled should be unaffected.

- In some cases, circuit board traces may have been vaporized (but repair may still be possible by simply jumpering across the crater). Some of these thin traces may be there specifically to act as fuses - and there may even be spares to use for just this situation!

- Assuming that the main fuse and power transformer primary checks out, then check the power supply for the controller next.

- As always, also check for bad solder connections.

If the controller power supply is working and there is still no sign of life (dead display and no response to buttons) the microcontroller chip or some other part may be bad. It could be a simple part like a capacitor or diode, but they would all need to be tested. At this point, a schematic of the controller board will be needed - often impossible to get - and replacement controller or even just the main chip may be nearly as expensive as a complete new oven.

No response to any buttons on touchpad

There can be many causes for this behavior (or lack of behavior):

- Door is not closed - on many ovens, there will be no response to any buttons - even setting the clock - unless the door is securely closed.

- You waited too long - some models (like Sharp) have a timeout. If you close the door but don't proceed to activate any functions with a couple of minutes, they will require you to open and close the door to reset their pathetic brains.

- Controller is confused - a power surge or random non-reproducible action of the universe may have resulted in the controller's program ending up in an infinite loop. Pull the plug for a minute or two to reset it.

- Defective interlock switches - this can result in the controller thinking the door is open and ignoring you.

- Faulty controller or its power supply - a power surge may have damaged the electronics. Other than checking for bad connections and obviously bad power supply components, diagnosing this will be tough without a schematic (and possibly much more).

- Touchpad or controller board contaminated by overenthusiastic cleaning - if you recently power washed the oven (or even if you only use some spray cleaner), some may have gotten inside and shorted out the touchpad or controller.

- Defective or damage touchpad - physical abuse is not a recommended technique for getting a microwave oven to cooperate. If there is any visible damage to the touchpad - the outer film is broken - it will probably need to be replaced.

Also see the section: Some of the keys on the touchpad do not function or perform the wrong action.

Oven runs when door is still open

WARNING: Needless to say, DO NOT operate the oven with the door open! While extremely unlikely, the microwave be generator could be running!

For microwaves to actually be generated with the door still open would require the failure of all 3 interlock switches. The only way this could really happen would be for the 'fingers' from the door that engage the interlocks to break off inside the oven keeping the interlocks engaged. In this case, the controller would think the door was always closed.

Where no such damage is evident, a failure of this type is extremely unlikely since power to the microwave generator passes through 2 of the 3 interlock switches. If both of these failed in the closed position, the third switch would have blown the fuse the last time the door was opened.

Another more benign possibility is that one or more fans are running as a result of either a defective sensor or normal operation to maintain air flow until all parts have cooled off.

Oven starts on its own as soon as door is closed

If the oven starts up as soon as the door is closed - regardless of whether a cook cycle has been selected, the cause could be a shorted triac or relay or a problem with the controller or touchpad.

First, unplug the oven for a couple of minutes to try to reset the controller.

If this doesn't help, put a cup of water into the oven and let it run for a minute to check for heating. (You could also note the normal sound change or slight dimming of lights that accompanies operation of the magnetron.) Much more must be enabled to actually power the magnetron so this might point more to the controller as being faulty but not always.

Also see the section: Whacked out controller or incorrect operation.

Oven works but totally dead display

If all functions work normally including heating but the display is blank (assuming you can issue them without being able to see the display), the problem is almost certainly in the controller or its power supply.

Try pulling the plug for a minute or two - for some reason the display portion of the controller may have been sent out to lunch by a power surge or alpha particle. It woudn't be the first time.

Check for bad connections between the display panel and the power supply and solder joints on the controller board.

With everything else operational, a bad microcontroller chip is not that likely but is still a possibility. If the oven was physically abused, the display panel may have fractured though it would take quite a bit of violence. In this case, more serious damage to the door seals may have resulted as well which would be a definite hazard.

Whacked out controller or incorrect operation

The following are some of the possible symptoms:

- All the display digits may have come on, EEEE or FFFF, or be displaying in Greek.
- The end-of-cooking cycle or keypress tone may be wailing away continuously. (By 'tone' I mean from the controller (not a low buzzing or humming when attempting to cook which would indicate a microwave generator power problem like a shorted magnetron).
- Pressing a button on the touchpad may result in a totally incorrect action such as entering the time resulting in the oven starting to cook. However, for the special case where pressing START results in erratic behavios, see the section: Erratic behavior.
- The oven may start cooking (or at least appear to) as soon as the door is closed. Pressing buttons on the touchpad may or may not have any effect. (This could also be a shorted triac or power relay).

First, try unplugging the oven for a couple of minutes - perhaps the controller is just confused due to a power surge, lightning strike or the EMP from a nearby nuclear detonation because it wanted attention.

If you recently cleaned the oven, some liquid may have accidentally gotten inside the touchpad or even the controller circuitry (though this is less likely). See the section: Some of the keys on the touchpad do not function or perform the wrong action.

If the oven seems to have a mind of its own - running a cycle you didn't think you programmed, are you sure a previous cook cycle was not interrupted and forgotten? Try to recreate the problem using a cup of water as a load.

Assuming this does not apply, it sounds like a controller problem - possibly just a power supply but could also be the controller chip. My guess is that unless you were to find some simple bad connections or an obvious problem with the controller's power supply, the cost to repair would be very high as the custom parts are likely only available from the manufacturer.

The controller's program may be corrupted (unlikely) but we have no real way of diagnosing this except by exclusion of all other possibilities. Depending on the model, some or all operations - even setting the clock - may be conditional on the door interlocks being closed, so these should be checked. Some ovens will not allow any actions to be performed if the door has been closed for more than a few minutes - open and close the door to reset.

A controller failure does little to predict the reliability of the rest of the oven. The microwave generator circuits could last a long time or fail tomorrow. The output of the magnetron tube may decrease slightly with use but there is no particular reason to expect it to fail any time soon. This and the other parts are easily replaceable.

However, unless this oven has a lot of fancy features, you can buy a replacement (depending on size) for $100-200 so it is probably not worth fixing unless it is something relatively simple and inexpensive.

Erratic behavior

There are three different situation:

- Whenever the oven performs unexpectedly both during setup and the cook cycle, suspect the controller power supply or bad connections.
- Where problems only occur when entering or during the cook cycle, suspect a power relay or mechanical timer (if used) with dirty or worn contacts, or (less likely) the power surge from energizing the microwave generator or microwave (RF) leakage into the electronics bay affecting the controller.
- However, if erratic simply means that it doesn't heat consistently, see the section: Oven heats but power seems low or erratic.

The filter capacitor(s) in the controller's power supply may be dried up or faulty. Check with a capacitor meter or substitute known good ones. Prod the logic board to see if the problem comes and goes. Reseat the flex cable connector to the touchpad.

For mechanical timers, the timing motor could be defective or require lubrication. The contacts could be dirty or worn. There may be bad connections or loose lugs.

The primary relay may have dirty or burnt contacts resulting in erratic operation. If the oven uses a HV relay for power control, this may be defective.

If the times and power levels appear on the display reliably but then become scrambled when entering the cook cycle or the oven behaves strangely in some other way when entering the cook cycle, there are several possibilies:

- The power surge caused by the cook cycle starting is resulting in changes to the settings or else the microcontroller is not interpreting them properly. This may be due to a faulty part of bad connections in the controller or elsewhere. As with intermittent problems, a thorough search for loose ground and other connections and bad solder joints may locate the source of the difficulty.
- Microwave (RF) leakage into the electronics bay due to an faulty joint between the magnetron and the waveguide or structure failure of the magnetron may be interfering with the operation of the microcontroller. Unless the oven was dropped or 'repaired' by an butcher, this sort of failure is unlikely. If you suspect either of these, inspect the integrety of the magnetron-waveguide joint and make sure the RF gasket is in place. Unfortunately, this is sometimes difficult to pinpoint because unless there is obvious mechanical damage, the 'problem' may disappear once the cover is removed for testing. See the section: Problems with internal microwave leakage.
- On rare occasions, the main fuse may become intermittent rather than failing completely. The surge or vibration of starting can jiggle the element open or closed. It is easy to try replacing it!

Problems with internal microwave leakage

(From: Charles Godard (cgodard@iamerica.net).)

I only service Amana's, but have serviced lot's of them over the years. I've only found a few that leaked with my expensive leak detector. The most memorable was the one with the leak that was due to the copper gasket that's between the magnetron tube and the cavity. I just reformed the gasket and reseated the magnetron and that fixed the leak.

The symptom was that the Touch Pad timer lights and indicators would change while the unit was cooking. I thought I had a timer problem. I took it apart and checked for loose solder joints and even cleaned the glass touch pad contacts.

For some reason that I don't remember now, I checked for radiation with the cover off the unit and found it extremely high.

It turned out that the radiation was affecting the controller.

From the outside, with the cover on, the unit didn't leak.

Long ago, I tried one of the cheapie detectors because one of my parts supply houses suggested it, and it detected leaks on everything. After that I shelled out the bucks and bought a real detector.

(From: Matthew Sekulic (goatboy@telusplanet.net).)

I have had a similar experience with a Sanyo, similar symptoms, but with the leakage from the spot welded waveguide inside the unit. Our calibration meter showed a two watt leakage, with none escaping the outer case when attached.

(My worst case of actual external leakage was from a misaligned door at .75 watts with the probe's styrofoam spacer placed against the door, of course dropping off to near zero a few inches away. My clue in was a spark between the waveguide and the case, when I was messing with the Controller PCB.)

Some of the keys on the touchpad do not function or perform the wrong action

Touchpads are normally quite reliable in the grand scheme of things but can fail as a result of physical damage (your spouse threw the roast at the oven), liquid contamination (from overzealous cleaning, for example), or for no reason at all.

Look carefully for any visible signs of damage or spills. The touchpads often use pressure sensitive resistive elements which are supposed to be sealed. However, any damage or just old age may permit spilled liquid to enter and short the sensors. A week or so of drying may cure these problems. If there is actual visible damage, it may be necessary to replace the touchpad unit, usually only available from the original manufacturer. Also, check the snap type connector where the touchpad flex-cable plugs into the controller board. Reseating this cable may cur a some keys dead problem.

Some people have reported at least temporary improvement by simple peeling the touch pad off of the front panel and flexing it back and forth a few times. Presumably, this dislodges some bit of contamination. I am skeptical as this could just be a side effect of a bad connection elsewhere.

With a little bit of effort (or perhaps a lot of effort), the internal circuitry of the touchpad can be determined. This may require peeling it off of the front panel). Then, use resistors to jumper the proper contacts on the flex cable connector to simulate key presses. This should permit the functions to be verified before a new touchpad is ordered.

Caution: unplug the microwave generator from the controller when doing this sort of experiment!

If the problem was the result of a spill into the touchpad, replacement will probably be needed.

However, if you have nothing to lose, and would dump it otherwise, remove the touchpad entirely and wash it in clean water in an effort to clear out any contamination, then do the same using high purity alcohol to drive out the water, and then dry it out thoroughly. This is a long shot but might work.

Microwave oven does not respond to START button

While all other functions operate normally including clock, cook time, and power setting, pressing START does nothing, including no relay action and the timer digits do not count down. It is as though the START button is being totally ignored. (However, if there is a momentary response but then the oven shuts off, see the section: Erratic behavior.

If there is an alternate way of activating the cook cycle, try it. For example, Sharp Carousel IIs have a 'Minute Plus' button which will cook for one minute on HIGH. Use this to confirm the basic controller logic and interlock circuitry. If it works, then the problem may indeed be a faulty START button. If it is also ignored, then there may be a bad interlock or some other problem with the controller.

Check for bad interlocks or interlocks that are not being properly activated.

Next confirm if possible that the START touch pad button is not itself faulty. If you can locate the matrix connections for this button, the resistance should go down dramatically (similar to the other buttons). See the section: Some of the keys on the touchpad do not function or perform the wrong action. The START button does, after all, sees quite a lot of action!

Assuming it is not the touch pad, it sounds like the controller is either not sensing the start command or refusing to cooperate for some reason - perhaps it thinks an interlock is open. Otherwise, the timer would start counting. Testing the relay or triac control signal will likely show that it is not there. Check that there are no missing power supply voltages for the controller and bad connection.

Microwave generator problems

Failures in the microwave generator can cause various symptoms including:

- No heat but otherwise normal operations.
- Fuse blows when closing or opening door.
- Loud hum and/or burning smell when attempting to cook.
- Arcing in or above oven chamber.
- Fuse blows when initiating cook cycle.
- Fuse blows when microwave shuts off (during or at end of cook cycle).

- Oven heats on high setting regardless of power setting.
- Oven immediately starts to cook when door is closed.
- Oven heats but power seems low or erratic.
- Oven heats but shuts off randomly.

Most of these are easy to diagnose and the required parts are readily available at reasonable prices.

No heat but otherwise normal operation

If the main power fuse is located in the primary of the high voltage transformer rather then at the line input, the clock and touchpad will work but the fuse will blow upon initiating a cook cycle. Or, if the fuse has already blown there will simply be no heating action once the cook cycle is started. There are other variations depending on whether the cooling fan, oven light, and so forth are located down stream of the fuse.

Some models may have a separate high voltage fuse. If this is blown, there will be no heating but no other symptoms. However, high voltage fuses are somewhat rare on domestic ovens.

A number of failures can result in the fuse NOT blowing but still no heat:

- Bad connections - these may be almost anywhere in the microwave generator or the primary circuit of the HV transformer. A common location is at the crimp connections to the magnetron filament as they are high current and can overheat and result in no or intermittent contact. See the section: See the section: Testing the magnetron.

- Open thermal protector - usually located on magnetron case. Test for continuity. It should read as a dead short - near zero ohms. See the section: Testing thermal protectors and thermal fuses.

- Open thermal fuse - some ovens have one of these in the primary circuit. It may be in either connection to the HV transformer or elsewhere. Test for continuity. It should read as a dead short - near zero ohms.

- Open HV capacitor - see the section: Testing the high voltage capacitor. A shorted HV capacitor would likely immediately blow the fuse.

- Open HV diode - see the section: Testing the high voltage diode.

- Open magnetron filament - This failure may also be due to loose, burnt, or deteriorated press (Fast-on) lugs for the filament connections and not an actual magnetron problem. See the section: Testing the magnetron.

- Open winding in HV transformer. See the section: Testing the high voltage transformer.

- Defective HV relay. A few models use a relay in the actual high voltage circuitry (rather than the primary) to regulate cooking power. This may have dirty or burnt contacts, a defective coil, or bad connections

- Shorted HV diode - see the section: Testing the high voltage diode.

- Short or other fault in the magnetron - see the section: Testing the magnetron.

* Short in certain portions of the HV wiring. See the section: Testing and repairing the wiring and connections.

A shorted HV diode, magnetron, or certain parts of the HV wiring would probably result in a loud hum from the HV transformer but will likely not blow the main fuse. (However, the HV fuse - not present on most domestic ovens - might blow.)

Depending on design, a number of other component failures could result in no heat as well including a defective relay or triac, interlock switch(s), and controller.

Timer and light work but no heat, cooling fan, or turntable rotation

This means the controller thinks the oven is working but the microwave generator AND motors aren't being powered. Note that these symptoms are subtly different than just having no heat and eliminates the actual components of the microwave generator from suspicion in most cases.

(From: Bonita Lee Geniac (bgen@wdl.net).)

When the timer counts down but nothing else works, 99% of the time the lower door switch is bad or else the door is not closing fully and the latch hooks are not depressing the upper and lower switches. There is also a slight possibility that the relay or triac on the control board is not closing but those usually do not result in these particular symptoms. Most of the microswitches used in recent production microwaves are very poor quality and the silicone lubrication used by some of the manufacturers migrates into the switch contact area and makes the switch fail even faster than it should.

Fuse blows when closing or opening door

This means that the main fuse in the microwave (or less commonly, the fuse or circuit breaker for the power outlet) pops when the microwave oven door is closed or opened. This may be erratic, occurring only 1 out of 10 times, for example.

The cause is almost certainly related to either the door interlock switches or the door itself. Marginal door alignment, broken 'fingers' which operate the switches, dislocated parts in the interlock mechanism, or a defective interlock switch may result in either consistent or erratic behavior of this type.

On some ovens, this can happen at any time regardless of the control panel settings or whether the oven is in the cook cycle or not. On others, it can only happen when interrupting the cook cycle by opening the door or when initiating the cook cycle from the front panel (if the switches are in the wrong state).

The rational for this basic design - some form of which is used in virtually all microwave ovens - is that a defect in the interlock switches or door alignment, which might result in dangerous microwave radiation leakage, will produce a hard permanent failure. This will prevent the oven from being used until it is inspected and repaired.

* As noted, one of the interlock switches is actually across the power line. If the switches are activated in the wrong sequence due to a misaligned door, that switch will not turn off before the other switches turn on shorting the power line. Similarly, if its contacts are welded closed, the power line will be shorted when the other switches close.

  See the section: Testing and replacing of interlock switches.

- Inspect the door, its mounting, and the plastic 'fingers' which operate the interlock switches as well. Again, if the sequence is not correct, the power line will be shorted blowing the fuse. If the oven was dropped, then such damage is quite likely. Look for broken or dislocated parts, warpage, and other indications of problems with the door and interlock mechanism Of course, if the oven was dropped, there could be much more extensive internal damage as well.

Loud hum and/or burning smell when attempting to cook

A loud abnormal hum is an indication of a short somewhere. The sound may originate from the HV transformer vibrating and/or from within the magnetron depending on cause. There may be a burnt odor associated with this behavior:

- Shorted HV diode - see the section: Testing the high voltage diode.

- Shorted magnetron (filament to anode) or other internal fault in the magnetron - see the section: Testing the magnetron. Arcing within the Magnetron case (visible through ventilation holes in the bottom section) is usually an indication of a bad magnetron.

- Other short resulting from frayed insulation or wires touching in the microwave generator.

- Shorted HV transformer - see the section: Testing the high voltage transformer.

- Short resulting from burnt on food (usually) in or around the waveguide. If the odor is coming from the oven chamber, see the section: Arcing in or above oven chamber.

The following procedure will quickly identify the most likely component if the problem is not food/spills/carbon related:

(Usually a loud hum is caused by a short in the HV transformer, HV diode, or magnetron. The other items listed below would likely blow the main fuse but possibly not always.)

(Portions from: Tony (tonyb@ramhb.co.nz).)

1. Discharge HV capacitor! (If there is a short it is doubtful if it has any charge but never hurts to be safe).

2. Remove one end of the lead from the HV capacitor to the transformer.

3. Start the oven.

    - Hum gone? If so, it is the HV circuitry, go to step 4.
    - If it still hums you probably have a faulty HV Transformer. (Not uncommon.)

4. Discharge the HV capacitor again, reconnect wire and disconnect the 2 wires to the magnetron.

5. Restart oven.

    - Hum Gone? If so, magnetron is shorted. Replace or get a new oven.

- Hum still there? If so, go to step 6.

6. You have either

   - Shorted HV capacitor,
   - Shorted HV Diode,
   - Shorted clamp diode across the HV Cap terminals (if one is present, about 30% of microwave ovens use these). (The oven will run 100% without this protection for the HV capacitor but it should be replaced if possible.)
   - Some older Panasonic ovens have a HV reed switch and these can also short but these are rare now because of the age.

Arcing in or above oven chamber

There is often a simple cause:

- Arcing in the oven chamber with a normal load (a cup of water, for example), often just indicates that a thorough cleaning of the oven chamber is needed, particularly around and inside/above the waveguide cover. Any food that gets trapped here will eventually burn and carbonize resulting in a focal point for further arcing. Usually, the waveguide cover is designed to be removable without taking the (cabinet) cover off of the oven. However, burnt food and carbon often make this difficult so that some disassembly will be required. See the sections: "SAFETY" and "Getting inside a microwave oven". Clean the waveguide cover and clean inside the waveguide as well. If the waveguide cover is broken or damaged seriously, a sheet of replacement material is available from places like MCM Electronics. Trim to fit with a pair of heavy duty scissors, metal snips, or a paper cutter. The oven will work fine without it but replacement will prevent contamination of the waveguide with food vapors or splatters which can lead to more expensive damage. Take extra care to cover all food (which you should do anyhow) until the waveguide cover is replaced.

- Any sharp metal edges may also result in arcing or sparking. However, the only way such damage could occur as part of the oven (not added knives or forks!) would be through physical abuse.

- If your oven uses a stirrer above the oven chamber (no turntable), it may be stuck. The result will be an uneven distribution of microwave energy and localized heating, arcing, and possibly melting plastic or metal.

- Flashing and sparking may also result from the stirrer/fan blades contacting the metal surrounding it due to the motor/bearings becoming loose or dislodged.

More on the waveguide cover and cleaning

That cover is made of an insulator transparent to microwaves, usually mica, not a metal. The material can be obtained from places like MCM Electronics which you then cut to size with a pair of scissors or a paper cutter.

First, completely clean below, above, inside, and whatever of the cover material is remaining. All traces of carbon and burnt on food must be removed. In particular, you need to clean inside the waveguide above the inside top of the oven as well.

Then run the oven (with the waveguide cover removed, if necessary) to verify that there are no other problems (there probably are none).

Sometimes, you need to remove the outside metal cover in order to remove the waveguide cover. There may be little plastic pins or snaps which tend to get gummed up with burnt food and may be difficult to pry off from inside the oven. If you do need to remove the metal cover, jot down the locations of each of the screws (they are not always all alike) and stay away from everything but the waveguide cover itself (especially the high voltage components!).

That waveguide cover is not essential to the operation of the oven but it does prevent food from entering the waveguide and getting trapped there.

Fuse blows when initiating cook cycle

The fuse may only blow when actually attempting to cook but depending on design, triacs and/or door switches may always be live and may result in a blown fuse at any time when plugged in or when the door is opened or closed.

The following can cause the fuse to blow (in approximate order of likelihood):

- Defective interlock switches or misaligned door. At least one of the interlock switches is across the power line and will blow the fuse if not activated in the correct sequence. See the sections: "Fuse blows when closing or opening door" and "Testing and replacing of interlock switches".
- Shorted HV capacitor. See the section: Testing the high voltage capacitor.
- Shorted HV diode (see note below). See the section: Testing the high voltage diode.
- Shorted magnetron (filament to anode - see note below). See the section: Testing the magnetron.
- Defective triac (shorted or partially shorted). See the section: Testing and replacing the triac.
- Old age or power surge. Fuses sometimes blow for no apparent reason.
- Defective HV transformer (shorted windings. See the section: Testing the high voltage transformer.
- Shorted wiring due to vibration or poor manufacturing quality. See the section: Testing and repairing the wiring and connections.

Note that a shorted magnetron or shorted HV diode - which you would think should blow the fuse - probably will not do so because current will be limited by the impedance of the HV capacitor (assuming it is not shorted as well). However, there will likely be a loud hum from the HV transformer as it strains under the excess load. Such a sound in conjunction with no heat is a likely symptom of a shorted magnetron or HV diode. If your oven has a separate high voltage fuse - somewhat rare in domestic ovens - it may certainly blow due to a fault in any of the HV components.

Fuses also die of old age. The types of fuses used in microwave ovens are subjected to a heavy load and you may find that all that is needed is to replace the fuse with one with equivalent ratings. (but check for shorts first). There could be an intermittent problem as well which will only show up at some random time in the future. A poorly timed power surge (as opposed to the well timed variety) could also weaken the fuse element resulting in eventual failure.

The fuses used in microwave ovens are usually ceramic 1-1/4" x 1/4" 15 or 20 A 250 V fast blow type. Replace with exactly the same type and rating.

Another possible cause of a blown fuse is a partially bad triac. Some ovens use a triac rather than a relay to control the main power to the high voltage transformer. One type of failure of a triac is for it to be totally shorted causing the oven to come on whenever the door is closed. Alternatively, the gate may be defective preventing the triac from ever turning on. A third, and most interesting possibility, is that one half of the triac is bad - shorted or open, or doesn't turn on or turn off reliably. Recall that a triac is in effect a pair of SCRs in parallel in opposite directions. If one side is defective, the main fuse will blow due to transformer core saturation since the triac will act as a rectifier and transformers really do not like DC.

See the chapter: "Testing and Replacement of Components" for more information on this and similar problems.

Fuse blows when microwave shuts off (during or at end of cook cycle)

This could be due to a number of faults including shorting wires or defective relay. However, a common cause that might not be obvious is that the triac used to switch power to the high voltage transformer is faulty. What is probably happening is that only one half of the triac (recall that a triac is controlled for both polarities of the line voltage/current) is turning off completely resulting in DC to the HV transformer, core saturation, and excessive current which blows the fuse. Drive to the triac could also be marginal but the bad triac is more likely.

Exactly how a bad relay could result in these symptoms unless it was actually arcing and shorting is unclear. However, there is anecdotal evidence to suggest that inspecting the relay contacts and cleaning them if necessary may cure it in some cases.

The following description applies directly to some GE and Hotpoint models. Modify it accordingly for your oven. Depending on model, the triac may be located on the control board or mounted directly on the chassis.

(From: John Gallawa (microtech@gallawa.com).)

I have seen exactly this problem; and I've seen it baffle many a repair shop. It is likely that the triac on the 'Power Control Board' is breaking down. This is a fairly common problem in GE and Hotpoint models that use this board.

You can usually confirm the problem by setting the oven to a lower power level, say "medium," and heat a cup of water. You will probably hear a 'thump!' each time the magnetron cycles on. This is an indication of a weakened triac.

Replace the triac (Q1) with either of the following: ECG 56010, or SK 10265. Finally, replace the line fuse, install the outer cover, and test the oven for proper operation.

The only other alternative is to replace the board. The cost used to be pretty reasonable, but now it's gotten expensive - probably about $80.00.

The triac is probably located beneath a red plastic guard on the power control board. Its designation is usually Q1.

(From: John Montalbano (jrmont@iquest.net).)

The microwave oven in my General Electric JHP65G002AD cooking center blew its 15 AMP fuse each time the timing cycle expired. Replacing the triac GE Part number WB27X5085 ($65.00 from GE) with a new NTE56014

($13.00) solved the problem.

(From: Les Bartel lbartel@veribest.com).)

I had the exact same symptoms on my GE microwave. I replaced the triac with a $3 15 amp off-the-shelf triac and it has been working for several years since.

See the chapter: "Testing and Replacement of Components" for more information on triac testing though replacement is probably the only sure test.

Oven heats on high setting regardless of power setting

Power levels in a microwave oven are controlled by cycling the microwave generator on and off with a variable duty cycle - kind of like slow pulse width modulation. For 'HIGH', it runs continuously; for low, it may run 10% on and 90% off; other settings are in between.

When the oven always seems to be stuck at high power, it is likely to be due to one of two possible causes - a faulty relay or Triac, or controller. The relay or triac may have failed in the on state. This will probably show up with ohmmeter tests (with the oven unplugged!) but not always.

Replacements should be readily available. If the problem is is the controller, it will be more difficult to diagnose as schematics for the controller are usually not readily available. However, it could be something simple like a bad connection or dirty connector.

Oven heats but power seems low or erratic

Some considerations are how old the oven is and did the problem happen suddenly or did it just gradually weaken over the years.

First, are you sure the problem is real? Perhaps you are just a little less patient than you used to be. Perform a water heating test or try to pop a bag of popcorn using you usual time setting. See the section: Testing the oven - the water heating test.

- If you are subject to brownouts or are running on your own generator, the line voltage may be low. Power output is quite sensitive to the AC input - there is no regulation. A 10% drop in line voltage is likely to reduce microwave power output by more than 20%.

- Magnetrons, like other vacuum tubes, can weaken with age and use. An oven that sees daily use may indeed weaken over the course of several years. It is unlikely that any other electronic components could change value in such a way as to significantly affect power output. However, a failure of the controller or sensor (if you have one) could result in short cycling.

  Testing on HIGH will eliminate this possibility. Make sure the magnetron is powered continuously and it is not cycling. You can often tell by listening for the relay clicks and/or by observing the oven light/other lights dimming as the magnetron kicks in. 50% power should result in approximately equal on and off times.

- If you run the oven on HIGH, can you tell if it is actually heating continuously or rather it thinks you want LOW? Many microwave ovens make a clicking sound as they use a relay to switch microwave power on and off - check if you can hear this. Alternatively, lights on the same circuit or the oven light may dim slightly when the magnetron kicks in. There should not be any cycling on HIGH - the microwave power should stay on continuously while it is cooking. If it is cycling, there may be a problem with the controller or you may unknowingly be in a low power mode - check it.

- Mechanical problems are also possible. Where a spinning paddle wheel is used to 'stir' the microwave energy (often where there is no turntable), its failure to rotate can result in hot and cold spots. Thus, you may see an unexplained variation in cooking times. The paddle is often accessible by unclipping a plastic cover above the oven cavity. Check for bearing failure, binding, broken or lose belt if direct driven, etc. Note that some are rotated by air flow from the cooling fan and require that cover to be in place to rotate. Therefore, it is not really possible to inspect for correct operation with the cover removed. However, you can put a microwave power indicator (NE2 neon light bulb with its leads twisted together) in the oven (with a cup of water for a load) and observe it through the window. You should see a periodic variation in intensity as the paddles do their job.

- There could be intermittent connections to the magnetron filament, thermal protector, or elsewhere. But, these would likely show up as erratic operation - no heat at all sometimes - not just a weak oven.

  Inspect and clean and tighten (if necessary) all connections in the microwave generator including the magnetron filament, HV transformer, HV Diode, HV capacitor, and thermal protector. Be sure to unplug the unit first and discharge the HV capacitor before touching anything!

- The thermal protector may be intermittent. Test by clipping a light bulb across it or monitoring with a multimeter on AC voltage. See the section: Testing thermal protectors and thermal fuses.

Oven heats but shuts off randomly

Everything operates normally, but the oven shuts off after varying amounts of time. This could be a faulty magnetron, bad cooling fan (or just built up dust and grime block ventilation grilles), bad thermal protector, faulty controller, some other intermittent component, or bad connections.

- If resetting it allows cooking to resume immediately, if even for a few seconds, I would not suspect the magnetron or thermal problem as no cool down time is required. It could be bad connections in the controller or elasewhere, a marginal door interlock switch, or a controller problem. Jiggle the door to see if this will cause it to shut off.

- If the magnetron was overheating, you would not be able to resume cooking until it cooled and the thermal protector reset. If it just stopped working (i.e., the filament opened), everything would appear normal but there would be no heating. If the magnetron were shorting, there would likely be a loud hum associated with the periods where there was no heat.

- If it is not possible to resume cooking for a few minutes indicating that something needs time to cool off, then the magnetron could be faulty but check for the obvious cooling problems first: blocked or dirty ventilation grill. Determine if the magnetron cooling fan is operating by listening for its sound or looking through the ventilation opening in the back of the oven. If it is not, there could be a broken or weak belt, gummed up or lack of lubrication, other mechanical problems, a bad motor, or bad connections.

- Extremely high power line voltage may also result in overheating on a poorly designed or oven where the components are marginal.

- Make sure the stirrer fan is turning normally. Should it gets stuck, some models may sense this and shut down/restart.

Oven makes (possibly erratic) buzzing noise when heating

Assuming operation is normal otherwise, this is most likely either a fan or other motor vibrating on its mounts, fan blades hitting something, or some sheet metal or the high voltage power transformer laminations vibrating. There may be something stuck under the turntable or above the waveguide cover interfering with the stirrer.

Something may have loosened up with age and use.

If the noise is caused be simple vibrations, no damage is likely to result. However, if the main cooling fan is on its way out and it stops or gets stuck, parts will overheat quite quickly at which point the oven will shut down (hopefully) and there could be damage to the magnetron or other components. Therefore, at least identifying the cause is probably a good idea.

The solution may be as simple as tightening a screw or weging a shim between two pieces of vibrating sheet metal.

Oven light does not work

If the oven light no longer works, believe it or not, a burned out light bulb is likely.

You would think that something like replacing a light bulb would be trivial and self evident. Unfortunately, not always so with microwave ovens. Light bulbs may be typically located in any of 3 places:

1. Oven chamber - it may be behind a mesh grill requiring a screw or snap to be removed. This is the easiest.

2. Rear - the bulb may be in a recessed compartment accessible by removing a screw or two on the back of the oven.

3. Inside - it may be behind a non-removable grille requiring the removal of the cover.

These are typically not your usual vanilla flavored appliance bulbs either.

Bad connections are also possible but not that likely.

Fans or turntables that do not work

There are up to 4 motors in a microwave oven:

- Magnetron cooling fan - always present.

- Mechanical timer (on inexpensive non-touchpanel or older units).

- Turntable.

- Convection air circulation (combo units only).

When any of these do not operate properly, the most likely causes are:

- Gummed up lubrication/dry bearings. Check for free rotation of the affected part(s). Clean and lubrication as needed. Also confirm that there are no other mechanical problems (e.g., turntable improperly installed).

- Loose or broken belt. Confirm that belt is properly installed. Test to determine if it is worn and flabby - stretch it by about 25%. It should return to its relaxed length instantly. Clean and/or replace if needed.

- Bad motor. Disconnect one wire and check for continuity with an ohmmeter. If open, winding is bad but check for break at terminal which you can resolder.

- Bad thermostat. Where a fan only runs when the oven is hot as in a microwave/convection oven, the thermostat or controller could also be at fault. Locate the thermostat and jumper across its terminals with power off. Plug the oven in and see if the fan now runs all the time or at least when the appropriate mode(s) are entered.

- Bad connections - trace wiring and check continuity (unplugged, capacitor discharge) to motor terminals.

Note that the opposite problem - a turntable and/or fan that runs *after* the cook cycle is completed may be normal for your oven. This is a "cool-down" function designed to allow the heat to equalize or possibly added by the company's legal department to reduce the number of lawsuits due to stupidity. :)

What to do if the door handle breaks off

Usually this happens at the places where the handle is screwed to the door.

I would NOT recommend making the repair in any manner that compromises the shielding properties of the door. (I have visions of someone using 1/2" stove bolts through the door and handle which would definitely be a bad idea). Anything that penetrates the door seal is a potential hazard - likely a very small one but it is not worth the risk.

Therefore, I would recommend staying with repairs that can be made totally externally unless there is no possibility of a change to the integrity of the door. For example, replacing the screws with similar sized screws that gripped better or using filler to reconstruct or strengthen the threaded holes would be acceptable.

Plastic is generally tough to glue where a strong bond is needed and where the joint is subject to abuse. However, depending on the type of plastic, one or more of the following may work: semiflexible adhesive like windshield sealer, plastic cement (the kind that fuses the plastic, not model cement), Duco cement, PVC (pipe) cement, or even superglue (though it seems not all brands are equally effective). Make sure the surfaces to be glued are perfectly clean (remove any residual library paste if you tried that!) and provide a means of clamping the pieces until the bond sets up (adhesive tape and/or rubber bands may be all you need). Consider providing some reinforcements around the joint (i.e., plastic splints or sisters depending on your profession) for added durability.

Replacement door handles and/or entire doors may be available from the manufacturer of the oven. Replacements for a few Panasonic models are even stocked by MCM Electronics (and no doubt other places as well).

(From: John Gallawa (microtech@gallawa.com).)

Here are the door disassembly instructions from the Amana service manual. Many others are similar:

1. Pry out the inner door trim with a small screwdriver on the latch side of the door.

2. Remove two screws securing the latch assembly and door handle to the outer panel (this may be all that's needed to replace the handle).

3. Remove six screws and release 4 spring fingers that secure the choke to the outer panel.

WARNING: A microwave leakage test must be performed any time a door is removed, replaced, disassembled, or adjusted for any reason.

Crack or other damage to door window

> "My microwave oven has a crack in the glass of its door. Is this safe to continue using or should I get it fixed? Will there be any radiation leakage?"

So you were throwing roasts at the oven again, huh? :-)

If the metal screen/mesh is behind and separate from the glass, there is no danger. In this case, the function of the glass is mostly cosmetic and a small crack should not be a problem.

However, if the screen is inside the glass and now broken as well, there could be microwave leakage. Even if it is not actually broken at this time, future failure is possible. Therefore, the glass panel or entire door should be replaced.

Also, any break large enough to allow something to touch the metal screen is a hazard because during cooking, there could be shock hazard due to microwaves inducing current in the screen. And, poking something metallic through the screen would make is susceptible to microwave pickup as well.

However, damage to the inner plastic is probably not a cause for concern as that is only there to keep the screen and inside of the door glass clean.

Repairing damage to the oven interior

If spilled food - solid or liquid - is not cleaned up soon after the oven is used, it will tend to harden and carbonize. Not only will this be much more difficult to remove, but hot spots may develop and result in possible sparking, arcing, and damage to the interior paint.

If this happens in the vicinity of the mica waveguide cover, it may be damaged as well. In addition, sometimes splatters may find their way above the waveguide cover and cause problems above the roof of the oven chamber in the waveguide.

Needless to say, clean up spills and food explosions as soon as possible. Not only will it be easier, the chance of future expensive problems will be minimized.

To prevent arcing and sparking, the interior needs to be smooth. Sharp edges and hard carbon in particular creates places where electric field gradients can become great enough to cause problems. Thus the warning not to use any metal utensils in a microwave.

Once damage occurs - paint blisters and peels, or totally hardened impossible to remove carbon deposits - more drastic action is called for:

- Assuming cleaning does not work on the carbon - even after repeated attempts, carefully scrape it off with a blunt knife or other suitable tool. This will probably damage the paint. Use fine sandpaper to completely smooth out the metal and feather the edges of the paint in the immediate area.

  Special microwave oven cavity paint is available but any common gloss enamel will work just as well (and costs about 1/10th as much). Use touch-up paint (with a small brush) or spray paint. The typical color is beige, almond, or some other form of off-white - just match it to your oven (if you care).

  Until you can obtain the paint, the oven will work fine but since the chamber is made of sheet steel, rust will set in eventually. So, do paint it.

- If the waveguide cover is damaged seriously - such that it no longer will prevent splatters from entering the waveguide, obtain replacement material, cut to fit. Leaving it larger than necessary is fine as well. Use a suitable bit in a hand drill to make holes in the mica for the mounting screws or plastic snaps.

  Alternatives to mica which can stand the elevated temperatures in a microwave oven may also be acceptable. Possible choices include plastic or fiberglass laminate but not all materials will allow microwaves to pass without some heating - check it out. Heat a cup of water and the candidate material on high for a couple of minutes. If the material doesn't heat up, it should be fine. Of course, it must also not have any metal coating (don't use a piece of one of those 'browning disks' :-). Mica is also non-flammable which is may not be the case with other materials.

- If the interior of the door is damaged seriously such that either it will not longer seal around the edge properly or that the mesh screening is breeched, a replacement will be required to assure continued safety with respect to minimizing microwave emissions.

Microwave oven cavity paint, waveguide cover mica sheets, and even some replacement doors are available from the parts suppliers listed at the end of this document. For most ovens, parts like doors will need to be obtained direct from the manufacturer, however.

Microwave/convection oven problems

In addition to the microwave components, these ovens also include an air circulating fan and an electric heating element as well as a temperature sensing themister. Any of these can fail.

- A convection oven which shuts down after a couple of minutes during the preheat cycle with the temperature display (if any) stuck at LOW (even though the oven is hot when opened) may have a bad thermistor temperature sensor.

- The overtemperature protection sensor (rather than the normal temperature sensor) is shutting the oven down. The termister will usually be accessible after removing the oven cover. It will be located centrally just above the oven ceiling duct or elsewhere in the convection air flow. It is a two terminal device that may look like a tiny resistor or diode and may be mounted on a metal header fastened with a couple of screws. Remove and test with an ohmmeter. An infinite reading means it is bad. As a test, jumper a 50 K ohm potentiometer in place of the thermistor. During preheat, as you lower the resistance of the pot you should see the temperature readout climb. The oven will then indicate READY when the simulated temperature exceeds the setpoint. Replacement thermistors are available from the oven manufacturer - about $20. Cheaper alternatives may be possible but you would need to know the exact specifications and it is probably impossible to obtain this information.

Also see the section:

- Sensor problems, below.

- If the convection preheat cycle never completes and the oven is cool when opened, then either the heating element is bad (test with an ohmmeter) or the relay controlling the heating element or the controller itself is bad. If the circulating fan runs off of the same relay and it is operating, then the problem must be the heating element.

- The heating element will be either a Calrod type (GE trade name?) which is a steel tube enclosing a Nichrome wire coil embedded in ceramic filler or a coiled Nichrome element strung between ceramic insulators. The former is probably only available from the oven manufacture, though it is worth trying an appliance parts distributor or a place like MCM electronics first. It may be possible to find a replacement Nichrome coil and form it to fit. Make sure the wire gauge and length are identical.

- The circulating fan is probably driven by a belt, which may break or deteriorate. Inspect the belt. If it is loose, cracked, or does not return to its normal length instantly after being stretched by 25% replace it. Check the fan motor and fan itself for adequate lubrication. Check the fan blades for corrosion and damage.

Sensor problems

Fancier microwave or microwave/convection ovens include various probes that can be used to shut off the oven when the food is supposedly done or maintain it at a preset temperature.

A problem with a sensor, controller, or wiring, may result in incorrect operation (never getting past 'preheat' or not terminating a cook cycle) or in a display of 'EEEE', 'FFFF', ERROR, or something similar:

(From: Wilton Itamoto (witam40231@aol.com).)

> "The 'FFFF' display is a common problem in older Panasonic convection ovens. The problem is the temperature sensor thermostat located on the top rear of the oven. This is the convection temp. sensor for the correct oven temperature. Replacing this open sensor will correct the problem."

When problems develop with these automatic features, the sensor and the probe cable are the primary suspects. However, it is possible that the electronic circuitry could also be affected by a damaged or defective probe unit.

- Check for bad connections where the probe plugs in as well as broken wires inside the cable particularly near the ends where it gets flexed.

- Temperature probes may use a thermistor similar to one that controls the convection portion of a microwave/convection oven. Steam/humidity probes may also behave similarly.

- If you have never tried the probe before, check your users manual. It may only be active in certain modes, etc.

The best test of the probe unit is to substitute a known good one. Of course, this is generally not convenient.

- There should be some resistance when measuring between the signal conductors of the probe cable. It may be high (hundreds of K ohms) but probably should not be open. A very low value (a few ohms or less) might indicate a short in the cable or sensor.

- See the section: Microwave/convection oven problems for a discussion of thermistors. Testing to determine if the controller is responding to the input from the sensor can be done in a similar manner except that access must be from inside the electronics bay while the oven is running (the probe normally plugs in inside the oven chamber). Substitute a fixed or variable resistor and see if you can get the oven to shut off (or stay on) as a function of resistance. CAUTION: Don't forget to put a cup of water in as a load if you are testing microwave operation.

If the resistor test determines that the controller is responding, than a bad probe unit is likely.

If the probe checks out or substituting a known good one makes no difference in behavior, look for corrosion or other deterioration of the socket in the oven chamber as well as bad connections. Faulty circuitry in the controller is also possible.

- Back to Microwave Oven Repair FAQ Table of Contents.

Testing and Replacement of Components

Please see Typical Microwave Oven Electronics Bay for parts identification.

Testing the oven - the water heating test

The precise number of degrees a known quantity of water increases in temperature for a known time and power level is a very accurate test of the actual useful microwave power. A couple of minutes with a cup of water and a thermometer will conclusively determine if your microwave oven is weak or you are just less patient (or the manufacturer of your frozen dinners has increased their weight - sure, fat chance of that!)

You can skip the heavy math below and jump right to the final result if you like. However, for those who are interested:

- 1 Calorie (C) will raise the temperature of 1 gram (g) of liquid water exactly 1 degree Centigrade (DegC) or 9/5 degree Fahrenheit (DegF).

- 1 Calorie is equal to 4.184 Joules (J) or 1 J = 0.239 C.

- 1 Watt (W) of power is 1 J/s or 1 kW is 1000 J/s.

- 1 cup is 8 fluid ounces (fl.oz.) which is 8 x 29.57 g/fl.oz. = 236.6 g. (For Avoirdupois ounces, use 28.35 g.)
- 1 minute equals 60 s (but you know this!).

Therefore, in one minute, a 1 kW microwave oven will raise the temperature of 1 cup of water by:

```
T(rise) = (60 s * 1000 J/s * 0.239C/J * (g * DegC)/C)/(236.6 g) = 60.6 °C.
```

Or, if your prefer Fahrenheit: 141 °F.

To account for estimated losses due to conduction, convection, and imperfect power transfer, I suggest using temperature rises of 57 DegC and 135 DegF.

Therefore, a very simple test is to place a measured cup of water in the microwave from the tap and measure its temperature before and after heating for exactly 1 minute on HIGH. Scale the expected temperature rise by the ratio of the microwave (not AC line) power of your oven compared to a 1 kW unit.

Or, from a Litton microwave handbook:

- Heat one Liter (L) of water on HIGH for 1 minute.
- Oven power = temperature rise in DegC multiplied by 70.

Use a plastic container rather than a glass one to minimize the needed energy loss to raise its temperature by conduction from the hot water. There will be some losses due to convection but this should not be that significant for these short tests. For the ultimate in accuracy (as these things go), put the water in a styrofoam cup, invert another styrofoam cup over it, and poke your thermometer through it.

(Note: if the water is boiling when it comes out - at 100 DegC or 212 DegF, then the test is invalid - use colder water or a shorter time.)

The intermediate power levels can be tested as well. The heating effect of a microwave oven is nearly linear. Thus, a cup of water should take nearly roughly twice as long to heat a specific number of degrees on 50% power or 3.3 times as long on 30% power as on full power. However, for low power tests, increasing the time to 2 minutes with 2 cups of water will result in more accurate measurements due to the long period pulse width power control use by microwave ovens which may have a cycle of up to 30 seconds.

Any significant discrepancy between your measurements and the specified microwave power levels - say more than 10 % on HIGH - may indicate a problem. (Due to conduction and convection losses as well as the time required to heat the filament of the magnetron for each on-cycle, the accuracies of the intermediate power level measurements may be slightly lower).

See the section: Oven heats but power seems low or erratic.

Testing the main fuse

Where the oven is dead or mostly dead, the main fuse is the place to start:

- UNPLUG THE OVEN and locate and remove the main fuse. It will usually be a 1" x 1-1/4" ABC ceramic type directly in-line with the Hot (black wire) of the power cord.

- Test it with an ohmmeter - the reading should be zero ohms.

    - If it is blown, suspect problems with the interlock switches, high voltage capacitor, or high voltage wiring.

    - If it is good but the oven makes a loud humming sound when you attempt to cook, suspect the magnetron or high voltage diode.

Testing and replacing of interlock switches

With the oven unplugged, put an ohmmeter across the AC input just before the interlocks (but beyond the power relay or triac if it precedes these). Open and close the door slowly several times - there should be no significant change in resistance and it should be more than a few ohms. If it approaches zero while opening or closing the door, the interlock switches and door alignment should be checked. (You may need to disconnect one side of the transformer primary since its resistance is a fraction of an ohm. Refer to the schematic pasted inside the cover.)

Replace with switches having a precisely identical fit and equal or better electrical specifications (terminal configuration, current rating). When removing the old switch make a note as to where each wire goes. Check the embossed marking on the old switch - don't depend on location as your replacement might just have a different arrangement. Make sure the new switch aligns correctly with the actuating mechanism and then check for correct electrical operation with an ohmmeter before applying power.

Making measurements inside microwave ovens

WARNING: In general, I DO NOT recommend making any sorts of measurements on the high voltage components of a live microwave oven. I only include this section for those who really want to know the details.

You may be temped to break out your Radio Shack DMM and start poking away inside a live microwave oven. DON'T! This isn't like a CD player! Most of the time, no measurements of any kind on the oven while it is operating will be needed to identify and correct the problem. However, where this is not the case, here are some guidelines to a long life:

WARNING: ALWAYS pull the plug and discharge the HV capacitor BEFORE doing anything inside! Never be tempted to make any changes of any kind while the oven is on - not even if your meter is being consumed by 5 foot flames! First, pull the plug and discharge the HV capacitor!

- High voltage - DON'T even think about this unless you have a proper high voltage probe or meter, or a proper microwave oven tester - AND KNOW HOW TO USE IT SAFELY. Even professionals have been killed performing measurements of this type using proper equipment! Luckily, current measurements can provide enough information to help make a diagnosis.

  WARNING: The high voltage components inside a microwave oven are at a NEGATIVE potential with respect to the chassis. DO NOT be tempted to interchange the probe and ground wire if you are using a high voltage probe on a meter with a POSITIVE input (e.g., for testing CRT HV) and no polarity switch! The ground cable doesn't have anywhere near the required insulation. Get the proper equipment!

One thing you can do relatively safely is to connect a Variac directly to the primary of the HV transformer. With this set at a MAXIMUM of 10 percent, the voltage on the filament terminals of the magnetron should read from -150 to -250 V with respect to the chassis. A scope can also be used if it has a proper 10:1 probe as long as you aren't tempted to turn up the Variac any higher! The scope waveform should be close to a sinusoid with its positive tips at 0 V. Such reduced voltage tests won't identify problems that only occur at full voltage, however.

- Magnetron current - Place a 10 ohm 10 watt resistor in series with the HV diode cathode and ground. Measure the voltage drop across this resistor. Sensitivity will be 10 V/A. Normal anode current is around 300 to 400 mA for a typical oven. This will be -3 to -4 VDC across the 10 ohm resistor with respect to chassis ground. SET EVERYTHING UP AND THEN STAND BACK and don't forget to DISCHARGE the HV capacitor after making the measurement:

    - If it is around this range, the magnetron is probably fine.

    - If it is very low or 0, magnetron is bad or HV is not working. Note that a shorted as well as open magnetron also results in no current. If the magnetron is shorted, it bypasses all current to ground. If the magnetron is open, the HV capacitor charges up and then there is no more current through the HV diode (but there will be an initial transient).

    - If it is much too high (whether fuse blows or not), capacitor is shorted.

(From: Michael Caplan (cy173@freenet.carleton.ca).)

A properly conducting magnetron will load down the HV power supply. If the magnetron is non-conducting, the voltage remains high.

The power supply will produce 3,500 to 4,000 volts DC, or more, open circuit (as when the oven is first turned on and the magnetron filament/cathode is not fully heated). With full conduction by the magnetron, the HV drops to between 1,800 and 2,100 V. Weak magnetrons conduct somewhat, but the HV remains well above the 2,100 V. (The voltages vary with design and model, but the magnitude of the change is the key.)

I check the HV using my 30 kV HV probe with a DMM, measuring between the magnetron filament connectors (either one) or at another equivalent point, and case ground. (Again, depends on the circuit, but I think this is a common configuration.) The HV at the magnetron filament is negative to ground.

Testing the high voltage components

WARNING: First, with power disconnected, discharge the high voltage capacitor. See the section Safe discharging of the high voltage capacitor.

Assuming the oven passes the above test for interlocks and door alignment, the triac (if used) may be defective. There could also be a wire shorting to the chassis. However, the most likely problems are in the microwave generator.

An ohmmeter can be safely used to quickly determine if the capacitor, HV diode, or magnetron are a dead short (as well as for an open magnetron filament).

Use an ohmmeter to test the diode and capacitor. While connected in circuit, the resistance in at least one direction should be several M ohms. (Try it in both directions, use the higher reading). Test the magnetron from the filament to chassis - it should be high in at least one direction. Test the filament for continuity - the resistance of a good filament is close to 0 (less than 1 ohm).

Where the capacitor and diode are combined into one unit, it should be possible to test each component individually. In some cases, it may also be possible to replace only the one that is found to be defective or make up a substitute HV cap/diode assembly from individual components if the combined unit is excessively expensive or no longer available.

These may be considered to fail/no conclusion tests - they can definitively identify parts that are bad but will not guarantee that they are good. Parts may test ok with no voltage applied but then fail once operated in-circuit. Connections may open up when they heat up. The magnetron may short out when full voltage is applied.

Don't overlook the wiring as no heat or erratic operation can result from simple bad connections!

An alternative way of determining if the problem is in the control circuits (triac, relay, wiring) or microwave generator (HV transformer, HV capacitor, HV diode, magnetron, wiring, etc.) is to connect the HV transformer primary directly to a line cord and plug. Tape the removed wire lugs to prevent shorts.

Plug the transformer cord into a switched outlet strip which includes a fuse or circuit breaker.

Put a cup of water into the oven cavity to act as a load.

- Power the oven via its line cord. Initiate a cook cycle. It should go through the normal cycle (of course no heat) without blowing the fuse or any unusual sounds. If there is a problem in this case, something in the controller or its wiring is shorted.

- Now, initiate a 1 minute cook cycle on HIGH and with the oven running, switch on the HV transformer.

    - If the transformer or other HV components are faulty, the outlet strip fuse will blow or circuit breaker will trip. Or, if a lamp is plugged into the outlet strip at the same time, it will likely dim significantly due to the heavy load before the fuse or breaker cuts out.

    - If the problem is with the triac or its drive, the oven will now heat normally. When the cook cycle is near its end, switch off the outlet strip. Check the water's temperature.

More complete information on testing and replacing the individual components is provided in the next few sections.

Testing the high voltage diode

WARNING: First, with power disconnected, discharge the high voltage capacitor. See the section [Safe discharging of the high voltage capacitor]

The HV diode can fail shorted (most likely) or open. It is not likely for there to be anything in between as so much heat would result that the diode would not remain that way for long.

- A shorted HV diode will likely result in a loud hum from the HV transformer when a cook cycle is initiated.

The main fuse will probably not blow.

- An open HV diode will result in AC instead of DC across the magnetron with a peak negative value (the only one that matters) about 1/2 of what it should be. The result will likely be little or no detectable heat but no other symptoms.

The resistance measured across the leads of the HV diode should be greater than 10 M ohm in at least one direction when disconnected from the circuit. However, the HV diode is composed of multiple silicon diodes in series to get the voltage rating. Its forward voltage drop will therefore be too great (6 V or more) for a DMM to produce a definitive answer as to whether it actually works as a rectifier.

The HV diode can be tested with a DC power supply (even a wall adapter of at least 12 or 15 V output), series resistor (to limit current), and your multimeter. This will determine proper behavior, at least at low voltages.

The following is the schematic of a simple HV diode tester:

```
              240 ohms, 1 W
   + o-----------/\/\---------+------------o +
                              |
                            __|__ HV        Good: 6 to 10 V
 15 VDC                     _\_/_ diode     Shorted: 0 to 2 V
                              |             Open or reversed: 15 V
                              |
   - o------------------------+------------o -
```

The voltage drop in the forward direction should be at least 6 V with a few mA of current but may be somewhat higher (8 V or more) with a few hundred mA. If your DMM or VOM has a resistance scale operated off a battery of at least 6 V, you may get a reading in one direction (but only one) without the need for an external power supply.

Or, assume for now that the diode is good if it is not shorted - which is likely.

Although a shorted HV diode is usually an isolated event, it is possible for failures elsewhere to have caused the diode to blow. Possible causes include a shorted HV cap, arcing between windings in the HV transformer, and possibly even a defective magnetron or damaged waveguide. These may only occur with full voltage so unless there is obvious physical damage (e.g., charring between the HV transformer windings or hole burned in the waveguide), it may be necessary to eliminate the other components one by one.

Replacing the HV diode

WARNING: First, with power disconnected, discharge the high voltage capacitor. See the section Safe discharging of the high voltage capacitor.

Most HV diodes have press fit (Fast-On) or ring lugs so replacement is very straightforward. Discharge the high voltage capacitor. Make sure you get the polarity correct if your replacement can be installed either way. Putting the diode in backwards will result in positive instead of negative high voltage and, needless to say, no heat, but no other symptoms either.

Note: the lugs on your new HV diode may just be crimped onto the wire leads and not welded or soldered. If this is the case, take care not to stress them excessively which might result in bad connections now or in the future. It may be a good idea to solder the lugs to the wires as well (though this may be overkill).

Where the diode is part of the capacitor assembly, it may be possible to just replace the diode leaving the old one unconnected (at one end) as long as the original diode isn't tied to ground inside the case. This will probably be much much cheaper than replacing the entire assembly.

HV diode ratings

Most replacement microwave oven diodes are rated 12 to 15 kV PRV at .5 A. A PRV of around 8 kV is actually required even for a small oven. Here is why: Until the magnetron heats up and starts conducting in its forward direction, what you have is a half wave rectifier/filter formed by the HV transformer secondary, the HV diode, and the HV capacitor. The reverse voltage across the HV diode will be equal to: 2 * 1.414 * (VRMS of the HV transformer). This can easily be 6 or 7 kV or more! Once the magnetron start conducting, the reverse voltage goes down somewhat.

HV diodes rated at .5 A are adequate for most domestic microwave ovens. For example, the largest of these will have a nameplate rating of around 1,800 W power line input and a HV transformer secondary of 2,500 VAC. While there are some losses in the HV transformer, and some power is used by the magnetron filament, controller, motors, and light, this still leaves, perhaps, 1,600 W into the HV generator. However, due to the design of the half wave doubler circuit, not all the power flows through the HV diode (as would be the case with a regular power supply. Thus, even though calculations using Ohms law (I = P/V = 1,600/2,500 or .64 A) would suggest that .5 A is not enough, closer to 1/2 of the total current actually flows through the HV diode.

To be doubly sure that your new HV diode is happy, run the oven on full power (high) for 10 minutes with two quarts of water as a load (or a roast). Unplug the oven (while your spouse prepares the veggies), quickly DISCHARGE THE HV CAPACITOR, and then check the HV diode for overheating. It might be warm but should not be too hot to touch. Unless you have the largest oven on earth, this test is probably not needed.

Testing the high voltage capacitor

WARNING: First, with power disconnected, discharge the high voltage capacitor. See the section Safe discharging of the high voltage capacitor.

- A shorted HV capacitor will blow the fuse instantly.

- An open HV capacitor will result in no heat but no other symptoms.

(The following assumes no internal rectifier or other circuitry except of a bleeder resistor. Adjust procedures accordingly if your oven is different.)

The resistance measured across the terminals of the high voltage capacitor should be very high - several M ohms for bleeder resistor. If it is less than 1 M ohms, the capacitor is definitely shorted. Yes, if you measure 0.00 ohms across the terminals (and they are not bussed together on the case), then the capacitor is positively, without a shadow of a doubt, bad!

A high resistance does not prove that the capacitor is actually functional, just not shorted with no voltage across it. If you have a capacitance meter, check it for proper value (should be printed on the case). Even this does not prove that it will not short when full voltage is applied. Substitution is the only sure test beyond this.

Replacing the high voltage capacitor

WARNING: First, with power disconnected, discharge the high voltage capacitor. See the section Safe discharging of the high voltage capacitor.

Make a diagram of the precise wiring as multiple connections are often made to the capacitor terminals. The capacitor is usually mounted with a clamp which is easily loosened. Sometimes, the capacitor is jammed into a location that requires moving some other components to extract it.

Replace in reverse order. Tighten the clamp securely but not so much as to distort the case.

Where the capacitor assembly also includes the HV diode, it is possible to just replace the capacitor if space permits leaving the old one unconnected (at one end). However, the cost of a generic replacement diode is small (around $3) so replacing both at the same time is usually best. However, you don't need to use the exact combined part - which may be very expensive or difficult to obtain. Just make sure the ratings of the capacitor and diode are correct (use a generic replacement microwave oven HV diode and a microwave HV capacitor with a uF rating within 10% or so of the old one and at least equal working voltage).

What if the HV diode or capacitor are leaky?

An (electrically) leaky HV diode or cap would likely fail totally in short order since it would be dissipating a lot of power. However, until this happened, the oven might continue to operate and not blow a fuse. The effect on performance in both cases would be to reduce the effective voltage across the magnetron and thus the output power.

I consider these sorts of failures somewhat unlikely as the HV diode and capacitor do not generally fail half-way!

Testing the magnetron

WARNING: First, with power disconnected, discharge the high voltage capacitor. See the section Safe discharging of the high voltage capacitor.

- A magnetron with an open filament will result in no heat but no other symptoms. The bad connection may be internal (in which case the magnetron will need to be replaced) or external at the filament terminals (which may be repairable).

- A magnetron with with a short between the filament/cathode and anode will likely result in a loud hum from the HV transformer and/or magnetron when the cook cycle is initiated but the main fuse will probably not blow.

- A magnetron with other faults may result in a variety of symptoms including erratic or low output power or intermittent operation. See the section: Comprehensive list of magnetron failure modes.

There is no totally definitive way to determine if a magnetron is good without actually powering it under operating conditions but the following tests will catch most problems:

- Magnetron filament. The resistance should be infinite from the filament connections to the case and a fraction of an ohm between the filament terminals with the wiring disconnected from the magnetron.

  While measuring resistance from filament chassis, gently tap the magnetron to determine if there is an intermittent short. However, such problems may only show up once the filament heats up and parts expand.

  It may be possible to determine if the magnetron filament is actually working by connecting just the filament connections to a low voltage high current supply on a Variac (e.g., a microwave oven transformer but just the filament connections). The ceramic insulators are translucent and should show a glow with a working filament. The one at the antenna may be visible if the magnetron is removed from the oven or with a dental mirror looking into the waveguide. WARNING: Make sure you ONLY have the filament connected!

- Evidence of arcing (visible blackening around ventilation holes in base or burnt odor) usually indicates a bad magnetron.

- Melting or other damage to the antenna cover ('bull-nose' or 'bullet') may be the result of arcing due to problems in the oven cavity or waveguide (perhaps operating with nothing in the oven) or a defective magnetron.

  (This part is only visible with the magnetron removed from the oven). If a problem elsewhere has been corrected, the damaged antenna cover can be pulled off and replaced from a magnetron that died of other causes - try your local appliance repair shop. (The shape doesn't matter as long as it fits tightly - there are several diameters, however.) Your magnetron may still be good.

  Note: Since the antenna is attached directly to one of the vanes which is part of the anode assembly, it will test as a dead short to the case on your multimeter using DC and is normal. At 2.45 GHz, this won't be the case! :)

Most common magnetron failure modes:

- Filament could be shorted to case - check with ohmmeter. Anything less than infinity means the tube is bad though it could be charring due to arcing outside the vacuum in the box with the filament connections. Tap the tube while measuring to check for intermittents.

- Filament could be shorted to itself - tough to test since it is such a low resistance to start. Compare with good magnetron. (Yeh, right. If you had one, this wouldn't be an issue!) Tap the tube while measuring to check for intermittents. This fault isn't really likely.

- Filament could be open - check with ohmmeter. Tap the tube while measuring to check for intermittents. However, loose filament connectors (Fast-Ons) are more likely than a broken filament. Therefore, check directly at the magnetron terminals with both lugs pulled off.

- Magnetron could be gassy (or up to air) and arcover internally once power is applied. The filament could expand, shift position, and short once heated. There is no easy way to test for these possibilities other than substituting a known good magnetron.

- Internal or external arcing resulting in physical damage. External arcing could be at the antenna or inside the filament box. Internal arcing will not leave any visible evidence but the damage will result in the magnetron failing totally or running with reduced output.

- Overheating might result from a broken or cracked magnet (reduced magentic field) or other internal problems. While there may be some output power, the thermal protector will shut down the oven prematurely.

Comprehensive list of magnetron failure modes

(Portions from: John Gallawa (microtech@gallawa.com).)

Here is a list of typical magnetron failure modes. The percentage of each type of failure varies. Currently, internal shorts and loose filament connectors are probably at the top of the list. An internal plate-cathode short may only manifest itself under the stress of high voltage during operation.

1. Shorts. (a) Internal plate-cathode/filament short or (b) Internal arcing.

   Symptoms: No heat, loud hum when entering cook cycle, possible blown HV fuse (but will not likely blow the main fuse).

   In ovens equipped with fuses that monitor the high voltage system, such as some commercial Sharp models and most commercial and domestic Amana models, the high voltage fuse would probably blow. But, rarely will a shorted magnetron cause the main line fuse to blow. (I suppose the transformer absorbs most of the current surge.) In fact, with reference to the other symptoms below, there are almost no failures where the magnetron causes the line fuse to blow.

2. Loose filament connectors (these may be repairable). There will often also be visual symptoms at the magnetron: Signs of overheating, such as discoloration; and evidence of carbon tracks or pits on magnetron terminals when the connectors are removed. An intermittent filament (internal) is also possible (but not repairable).

   Symptoms: No heat or erratic heat.

   The slip-on connectors can loosen, overheat, build up resistance and eventually loose contact. If the the magnetron terminal(s) have not been burned too severely, the connection(s) can usually be repaired. We prefer cleaning up the terminal, then soldering the filament wires directly to the terminal.

   Note: when discharging HV capacitor, since there is no load, it may end up being charged to a much higher voltage than is normal. Be prepared for a larger spark if you use a screwdriver to discharge it!

3. Open filament.

   Symptoms: No heat.

   See note about HV capacitor in (2) above.

4. In the older glass-dome models, the vacuum envelope can rupture.

   Symptoms: No heat, loud buzz due to arcing when entering cook cycle, possible blown HV fuse.

See comments about fuses in (1) above.

5. Filament breakdown. Usually occurs after a few minutes of normal operation, possible blown HV fuse.

   Symptoms: No heat, loud hum once it occurs.

   See comments about fuses in (1) above.

6. Low output. Occurs as cathode emission decreases from long use.

   Symptoms: Reduced cooking power.

7. Moding. Occurs when magnetron oscillates in one or more undesirable frequencies.

   Symptoms: (a) Reduced or no cooking power, (b) RF interference. However, some food products (with high water content) may cook normally, whereas the result with other foods is very unsatisfactory. RF interference is possible but usually only occurs if there is actual structural damage to either the magnetron, its RF gasket or waveguide flange, or its RF (feed-through) capacitors.

8. Off frequency. Physical characteristics can change and cause magnetron to oscillate at frequencies slightly higher or lower than 2.45 GHz.

   Same as (7a) above.

9. RF leakage. Structural failure can cause leakage from magnetron housing.

   Symptoms: Microwave leakage into electronics bay, erratic control panel behavior. It can be very frustrating because the symptoms disappear when the oven's outer cover is removed. With the cover in place, the escaping RF energy is confined, and eventually builds up around the control panel circuitry causing unusual symptoms.

10. Insulation breakdown of the internal leads or at magnetron insulators or antenna terminal.

    Symptoms: Arcing, burning smell from magnetron, loud hum, no heat.

11. Cracked magnet(s).

    Symptoms: Reduced or no cooking power, magnetron overheating, occasional 'snapping' sound.

Where to obtain replacement magnetrons

Depending on the age of your oven the magnetron may still be under warranty. Check the original paperwork that came with the oven - either the users manual or a separate warranty document. Contact the manufacturer if specific instructions on how to file claims are not provided. Full coverage on the magnetron of several years is common. If you have not sent in the warranty registration card (right, who actually does this?!), a copy of the sales receipt or other proof of date of purchase may be required.

Both original and generic replacement magnetrons are available. Going direct to the oven manufacturer will guarantee a compatible magnetron but is by far the most expensive option. For a typical oven, one without the gold-plated trim :-), such a replacement may be more than half the cost of a similar new oven. In some cases (like Sears), you may need to convince their service department that you are qualified to be poking around inside one of *their* appliances before they will consider selling one to you (too many lawyers).

In some cases, original magnetrons may also be available from parts suppliers like MCM Electronics - at somewhat less rediculous prices. They will be identified as 'original' or 'genuine' along with the manufacturer and their part number.

Generic replacement magnetrons are available for the majority of microwave ovens. These will almost certainly be much less expensive than original parts. Essentially, there is only one type 'tube' (at least for any similar power range). The differences are mostly mechanical. However, quality may vary. In some cases, the generic variety may actually be better than the original. See the section: Comments on replacement magnetron quality for some recommendations.

Comments on replacement magnetron quality

(From John Gallawa (microtech@gallawa.com).)

In my experience, mags purchased from after-market suppliers may or may not be OEM parts (there are not that many manufacturers of magnetrons in the world). Here's the interesting thing, though: In many cases, these after-market tubes are actually higher in quality than the original tube, as in the case of the OEM Sanyo magnetrons, which tend to fail prematurely. Of course, the opposite can also be true, depending on the after-market supplier. Some manufacturers, such as Toshiba and Hitachi, produce both high and low end magnetrons. They sell these under a variety of specialty names, as well as under manufacturer brand names. I have seen the low-end tubes in many brand-new microwave ovens.

When buying magnetrons from other than the manufacturer, I have found it best to go to a supplier who specializes in microwave oven parts (i.e. AMI, Global Micro-parts, QB products). These sales people are usually more knowledgeable about the magnetrons they sell, and they can help you with proper choice and application.

Replacing the magnetron

WARNING: First, with power disconnected, discharge the high voltage capacitor. See the section Safe discharging of the high voltage capacitor.

When you receive the replacement, compare it with the original. It is critical that the replacement magnetron be mechanically identical: this means that the mounting configuration (studs or holes and their location), waveguide seating surface, and the orientation of the filament connections and cooling fins are the same. The studs may be removable so that the same assembly can be used with or without them. The cooling fins are particularly important as there must be adequate airflow from the fan for removal of the substantial waste heat - up to half of the input power to the magnetron ends up as heat. The shape of the antenna terminal - cone, bull nose, or square - doesn't matter.

Magnetron replacement is generally straightforward but other assemblies like the cooling fan may need to be removed to gain access. Make careful notes of both the wiring and mechanical relationships. Usually, the magnetron is fastened to the waveguide with 4 nuts on studs. When removing it from its mounting, do not lose the RF gasket - a metal mesh ring which seals the connection against microwave leakage. Reuse it unless your replacement magnetron comes with a new one. Transfer any thermal protector to the new unit. Replace other components in reverse order and then reattach the filament and HV wires.

Although the magnetron is a vacuum tube, there is probably no glass in yours (unless it is quite old) so it isn't really very fragile. However, a sharp blow or fall (during shipping as well if not properly packed) could shatter the filament. Do keep it (the magnets) away from your diskettes unless you want them bulk erased!

As for the old one, see the section: The magnets in dead magnetrons. :-)

Testing the high voltage transformer

WARNING: First, with power disconnected, discharge the high voltage capacitor. See the section Safe discharging of the high voltage capacitor.

- A shorted winding or short between a winding and the core/chassis in the HV transformer may result in a blown fuse, loud hum, overheating, audible arcing, a burnt aroma, or simply no heat.

- An open winding will likely result in no heat but no other symptoms.

The typical schematic is shown below:

```
                            +--------------------o White wire
                          ||( Filament winding
                          ||  +--------------------o White wire
                          ||
                          ||  +--------------------o Red Wire
           AC H o---------+ ||(
                          )||(
                          )||( HV Winding
                .1 to .5 )||( 1.5 to 2.5 KV RMS
                    ohms )||( .5 A or MORE
                          )||( 25 to 150 ohms
                          )||(
           AC N o---------+ ||(
                           | +-+ HV return connected to frame
                           |   |
           AC G o------------+---+
```

Disconnect terminals as required to make the following tests:

- The resistances of the primary should be .1 to .5 ohms (.2 ohms typical).

- The resistance of the filament winding will likely be so low as not to be detectable with your multimeter. The only measurement easily made would be that there is no short to the chassis.

- Typical resistance readings for the transformer HV secondary are in the 25 to 150 ohms range (depending on the power rating of the oven) from HV connection to chassis. A typical midsize might be 65 ohms. An open would be an obvious failure. However, based on the way these are wound, a winding-to-winding short would not cause enough of a resistance change to be detected with an ohmmeter unless you could compare with an identical model transformer from the same lot number.

- Check the resistance between all windings (and to the core):

  - Filament to primary, high voltage, and core, should be infinite.

    It may be possible to repair a filament winding which is shorted to the core (the only likely place) as it is only 2 or 3 turns of heavy wire. However, it must be insulated for 5,000 V, may get quite hot with normal use, and similar fire resistant materials must be used for the repair as were present original. However, if the filament winding is adjacent to the HV winding (in the same channel), the arcing may have been taking place to the HV winding rather than the core. Therefore, you need to make sure that it hasn't been damaged as well.

  - Primary to high voltage and core should be infinite.

  - High voltage to core should be between 25 and 150 ohms as discussed above.

- If you have a clamp-on ammeter, you can measure the primary current with all secondaries disconnected. See the section: Testing the HV transformer using an AC current meter.

Testing the high voltage transformer more fully is difficult without fancy equipment. Only major short circuits can be identified in the transformer with an ohmmeter since the nominal resistance of the windings is unknown. However, open windings (not very likely) can be located and other faults can be identified by the process of elimination.

Note: in the discussion below, it is assumed that the fuse is blowing due to a possible short in the HV transformer. Alternatively, there may be a loud hum as the HV transformer struggles due to a fault in the HV transformer or a shorted HV diode, magnetron, or a short in the HV wiring. Also note that depending on the severity of the fault, the fuse may not actually blow (at least not immediately) but there will likely be a loud hum when the HV transformer is powered.

- Disconnect the primary of the HV transformer and initiate a cook cycle. If the fuse still blows, you have a problem elsewhere such as a defective interlock or shorted wire.

- Assuming the fuse does not blow, unplug the oven and reconnect the primary of the HV transformer.

- If the other components - HV diode, HV capacitor, magnetron - test out, remove the high voltage and filament connections to the transformer, power up the oven, and initiate a cook cycle. If the fuse does not blow, the transformer is likely good and there are still problems in the high voltage components. Possibly something is failing only when full voltage is applied.

- If the fuse still blows, then the problem is likely with the triac (if used), a shorted wire, or shorted transformer.

- If the fuse does not blow with the secondary isolated, reconnect only the magnetron filament (not the HV) to the transformer and power it up again. If the fuse now blows, then it is possible that the magnetron filament is shorted.

- If your oven uses a triac, remove and bypass it. Now, if the fuse still blows when the oven is plugged in (door closed to enable the interlocks), the problem is likely with the transformer.

  Unplug the oven, discharge the HV capacitor.

- Check for damaged wires that may be shorting to the chassis. Repair or replace these as necessary.

Testing the HV transformer using an AC current meter

Where the HV transformer doesn't blow a fuse but overheats or produces insufficient output, this test may be useful. If you have a clamp-on AC ammeter, the transformer can be powered up to see if the primary current it draws is reasonable with no load.

WARNING: Up to 3,000 VAC on HV terminal - AND possibly other windings if there is a short in the transformer somewhere. Use a 3 prong cord with H and N connected to the primary and G firmly screwed to the transformer core/mounting structure. Or, just remove the 3 secondary connections and power it through the existing wiring using the normal oven controls. The meter's clamp needs to go around H or N but not both. Stand well clear when you apply power!

Use of a Variac is recommended but not essential. However, here are the input current readings at various input voltages for the HV transformer from a typical mid-size microwave oven:

```
  Input VAC   Input Amps
 ------------------------
     80           .3
     90           .6
    100          1.1
    110          2.0
    115          3.0
    120         >4.0
```

Above about 100 VAC, there was also a noticeable hum (though not nearly as great as with a secondary short).

No, these readings do not indicate a problem. Microwave oven transformers are designed with as little copper as possible. And, yes, the non-linear increase in current indicates that the core is saturating with no load.

If your readings are similar to these, the transformer is likely good. Shorted turns would result in much higher current at all input voltages.

Replacing the high voltage transformer

WARNING: First, with power disconnected, discharge the high voltage capacitor. See the section Safe discharging of the high voltage capacitor.

Replacement of a HV transformer is straightforward but other assemblies may be using the transformer bolts for their mounting and/or may block your way.

Label the wires before pulling off the Fast-Ons if there is any doubt as to where they go.

If the replacement transformer is not mechanically identical, you may need to use some creativity in anchoring it and any structures that are attached to its frame. However, the transformer must be secure - don't just sit it in place.

Try not to drop either the old or new transformer on your foot!

Testing and repairing the wiring and connections

WARNING: First, with power disconnected, discharge the high voltage capacitor. See the section Safe discharging of the high voltage capacitor.

Inspect the wiring - especially between the magnetron, HV transformer, and other components of the high voltage circuits for signs of arcing and excessive heating or burning. Arcing may be the result of the wire scraping against a sharp sheet metal edge due to poor placement and or vibration. A bit of electrical tape may be all that is needed.

Since the magnetron filament in particular uses high current, any resistance at the press (Fast-On) connections will result in heating, weakening of the lug, more heating, and eventual failure or erratic operation. Try to pull off each of the lugs. They should not be loose - you should have to work at removing them. However, note that some lugs are of the locking variety and require that you push a little tab to release them.

Check for loose, burnt, or deteriorated lugs in the filament circuit (not just the magnetron). If you find evidence of this:

- Remove the lugs and clean the terminals with fine sandpaper or a file. If they are not too badly deteriorated, they will still work even if they are somewhat ugly.

- If the lugs and their wire connections appear to be in good condition but come off their terminals easily, try squeezing them a little tighter with a pair of pliers and reinstall. Otherwise, cut off the old ones and replace them.

- If any connections between the lug and the wire or HV diode are at all loose, solder it with a high wattage soldering iron or soldering gun.

- Alternatively, use a drill to make a hole in each terminal, and then fasten the (tinned) wire directly (or better yet) a new ring lug to the terminal with a machine screw, nut, and lockwasher. Soldering is also possible.

  These approaches will work as long as there is enough metal remaining for a solid connection and may permit you to salvage a magnetron or HV transformer that would otherwise need to be replaced.

Also check for bad solder connections between the terminals on the high voltage transformer and the enameled wire used for its windings. If you find anything suspect, scrape away the enamel and surface corrosion and resolder with a high wattage soldering iron or soldering gun.

Testing thermal protectors and thermal fuses

There may be two types of devices present in your oven:

- Thermal protectors are thermostats that open a set of high current contacts at a preset temperature. They should reset when they cool off. However, like a relay or switch, the contacts sometimes deteriorate.

- Thermal fuses will open at a preset temperature but do not reset. They blow and need to be replaced.

At room temperature, both types should read as a dead short with an ohmmeter (disconnect one terminal as there may be low resistance components or wiring which may confuse your readings). If the resistance is more than a small fraction of an ohm, the device is bad. Replacements are somewhat readily available. You must match both the temperature and current ratings.

If you suspect a bad thermal protector in the HV transformer primary, clip a 100 W light bulb or AC voltmeter across it and operate the oven. If the thermal protector is functioning properly, there should never be any voltage across it unless there is actual overheating. If the bulb lights up or the meter indicates approximately line voltage - and there is no sign of overheating - the thermal protector is defective and will need to be replaced.

An overheating condition would generally be obvious as the mounting surface on which the thermal protector is located would be scorching hot when it tripped - too hot to touch (but discharge the HV capacitor first - a burn from the heat will be nothing compared to the potential shock!).

Replacement of a thermal protector is very straightforward as it is almost always screwed in place with push-on lug terminals. The new thermal fuse will probably come with lugs attached.

Testing and replacing the triac

A triac may fail in a variety of ways:

- A shorted triac would result in the oven coming on as soon as the door is closed or the power being stuck on high no matter what the touchpad setting.

- An open triac or one that didn't respond to the gate would result in no heat and possibly other things like the fan and turntable not working as well.

- A triac that didn't turn off would result in the parts of the oven continuing to run even after the timer counted to zero.

- A triac where one half was shorted would result in a blown fuse due to it acting as a rectifier pumping DC through the HV transformer.

- A triac where one half doesn't properly turn off would result in the main fuse blowing when the cook cycle completed.

Nearly all triac failures will be shorts. Thus, measuring across the MT1 and MT2 terminals of the triac (the power connections) should read as a high resistance with a multimeter. A few ohms means a bad triac.

As noted above, triacs can fail in other - possibly peculiar ways - so substitution or bypassing may be necessary to rule out all possibilities.

Replacement is very straightforward - just don't get the wires mixed up.

Testing and replacing the power relay

A defective relay can result in a variety of symptoms:

- A relay with its contacts welded (stuck) closed would result in the oven coming on as soon as the door is closed or the power being stuck on high no matter what the touchpad setting.
- A relay that doesn't close (due to defective contacts or a bad coil) would result in no heat and possibly other things like the fan and turntable not working as well.

If the relay is totally inoperative, test for voltage to the coil. If the voltage is correct, the relay may have an open coil. If the voltage is low or zero, the coil may be shorted or the driving circuit may be defective. If the relay makes a normal switching sound but does not correctly control its output connections, the contacts may be corroded, dirty, worn, welded closed, binding, or there may be other mechanical problems.

Remove the relay from the circuit (if possible) and measure the coil resistance. Compare your reading with the marked or specified value and/or compare with a known working relay of the same type. An open coil is obviously defective but sometimes the break is right at the terminal connections and can be repaired easily. If you can gain access by removing the cover, a visual examination will confirm this. If the resistance is too low, some of the windings are probably shorted. This will result in overheating as well as no or erratic operation. Replacement will be required.

The resistance of closed contacts on a relay that is in good condition should be very low - probably below the measurable limits on a typical multimeter - a few milliohms. If you measure significant or erratic resistance for the closed contacts as the relay is switched or if very gentle tapping results in erratic resistance changes, the contacts are probably dirty, corroded, or worn. If you can get at the contacts, the use of contact cleaner first and a piece of paper pulled back and forth through the closed contacts may help. Superfine sandpaper may be used as a last resort but this is only a short term fix. The relay will most likely need to be replaced if as in this case the contacts are switching any substantial power.

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Items of Interest

Microwave leakage meters

A routine test for radiation leakage should be done before returning an oven you have worked on especially if the door or magnetron/waveguide were disturbed during the repair process. Use it around the door seem and ventilation holes in the cabinet. An inexpensive meter is better than nothing but will not be as sensitive and will not allow you to quantify the amount of any leakage.

If you work on microwave ovens, such a meter is a *must* for personal safety reasons as well as minimizing the risk of liability after returning them to your customers.

These should be available wherever you buy quality test instruments. They are usually made by the same companies that manufacture other service equipment. Prices and capabilities vary widely. MCM Electronics sells an inexpensive unit suitable for quick checks on a go/no-go basis for $6.99 and an FDA approved unit (including calibration), for $388.

Note: you should also perform an electrical leakage test to assure that all case parts are securely connected to the Ground of the AC plug.

Comments on microwave leakage meters

(From Barry Collins (bcollins@mindspring.com).)

I found an old manual for a Narda 8100B Electromagnetic Leakage Monitor. (I used to work for a manufacturer of Microwave ovens.) While I don't personally recall ever having damaged a probe while checking for leakage, I do know that it is possible to do so and did happen on rare occasions.

The Narda manual states that their probes use an antenna/thermocouples design. Holaday (sp?) makes another line of detectors and those may use a thermistor array.

I have confirmed that by removing the styrofoam cone from the end of a Holaday uW leakage detector's probe and then bringing its tip near a heat source (40W bulb) caused the meter to have a significant deflection. Thus, the cones are not only used as spacers. They prevent radiant heat sources from affecting the meter reading, as well.

The Holaday probes that I used had 8 diodes in the tip that formed an array.

Newer designs (Holaday) claim to be more or less immune to damage resulting from placing them into high energy fields. I do know that the older Narda equipment was prone to such damage.

There is a section in the Narda manual that details how to select the proper probe to measure "unknown" leakage levels. In a nutshell, one should start with the highest power rated probe and work toward the lowest power rated probe (three listed in all). The goal is to have a meter deflection of more than 10% of it's scale while not going off scale for sake of accuracy. While it didn't specifically mention damage to the probes, there were overtones throughout the text that implied such (watch needle, listen for alarm, stop and replace probe, etc...).

The three probes were listed as (high/low range for each):

```
  Probe          Range
----------------------------------------
  8120A    0.2 mW to   2.0 mW/square cm
  8121A    2.0 mW to  20.0 mW/square cm
  8122A   20.0 mW to 200.0 mW/square cm
```

This is from memory, but I believe that the maximum leakages we were allowed by the governmental agency were:

- Less than 2.0 mw/square cm off of our assembly line
- Less than 3.0 mw/square cm leaving the warehouse
- Less than 5.0 mw/square cm in consumers home

As you no doubt know, with a hole cut in the oven (in reference to those who want to modify one - see the section: Microwave ovens for non-standard applications --- sam), the density can easily reach several times these numbers, especially on the newer 1,000 watt plus models. Damage would occur where one intentionally held the lower power rated probe in the strong field until the thermocouple (or thermistor?) overheated.

Simple microwave leak detectors

Since these do not really provide an absolute measurement, their utility is somewhat limited. All microwave ovens leak to some extent. Determining by how much is why you pay the big bucks for a real leakage meter!

WARNING: These are no substitute for a properly calibrated commercial unit!

(From: Leon Heller (leon@lfheller.demon.co.uk).)

A very simple design I saw somewhere (Electronics World, probably) consisted of a half-wave dipole with a Shottky diode detector between the two elements. I think one measured the voltage across the diode via a resistor and capacitor smoothing arrangement using a 50 uA meter. You can buy these detectors quite cheaply.

(From: Ren Tescher (ren@rap.ucar.edu).)

I saw an article about it in Modern Electronics in the early eighties. It is simply a Schottky Barrier Diode (SBD) and an LED wired together. The leads of the SBD are left intact and straight and act as a 1/4 wavelength dipole.

Here's the circuit:

```
                             SBD
      <-----------------+-|<|-+----------------->
                        |     |
                        +-|>|-+
                             LED
```

The LED is soldered close to SBD using as short of leads as possible (being careful not to ruin either part with too much heat). (Note that the diodes are connected anode to cathode, not cathode to cathode.)

I then taped/glued it 1 1/2 and perpendicular from the end of a popsicle stick (this gives it a 'standoff' distance).

Put a large container of water (>=2 cups) in the microwave and run it on HIGH for 2 minutes. While it is running, slowly sweep the tester around the door seal, hinges and door latch. You may have to dim the lights to see if the LED lights up.

Any leaking uwaves will be picked up by the dipole 'antenna', the SBD will rectify the waves, and when sufficient rectified voltage has built up, the LED will light up.

I built 10 of these at home and then compared them to the commercial tester we had at work. The commercial tester had three ranges and the most sensitive range was divided into 3 color bands, red, yellow, green. The home-built testers all 'fired' at some point in the 'yellow' range. I attribute the variances within the yellow (caution) range to individual characteristics of the diodes - they all came from the bargain bin at Radio shacks....

A solid glow would indicate excessive leakage, especially if the tester still glows if it is pulled beyond the 1-1/2 inch standoff distance to 3 inches. Typically the LED just flickers, around the hinge/latch areas. (US law allows increased leakage as the oven ages).

You may notice that no radiation leaks through the viewing window, contrary to the old wives tale of not looking through the window while it's cooking. (The screen really is a very good microwave shield --- sam).

Small leaks may be remedied by adjusting or cleaning the door and hinges and/or by distance (square law= doubling the distance quarters the power). Large leaks - trash the oven.

(From: James P. Meyer (jimbob@acpub.duke.edu).)

Get a small neon bulb. The NE-2 size is a good one. Use some resistors to make a voltage divider for 115 VAC to feed the bulb. Adjust the voltage across the bulb so that it's just barely glowing. Make the divider network resistance large enough to limit the current through the bulb to just a couple of mA. Put the bulb on the end of a line cord and plug. INSULATE everything completely.

Adding this onto a neon circuit tester is one option and will provide an insulated housing as well.

Plug the whole thing into an AC outlet. Wave the bulb around the door gaskets and if it gets brighter when the oven is turned on, then you have located a leak. The bulb detector can be very sensitive. You may even be able to use it to find wires behind drywall in your house.

How safe is a repaired microwave oven?

So you fixed up Aunt Minnie's Radarange or picked up a microwave at a yard sale or scavenged one off the curb. The only problem you could find was a blown fuse, truly horrible mess of decayed burnt-on food, or a thriving community of cockroaches inside. How safe is it to use (assuming you evicted the cockroaches)?

As long as there is no serious damage to the door (a 6 inch hole would quality as serious damage) and the door fits square, it should be properly sealed. As long as the waveguide is tightly mounted and undamaged, there should be no leakage from there. Make sure the metal cover has all its fingers engaged around the front (though with a properly installed magnetron, there should be minimal microwave leakage into the electronics bay).

An inexpensive leakage tester - around $8 - will not be as sensitive or accurate as the $500 variety by may provide some peace of mind. However, as noted below, they may indicate dangerous leakage even when your oven is within acceptable limits.

The most important considerations are the door and door seal.

(From Barry Collins (bcollins@mindspring.com).)

Those inexpensive hand held meters (from Radio Shack, etc..) can give very inaccurate readings. While they definitely serve a purpose, they have caused a more than a few people to unnecessarily fear microwave ovens over the years. Also, I just changed jobs from working for a company that made gas ranges. CO detectors caused similar panic among users of the appliances. I'd highly recommend anyone with gas heat or appliances to purchase a quality CO detector, but not one of those inexpensive type that go off whenever there is a thermal inversion of smog a city.

Efficiency of microwave ovens

The efficiency of an electric heating element is 100% - period. However, using an electric stove to heat 1 cup of tea may result in much wasted energy as the element and pot must be heated as well and there are losses due to convection and conduction to the surrounding environment. Furthermore, you won't heat just *1 cup* of tea but more likely 2 or 3 just to be sure you have enough!

A microwave oven is not likely to be more than 60% efficient - possibly as low as 50 percent or even less. While the magnetron tube itself may have an efficiency rating of 75%, there are losses in the high voltage transformer, cooling fans, and turntable motor (if used). The light bulb and controller also use small amounts of power. These all add up to a significant overhead. In addition, the waveform applied to the magnetron by the half wave doubler circuit is not ideal for maximum efficiency.

However, you are not heating the surrounding countryside as the microwaves only affects what you are cooking and not the container or oven cavity itself and you are more likely to only load the amount of food you expect to be eating. For a single cup of tea, the microwave oven may use 1/10th the energy of a typical electric cooktop element to bring it to a boil!

Therefore, it makes sense to use a microwave oven for small short tasks where the losses of an electric or gas oven or cooktop would dominate. However, gastronomic preferences aside, a conventional oven is better suited for that 20 pound turkey - even if you could distort its anatomy enough to fit the typical mid-size microwave!

Microwave oven design and cost reduction

(From Barry Collins (bcollins@mindspring.com).)

Microwave oven design is a black art. What one hopes for is to deliver all the power from the magnetron into the food and not have a high SWR reflect back into the magnetron and burn it out. Size, shape, placement of food items affect the SWR. The microwaves are designed for the most part to work optimally with an average load. Models equipped with turn-table models compensate for this by breaking up the SWR as the food revolves. My oven has a stirrer fan design and has been working for going on 18 years now without the first hint of a problem (maybe a little less power). I personally know that it had one of the lowest SWRs available at the time. Not to mention it has an older design, non-cost reduced, cooler running, more efficient magnetron (that cost $13.00 instead of $9.45). The thing that I found disturbing about microwave oven design was the trends to go with hotter an hotter insulation classes on the components used in them. The original transformers were class H while the newer ones are now class N. This was all done in the name of cost reduction to remain competitive. The windings AWG got smaller and the temperature rise went up accordingly. The magnetrons were cost reduced in a similar fashion. Size was reduced and the number of fins were reduced. Their temperature went up while their efficiency went down. But then the cost went from $300 to $149 while life went from 10 years-plus to 5 years or less and they became disposable items. That's one area, I'd almost hesitate to hope the Government would have mandated an efficiency.

Problems with running a microwave oven with metal inside or totally empty

Metal in microwave ovens may or may not be a problem depending on the specific situation. Sharp edges and points create strong field gradients which tend to spark, arc, or create other fireworks. With some food in the oven to absorb the power, this is probably not likely to damage the oven. You will note that some ovens come with metal fixtures in addition to the oven walls themselves (e.g., Sharp convection/microwave combo).

Having absolutely nothing in the oven chamber or just metal is the potentially more likely damaging situation for the magnetron as you are dumping several hundred W to over a kW of power into a reflective cavity with no load. In the worst case, you could end up with a meltdown inside the waveguide requiring replacement of various expensive components including the magnetron.

Older microwave ovens with used glass magnetrons were perhaps more susceptible to these disasters (all modern overs use magnetrons with ceramic construction but I really don't know how much this matters) but it's still a good idea to avoid running a microwave empty. They don't need preheating! :)

More on metal in the microwave

(From: Don Klipstein (don@Misty.com).)

Mainly, you need exposed water or food to absorb the microwaves. Otherwise, they just reflect around the oven and get back to the magnetron tube. This may be bad for the tube, and in an unpredictable manner.

It is even not too good to run a microwave empty. The walls of the main cooking chamber are metal.

In the event the microwave runs empty OK, adding metal objects change the microwave reflection pattern and might possibly unfavorably change things.

If you have exposed food or water, the tube should not mind some stray metal too much. If the added metal does not interfere with microwaves mainly getting from the tube to the target food or water and being absorbed, the magnetron should be OK.

Even if the tube does not mind, there is another concern. Metal objects close to other metal objects or to the walls of the cooking chamber may arc to these. Any arcing is generally not a good thing. If you add metal objects in a manner safe for the tube, try to keep these at lease a half inch (a bit over a cm.) from the walls to avoid arcing. Safe distances are uncertain and are usually less if the metal objects are small and a large amount of food or water is exposed.

If any metal object has major contact with a microwave absorbing food target and such target is still heavily exposed, you should be OK. Examples would be wrapping foil around the wingtips of a whole chicken or whole turkey, or a bottle of liquid (on its side) with a metal lid with liquid contacting much of the lid. This is usually OK. Just avoid unrelated problems due to major temperature change of anything in contact with a non-heat-rated glass container.

A plain glass bottle if ice-cold stuff might possibly break from thermal shock when heated, but any metal lid on a bottle largely full of microwave-absorbing stuff should not present a problem especially if the bottle is on its side so that stuff is contacting or very nearly contacting much of the lid.

Burnt smell from oven - after incident

> "My daughter tried to heat up one of those 'soup in a box' containers and it burned - actually charred. I wasn't home at the time, so I don't know if it was neglect or inappropriate use, but the lasting effect is that there is a strong odor, similar to that which you smell after a fire that I cannot seem to get rid of. What do you recommend. I have a Sharp Convection/Microwave, that even after the incident described still performs well."

Start by cleaning the interior of the oven thoroughly with mild detergent and water. You may have to do this several times to get all of the sticky film left behind. If this doesn't help enough, smoke may have gotten into the waveguide above the oven chamber. If possible, remove the waveguide cover and clean it and as best as possible the accessible part of the waveguide.

However, the odor may persist since the smoke can penetrate to places you cannot access for cleaning. With a combination convection and microwave oven especially, there are many passages where the air would normally circulate in convection mode which will be coated even if the oven was used in microwave mode. However, I would expect that the smell will decrease and eventually go away. Most likely, nothing in the oven has actually sustained any damage.

Some have suggested boiling a cup of lemon scented water or vinegar to help speed things along. It won't hurt - maybe even help. :)

Microwave ovens and grounded dedicated circuits

A microwave oven should be used only on a properly wired 3 wire grounded circuit. Check with a circuit tester to make sure your 3 prong outlet is correctly wired. Many are not. Install one if it is not grounded. There is a very important safety reason for this requirement: the return for the high voltage is through the chassis. While unlikely, it is theoretically possible for the entire high voltage to appear on the metal case should certain internal connections come loose. With a properly grounded outlet, this will at most blow a fuse. However, with the case floating, a shocking (or worse) situation could develop - especially considering that microwave ovens are usually situated near grounded appliances like ranges and normal ovens and wet areas like kitchen sinks.

A dedicated circuit is desirable since microwave ovens are significant users of power. Only about 50 to 60% of the electricity used by a microwave oven actually gets turned into microwaves. The rest is wasted as heat. Therefore, a 700 W oven will actually use up to 1400 W of power - nearly an entire 15 Amp circuit. Convection ovens have heating elements which are similar energy hogs. At least, do not put your refrigerator on the same circuit!

Microwave ovens and GFCIs

A Ground Fault Circuit Interrupter (GFCI) protects people from shocks should a situation develop where an accessible part of an appliance should short to a live wire. Touching this may result in a shock or worse. A GFCI detects any difference between the currents in the Hot and Neutral wires and shuts off the power should this difference exceed a few mA.

A GFCI is not needed with a properly grounded microwave oven as any such fault will blow a fuse or trip a circuit breaker. In most cases, it will not hurt to have a GFCI as well. However, with some combinations of oven design and your particular wiring, due to the highly inductive nature of the high voltage transformer, nuisance tripping of the GFCI may occur when you attempt to cook anything - or at random times. However, this usually does not indicate any problem. Plug the oven into a properly grounded circuit not on a GFCI.

Can a microwave oven be built into (or hung under) a cabinet?

Assuming it is a regular microwave and not a convection/microwave combo, the major issues are:

- Providing adequate air flow through its ventilation grill which is usually located in the rear.

(A convection/microwave can get quite hot and have ventilation in other places. In this case I would suggest contacting the manufacturer of the oven for specific requirements.)

- Providing adequate structural support so the microwave doesn't end up in the soup. :-(These are HEAVY appliances - cabinetry and/or drywall may not be up to the task. Models designed as over-the-range or combined microwave and exhaust fan units mount via a massive plate fastened securely into the wall structure (screwed directly to the studs, not just the sheetrock!). They may additionally be bolted into the cabinet above but this will not (or should not) be the sole means of support.

- Local building codes may specify when and if this approach can be used. So, before doing any demolition, check with your friendly township inspector!

There are special (likely highly overpriced) models available for this type of mounting.

To use a normal microwave, my recommendation would be to build a shelf rather than a totally sealed, enclosed, conformal cabinet. It can have sides and a top as long as you leave a couple of inches all around. This will result in a microwave oven that is much more easily serviced should the need arise and replaced in the future with a model that is not quite identical.

Just make sure it is securely supported - the microwave weighs quite a bit and must endure a fair amount of abuse from heavy casseroles and the inevitable door yanking/slamming!

Note that one of the advantages of buying a microwave oven designed for under cabinet or wall mounting is that it may provide convenient access for servicing from the front - not having to remove the entire unit to check or change a fuse! For example, some GE units have a hinged front panel - remove a couple of screws and most of the internal components can be accessed for service. This would not be possible where a countertop oven is used in a permanent installation.

(From: Roy Smith (roy@popmail.med.nyu.edu).)

I've installed a GE over-the-range microwave. It really was quite straight-forward. There is a backplate which you attach to the wall with whatever combination of lag bolts, screws, expansion bolts, etc you can get to work (i.e. wherever you can find studs, etc). It comes with a template to make this easy. The rear-bottom edge of the oven then clips onto the backplate to form a kind of hinge, and you pivot the oven up into place. There are two long bolts that run the depth of the oven near the top which you use to complete the attachment of the oven to the backplate. You then bolt it into the cabinet above it for additional security.

Taking a microwave oven oversees (or vice versa)

Microwave ovens are high power appliances. Low cost transformers or international voltage adapters will not work. You will need a heavy and expensive step down or step up transformer which will likely cost as much as a new microwave oven. Sell the oven before you leave and buy a new one at your destination.

Furthermore, for microwave ovens in particular, line frequency may make a difference. Due to the way the high voltage power supply works in a microwave oven, the HV capacitor is in series with the magnetron and thus its impedance, which depends on line frequency, affects output power.

High voltage transformer core saturation may also be a problem. Even with no load, these may run hot even at the correct line frequency of 60 Hz. So going to 50 Hz would make it worse - perhaps terminally - though this is not likely.

- Going from 50 Hz to 60 Hz at the same line voltage may slightly increase output cooking power (and heating of the magnetron). The line voltage could be reduced by a small amount to compensate.
- Going from 60 Hz to 50 Hz may slightly decrease output power and possibly increase heating of the HV transformer due to core losses. Using a slightly lower line voltage will reduce the heating but will further decrease the cooking power.

The digital clock and timer will likely run slow or fast if the line frequency changes as they usually use the power line for reference. Of course, this may partially make up for your change in output power! :-)

Microwave oven test-mode

(From Mark Paladino (paladino@frontiernet.net).)

Some microwave ovens have a self-test feature. This self-test is usually accessed by pressing a couple of keys on the touch pad. You can usually test things like keys, switches controller etc. Check the manual for any self-test info. Some microwaves have this information tucked in a pocket or hidden somewhere behind panels.

High frequency inverter type HV power supplies

While the vast majority of microwave ovens - perhaps every single one you will ever see - use minor variations on the tried and trusted half wave doubler circuit, a few models have been designed using solid state high frequency inverters - in many ways similar to the deflection/HV flyback power supply of a TV or monitor.

A typical circuit (from a Sharp microwave oven) uses full wave rectified but mostly unfiltered pulsating DC as the power to a large ferrite inverter transformer which sort of looks like a flyback on steroids. See High Voltage Inverter Power Supply from Sharp Microwave Oven. This means that the microwave output is pulsing at both 60 Hz and the frequency of the inverter!

```
        Bridge Rectifier         Inverter Transformer            Magnetron
                                       o
  H o----+---|>|------+--------+-------+    +--------------------------+
        ~|            |+      _|_ Drive )::( Filament 1T #18           |
         +---|<|---+  |       ---    25T ):: +--------------+------+    |
 115 VAC           |  |        |    #12 )::   HV Cap       |    +-|----|-+
         +---|>|---|--+        +-------+ :: +-------||-----+    | |_  _| |
         |         |           |         ::(    .018 uF    |    |   \/   |
  N o----+---|<|---+   Drive |/ C        ::(    2,400 V  __|__  |   ___  |
        ~          |-    o---|   Chopper ::( HV         _\_/_  +----|:--+
 (Interlocks and   |         |\ E        ::( 250T         | HV       |'-->
  fuses/protectors |           |         ::( #26   Sense   | diode    | uWaves
  not shown)       +-----------+            +--+---/\/\----+---------+
                                             o  |    1.2  _|_
 (Except for filament, # turns estimated)       o H1       -   Chassis Ground
```

The chopper transistor is marked: Mitsubishi, QM50HJ-H, 01AA2. It is a LARGE NPN type on a LARGE heatsink. :-)

Note the similarity between the normal half wave doubler circuit and this output configuration! Base drive to the chopper transistor is provided by some relatively complex control circuitry using two additional sets of windings on the inverter transformer (not shown) for feedback and other functions in addition to current monitoring via the 'Sense' resistor in the transformer return.

It is not known whether power levels in this over were set by the normal long cycle pulse width modulation or by control over a much shorter time scale. However, since the filament of the magnetron is powered from the same transformer as the HV - just as in a 'normal' microwave oven, this may not be very effective.

Compared to the simplicity of the common half wave doubler, it isn't at all surprising why these never caught on (what is diagramed above includes perhaps 1/10th the actual number of components in a typical inverter module, which can be seen in the photo). Except for obvious problems like a tired fuse, component level troubleshooting and repair would be too time consuming. Furthermore, as with a switchmode power supply (which is what these really are) there could be multiple faults which would result in immediate failure or long term reliability problems if all bad parts were not located. Schematics are not likely available either. And, a replacement module would likely cost as much as a new oven!

This is simply a situation where a high tech solution was doomed from the start. The high frequency inverter approach would not seem to provide any important benefits in terms of functionality or efficiency yet created many more possibly opportunities for failure. The one major advantage - reduced weight - is irrelevant in a microwave oven. Perhaps, this was yet another situation where the Marketing department needed something new and improved!

Dangerous (or useful) parts in a dead microwave oven?

A microwave oven with its power cord cut or removed AND its high voltage capacitor safely discharged is an inanimate object. There are no particularly hazardous parts inside. Of course, heavy transformers can smash your feet and sharp sheet metal can cut flesh. And, the magnets in the magnetron may erase your diskettes or mess up the colors on your TV.

Some may feel there is nothing of interest inside a microwave oven. I would counter that anything unfamiliar can be of immense educational value to children of all ages. With appropriate supervision, an investigation of the inside of a deceased microwave oven can be very interesting.

However, before you cannibalize your old oven, consider that many of the parts are interchangeable and may be useful should your *new* oven ever need repair!

For the hobbiest, there are, in fact, some useful devices inside:

- Motors - cooling fan and turntable (if used). These usually operate on 115 VAC but some may use low voltage DC. They can easily be adapted to other uses.
- Controller and touchpad - digital timer, relay and/or triac control of the AC power. See the section: Using the control panel from defunct microwave oven as an electronic timer.
- Interlock switches - 3 or more high current microswitches.

- Heavy duty power cord, fuse holder, thermal protector, other miscellaneous parts.

- High voltage components (VERY DANGEROUS if powered) - Typical HV transformer (1,500 to 2,500 VRMS, 0.5 A), HV rectifier (12 to 15 kV PRV, 0.5 A), and HV capacitor (approximately 1 uF, up to 1,500 to 2,500 VAC (4,200 to 7,000 VDC).

- Magnetron - there are some nifty powerful magnets as part of the assembly. Take appropriate precautions to protect your credit cards, diskettes, and mechanical wristwatches. See the section: The magnets in dead magnetrons.

DOUBLE WARNING: Do not even think about powering the magnetron once you have removed any parts or altered anything mechanical in the oven. Dangerous microwave leakage is possible.

The magnets in dead magnetrons

The dead magnetron you just replaced is fairly harmless. There is no residual radiation but it does contains a pair of powerful ferrite ring magnets. These can be removed without extensive disassembly and make really nice toys but should be handled with care. Not only can they pinch flesh (yes, they are that powerful) but they will suck all the bits right off your tapes, diskettes, and credit cards. If you do want to save the magnets:

- Disassemble the magnetron assembly as follows:

    - Remove the top portion of the magnetron - it is either fastened with screws or some metal tabs which are easily bent out of the way.

    - Remove the cover over the box where the filament connections are located. This usually requires peeling off the sheet metal around the edges.

    - Cut the thick copper connections to the filament near the tube itself. (The thick copper coils are RFI chokes and prevent any microwave energy from escaping via the filament circuit.)

    - Spread the frame apart just a bit and lift out the tube with heat sink fins. CAUTION: the sheet metal fins may be sharp!

    - The magnets can now be pulled off. They may need cleaning. :-(

    - The magnetron tube itself can be disassembled by grinding off the welds around the edges of the large cylinder or cutting around it outer edge near one end with a hack saw but it takes quite a bit of curiosity to make this a worthwhile exercise. There is a slight chance that the coating on the filament is poisonous so don't take chances. You don't need to get inside to remove the magnets.

- Keep the magnets a safe distance away from any magnetic media including what might be in your back pocket, mechanical wrist watches, and color computer monitors and TVs.

- Paint the magnets with plastic enamel or coat them with the stuff used on tool handles to reduce their tendency to chip. The chips are as magnetic as the overall magnet. The ferrite is basically a ceramic and fragile. Smack them too hard and they will shatter.

- Take care not to get your skin between the magnets when you bring them together since the attractive force when nearly touching is substantial.

- Store the magnets in a box packed in the center of another box with at least 4 inches on all sides. Clearly mark: powerful magnets with appropriate warnings.

Having said that, these magnets can be used to demonstrate many fascinating principles of magnetism. Have fun but be careful.

Also see the section: Magnetron construction - modern microwave oven.

Using the control panel from defunct microwave oven as an electronic timer

It is usually possible to remove just the touchpad and controller board to use as a stand-alone timer with a switched output. Be careful when disconnecting the touchpanel as the printed flex cable is fragile. With many models, the touchpanel (membrane touchpad) needs to be peeled off of the front plastic panel or the entire assembly can be removed intact.

The output will control a 10-15 A AC load using its built in relay or triac (though these may be mounted separately in the oven). Note that power on a microwave oven is regulated by slow pulse width modulation - order of a 30 second cycle if this matters. If it uses a triac, the triac is NOT phase angle controlled - just switched on or off.

Precise control of microwave oven power

For heating a casserole, the 10 to 30 second cycle time typically used for microwave oven pulse width heat control is fine. However, for other purposes, this results in unsatisfactory results. This question was posed by someone who wanted to modify the circuitry to their microwave oven to provide continuous control and a constant heating rate.

Just cycling faster (without any other modifications is not the answer). One problem is that the filament of the magnetron is turned on and off as well. This would result in a very non-linear relationship between on-time and power as the cycle became shorter and shorter.

It should be possible to put a Variac (variable autotransformer) on the input to the high voltage transformer - between the controller and HV primary. (For safety, DON'T attach it externally, DON'T bypass or disable any door interlocks, and make sure the cooling fan is always powered from the full line voltage.) The power to the filament will still be affected but there will be a range over which continuous control will be possible. My guess is that this would be between 60 and 80 percent and full voltage from the Variac will result in 0 to 100 percent of cooking power (the magnetron is a non-linear device - there is a threshold voltage below which no output is generated). However, there will be a lag as the filament heats and cools. Also, running for an extended period of time at reduced filament temperature may eventually damage the cathode coating. I do not know if this is likely.

Where manual control is all that is needed, this approach may be the adequate.

If the filament were put on its own transformer (with appropriate insulation ratings), then instantaneous control of power should be possible using a Variac on the HV transformer primary or a phase control scheme using a triac - a high power light dimmer or motor speed control might even work. Alternatively, a triac or solid state relay can be turned on and off at the peaks of the AC (to minimize inrush) similar to the pulse width modulation that is normally used for the oven - but at a much higher frequency. This could easily be computer controlled with feedback from a temperature sensor.

In any case, you want everything else - including cooling fans - to be on the full line voltage not affected by any power control scheme or timer.

Has technology gone too far?

Don't you just hate it when your kitchen appliances have the highest IQ in the household? What more could you want? Maybe, a microwave with a robot arm to retrieve the food from your fridge or freezer! But wait, you haven't seen it all. Just the the World needs is a smart microwave. You WILL see ovens (if they don't exist already) that with the help of a barcode or Dallas ID chip on the frozen package or food container, will contact a recipe database at the Web site for the product to determine exactly how to optimally overcook it and turn it into rubber. :)

(From: Dave Marulli (marulli@rdcs.kodak.com).)

We bought a Sharp unit with the Interactive Display feature.

There is a list of common items that you might Defrost, Cook, or Reheat. You pick one of those tasks, choose a number from the list, enter the 'quantity', hit start and it picks the time and power level. There is even an 'on-line' help feature. A typical session goes like this:

```
    Button Pressed                                    Screen Output
   ----------------                                ------------------------------
      CompuCook                                     Enter Food Category
          1                                         Baked Potato, Enter Quantity
          4                                         Press Start
```

Unit turns on and starts cooking. If the little word HELP lights up, you press the HELP button and it gives you little hints like, DO NOT COVER, or CUT IN HALF, etc.

For things like CompuDefrost, you tell it what you are defrosting, how many pounds, and hit start. It will turn on for a while, then beep at you and tell you to break the pieces apart, cover the edges, etc. You do as you are told, close the door hit start and it continues until it's time for you to do some thing else.

Same idea for CompuReHeat: Tell it how many slices of pizza or bowls of pasta you want to reheat, and it sets itself up and takes off.

It even has the obligatory POPCORN button!

Another neat feature is that you can hold the start button on without setting any time and it will stay on for as long as you hold the button. This is great for melting cheese, softening butter or chocolate, etc.

But, does it run Lotus??? :-) --- sam.

(From: Steve Dropkin (sdropkin@isd.net).)

The one we bought has an LCD screen that's maybe three inches square, takes you step-by-step through anything the oven can do, and includes 600 recipes (!). While that sounds like overkill, the attraction for me was that the menu-driven interface actually seemed simpler and more inviting than the ovens with timing buttons and 24 others marked "popcorn," "baked potato," "hot dog," "frozen dinner," "beverage," "sandwich," "waffles," etc. They looked just way too busy. (Same argument I have against a lot of mainstream HiFi equipment these days. I just want to listen to the music, not reengineer the sound source ...)

(From: Andrew Webber (webbers@magma.ca).)

Our microwave has a button for popcorn. As far as I can tell, all it does is automatically set 5 minutes. The manual says to monitor the popcorn anyway since it varies based on bag size, etc. So on principal I choose 5 minutes on high and stop it at 1:45 (why not set for 3:15? because the one time I tried it the popcorn was burnt!). I can choose 5 minutes with two presses (QUICK, 5) and popcorn with two presses (POPCORN, START).

But that popcorn button sure is a good selling point! :)

Microwave ovens for non-standard applications

Occasionally, people ask questions about the use of a microwave oven to do things other than heating food. In general, these have to be taken on a case-by-case basis. Obviously, softening sticks of Dynamite is probably not to be recommended! (There actually is a reason for this - a microwave can develop hot spots - heating is not as uniform as with normal ovens. Do your dynamite softening in a normal oven).

Special kilns that will fit inside a microwave oven are apparently available to achieve really high temperatures. They consist of a ceramic (expanded alumina or something similar) insulating cylinder lined with a microwave susceptor - possibly a ferrite material. Temperatures exceeding 1000 degrees C (yellow-white heat) are possible after a few minutes on high. See for example Microwave Melting of Metals.

If any modifications are made to the oven that would compromise the integrity of the door seals or provide other places where microwave radiation could escape, then special tests MUST be done to assure the safety of the users of the equipment. The following is one such case in point:

> "My Dad and I are using a microwave oven to heat oak strips by passing them through the microwave field of a 1000W oven. We cut out squares (4"x 4") in the glass front and metal back of the oven to allow these strips to pass through the field. I am concerned about potential microwave leakage of a harmful nature."

Geez!!! You guys are out of your collective mind. Sorry, having said that I feel much better. :-(

My first recommendation (though this is too weak a term) would to not do this.

My second (and up to N where N is a very large number) recommendation would be not to do this.

However, if you insist, use a good conductive sheet metal such as copper or aluminum to reduce the size of the opening as close to the material as possible. The wood stock will tend to reduce leakage while it is in place but the opening will leak like crazy when there is nothing in the hole. The sheet metal must be in electrical contact with the mesh in the door and the metal back. The smaller the opening, the less will be the leakage. Also, make sure there is always a load in the oven (a cup of water, for example) to keep the magnetron happy.

Next, borrow an accurate microwave leakage detector. A large appliance repair shop or electronics store may rent you one if you are persistent enough. Use this to identify the safe limits front and back. Label these and don't go closer while the oven is in operation. The operators may have to remain further away or some additional shields may needed if these distances are not satisfactory. The leakage detector or microwave field strength meter should come with information on acceptable power limits. It is something like 2 mW per square cm a foot or so from the oven - check it out. However, there is no assurance that even this limit is safe.

CAUTION (In addition to the loony nature of this entire project!): Since the leakage you encounter may be orders of magnitude greater than what is typical of even a misaligned microwave oven, start with the probe at a distance of a few feet and slowly move it closer while watching the meter or readout. Don't set it next the opening as you hit START! This will prevent the possibility of damage to the expensive leakage tester (which could be costly) and exposure risk to you as well.

The only known confirmed danger from microwave radiation is from internal heating effects. The eye is particularly sensitive to this and it doesn't take much of an increase in temperature to denature the tissue of the central nervous system (i.e., scramble your brain). The human body does not have an adequate warning system since nerve endings sensitive to heat are somewhat sparse. Thus, while the dangers may be overstated, it doesn't make sense to take chances.

What is wrong with radiant heat???

(From Barry Collins (bcollins@mindspring.com).)

You did the right thing to discourage people from breaching the integrity of a microwave oven, because there are so many factors involved that one has to assume personal (or property) injury (or damage) may result from such actions.

I personally don't feel uncomfortable with what the person was doing, provided they had taken reasonable precautions (too numerous to list). Power does fall off with the square of the distance and microwaves, barring any reflective surface, are very directional by nature. Just don't stand in front of the source. (I met one of the Japanese engineers who had unintentionally placed his head in a test oven that was working. He reported warmth, but no lasting damage, aside from the resulting joke.) Field density and exposure time is a large factor. One tends to remove one's hand when one senses heat. I think the story goes that this was how the heating affect was originally discovered.

The number one precaution I've always held near and dear to me is to protect one's eyes. The Narda manual has multiple warning in it about this. The aqueous membranes of the eyes are perfect absorption material for stray microwaves. This can happen much faster than with fleshy parts of the body and don't heal anywhere near the way a flesh injury does. It is this that you might want to point out in your FAQ's.

Short course on Amana

(From: Charles Godard (cgodard@iamerica.net).)

Everything depends on "Air Flow". If the stirrer does not turn, you will always get a "Hot! spot" on the left bottom of the door. In addition the stirrer bearing will sometimes arc and may melt at the spots where it arcs.

If your blower is running up to speed, remove the cover and replace the foam gasket material. This forces air over the stirrer when the cover is replaced. If stirrer still does not turn, remove the grease shield and check the stirrer for burns that are causing it to stick. If this is ok or you correct it and stirrer still does not turn, then replace the grease shield with a later model that looks almost the same as the original, but has one small modification which you will see when you compare the two.

Never let one go out of the shop unless the stirrer is turning. It will soon be back unless all they do is heat coffee. Next time it may be a cavity or magnetron overload that has opened due to the stirrer not turning.

It's good work on a quality product. I wish I had a hundred restaurant customers using them. The older Amana's power stays near 1500 watts forever. Retail customers are junking them because of $100 - to $125 repair bills. What a waste!

Computer system near microwave oven?

> "Can placing my microwave oven in close proximity to my computer and printer do any damage to either of them? The back of the oven would be right next to the printer and about 16 inches from the computer. I have gotten conflicting answers from the guy who rebuilt my computer and the guys at Radio Shack."

Did the kids at Radio Shack even understand the question??? :)

Your request is certainly a bit unusual. My feeling is that it should be fine. The problem would more likely be the magnetic field from the large transformer in the microwave oven causing interference on your monitor (wiggling, jiggling, shimmering, etc. due to its effect on the electron beams in the CRT). There should be no significant microwave leakage from the oven, especially the rear. Keep in mind that there is a computer of sorts inside the microwave controlling it!

However, you will need separate grounded electrical circuits for the microwave and computer equipment if you intend to ever use them at the same time.

Why Microwave-Safe Containers Get Destroyed

You probably have a cabinet full of so-called microwave-safe containers that look like they have been exposed to damage from a nuclear explosion. Why? It probably comes down to unequal heating of the contents or heating continuing long past the point where boiling takes place. I would assume that putting a microwave-safe container in an oven with a cup of water in a separate container wouldn't result in any damage to the microwave-safe container. But if the contents of the microwave-safe container are being heated, then some parts will get much hotter than others resulting in local melting and other damage. I doubt it is the microwave radiation itself doing anything to the material of the container directly and complaining to the oven manufacturer isn't likely to be very satisfying. :)

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Service Information

Advanced troubleshooting

If the solutions to your problems have not been covered in this document, you still have some options other than surrendering your microwave to the local service center or the dumpster.

Unlike most other types of consumer electronic equipment, a service manual is rarely required. A sufficiently detailed schematic is nearly always pasted to the inside of the cover and includes all power components, interlocks, fuses, protectors, and wiring. This is entirely sufficient to deal with any problems in the microwave generator. No adjustments or alignment should even be required so detailed procedures for these are not needed.

However, when tackling electronic faults in the controller, a service manual with schematics will prove essential. Whether these are available depends on the manufacturer. For legal reasons, some manufacturers are reluctant to sell service information or replacement parts for microwave ovens. They are concerned with litigation should an unqualified person be injured or killed.

Suggested Reference

I know of at least one book dealing specifically with microwave oven repair. It is very complete and includes many actual repair case histories. There is a good chance that your specific problem is covered.

1. Microwave Oven Repair, 2nd Edition
   Homer L. Davidson
   TAB Books, a division of McGraw Hill, Inc., 1991
   Blue Ridge Summit, PA 17294-0850
   ISBN 0-8306-6457-2 (hard), ISBN 0-8306-3457-6 (pbk.)

This may be available at your public library (621.83 or 683.83 if your library is numbered that way) or from a technical bookstore.

Cost of repair parts

Assuming you have located one or more bad components, the question is whether an oven that is a few years old is worth fixing. Typical parts cost for generic replacements:

- HV diode: $2-5 (except for the bolt-on variety which can range up to $50. It should be possible to replace these with the $2 variety with wire leads);

- Power fuse: $.40.

- HV Capacitor: $10-20.

- Magnetron: $30-100. Common generic replacements are $30-40.

- Overtemperature thermostat (thermal protector): $4.50.

- Interlock Switch: $2.50.

- Triac: $12.00 (unless original replacement in which case you will need to take out a mortgage - try the generic variety).

Parts suppliers like MCM Electronics can provide these components to fit the vast majority of microwave ovens.

Touchpads and controller parts like the microprocessor chip are usually only available from the manufacturer of the oven. Prices are high - a touchpad may cost $30 or more.

Sensors and other manufacturer specific parts will be expensive.

While the HV transformers are fairly standard, they are not readily available from the common replacement parts sources. However, they do not fail that often, either.

Here is one place that seems to stock some: AMI Parts, Eagle Grove, IA. Voice phone: 1-800-522-1264. However, they won't be cheap - expect to pay $50 or more!!! In addition, MCM Electronics now lists at least one Goldstar model replacement.

With the prices of microwave ovens dropping almost as fast as PCs, a few year old oven may not be worth fixing if the problem is a bad magnetron or touchpad. However, except for a slight decrease in power output as the oven is used over the years and the magnetron ages, there is little to go bad or deteriorate. Therefore, you can expect a repaired oven to behave just about like new.

Interchangeability of components

The question may arise: If I cannot obtain an exact replacement or if I have another microwave oven carcass gathering dust, can I substitute a part that is not a precise match? Sometimes, this is simply desired to confirm a diagnosis and avoid the risk of ordering an expensive replacement and/or having to wait until it arrives.

For safety related items, the answer is generally NO - an exact replacement part is needed to maintain the specifications within acceptable limits with respect to line isolation, radiation emission, and to minimize fire hazards. For microwave ovens such parts include the power fuses, interlock switches, and anything else that could potentially lead to microwave radiation leakage - like a magnetron which did not fit the waveguide properly.

Fortunately, while an exact match may be required, it doesn't have to be from the original manufacturer - most parts are interchangeable. Thus the organs from that carcass may be able to provide renewed vitality to your ailing microwave.

Here are some guidelines:

1. Fuses - exact same current rating and at least equal voltage rating. This will probably be a ceramic 1-1/4" x 1/4" 15 or 20 A 250 V fast blow type. For the repair, use an exact replacement. For testing only, a similar type may be used.

2. Thermal protectors - same temperature and maximum current rating. You must be able to mount it securely and flush against the same surface as the old one.

3. Interlock switches - must have the same terminal configuration and at least equal current rating. Of course, a secure fit is very important as well for it to perform its safety function. Many of these are interchangeable.

4. HV capacitor - similar (within 5%) and at least equal working voltage. Note that the working voltage rating of these capacitors is not consistent with the way capacitors in other electronic equipment are specified and is usually the RMS voltage of the AC input from the HV transformer. There- fore, it is not possible to substitute something from your junkbox unless it is from a microwave oven. In addition, this is one situation where

higher capacity (uF) is not better. The power output is related to capacitance. Thus, the value should be matched fairly closely or else other parts may be overloaded. However, a smaller one can be used for testing.

5. HV diode - most of these have similar electrical ratings so a substitution is possible if you can make it fit physically. This would be particularly desirable where your oven has one of those chassis mount $50 dollar varieties - it may be acceptable to use a $2.75 generic replacement.

6. Relays and triacs - substitutes will generally work as long as their specifications meet or exceed those of the original. Creative mounting may be required.

7. Magnetrons - a large number of microwave ovens use the same basic type but the mounting arrangement - holes vs. studs, orientation of the cooling fins, etc., differ. You can safely substitute a not exact match for testing purposes IF you can make it fit the waveguide securely without gaps. However, if the cooling fins end up being on the wrong side, it will heat up very quickly - 50% of the input power goes to heat - and will not be suitable as a permanent replacement.

8. HV transformer - same (within 5%) voltage and at least equal current rating. Mounting should not be a problem but don't just leave it loose - you could end up with a disaster.

9. Fans and motors - speed/power and direction must match and mounting must be possible. Speed isn't so critical for a turntable but for a magnetron cooling fan, inadequate air flow will result in overheating and shutdown or failure. Common shaded pole type motors may be interchangeable with other appliances or if a mounting arrangement can be cobbled together.

10. Mica waveguide cover - cut to match.

11. Turntable and mode mixer components - if they fit, use them.

12. Light bulb - similar ratings and base.

13. Temperature sensors, thermistors, etc. - depends on the particular model.

14. Mechanical timers - compatible switching and mounting arrangement.

15. Cordsets - must be 3 wire heavy duty grounded type. Make sure the replacement has at least as high a current rating as the original. Observe the color code!

16. Controller and touchpad - small parts like resistors, diodes, capacitors, and so forth can often be substituted. Forget about the controller ICs or display. The touchpad is likely to be custom both electrically and physically as well unless you have a similar model microwave to cannibalize.

Can I substitute a slightly different HV capacitor for a blown one?

It is not always possible or convenient to obtain an exact replacement high voltage capacitor. What will the effects be of using one that is a slightly different value?

First, the voltage rating must be at least equat to that of the original. It can be higher but never never lower or you will probably be replacing it again in the very near future.

Now for the uF rating:

Unlike a conventional power supply filter capacitor, the capacitor in a microwave is in a voltage doubler and effectively in series with the load (magnetron). Therefore, its value **does** have an impact on output power. A larger capacitor will slightly increase the output power - as well as heat dissipation in the magnetron. Too small a capacitor and the doubler will not produce full output.

As an example, the impedance of a 1 uF capacitor at 60 Hz is about 2.5 K ohms. The cap is in effect in series with the magnetron. A 1 kW magnetron running on just over 3 kV RMS is about 10 K ohms. These are really really rough calculations.

Thus the power difference is not a straight percent for percent change - I estimate that it is about a 1:4 change - increase the capacitor's uF rating by 10 percent and the power and magnetron heat dissipation will go up by 2.5% (assuming the relationship is linear right around the nominal value). I have not confirmed this, however.

Therefore, I would say that using a capacitor with up to a 10-15% difference (either way) in uF rating is probably acceptable but a closer match is better.

Obtaining replacement parts for microwave ovens

For general electronic components like resistors and capacitors, most electronics distributors will have a sufficient variety at reasonable cost. Even Radio Shack can be considered in a pinch.

However, places like Digikey, Allied, and Newark do not have the specialized parts like magnetrons, HV capacitors and diodes, interlock switches, thermal protectors, etc., needed for microwave oven repair.

Your local appliance distributor or repair parts outlet may be able to obtain an exact replacement or something that is an ecceptable substitute. However, the cost will be higher than for generic parts from the places listed below if they carry what you need.

Going direct to the manufacturer is a possibility but expect to pay more than might be charged for generic replacement parts by an independent company. Also, some places like Sears, may refuse to sell you anything microwave oven related due to safety concerns - unless they are convinced you are a certified repair technician, whatever that might mean. Their prices are inflated as well.

Another alternative is to determine who actually made your oven. This is obvious with name brands like Panasonic and Sharp. However, Sears doesn't manufacture their own appliances, but an inspection inside may reveal the actual manufacturer. Then, go direct to the horse's mouth. Many companies will be happy to sell service parts but availability may be a problem on older ovens. I had to give up on a Sharp microwave/convection oven that was 15 years old because specialized replacement parts were no longer available from Sharp.

Note: I have heard that in other parts of the world, there may be restrictions on who can actually purchase microwave oven parts other than things like light bulbs, turntables, and standard door switches. In the U.S., certain companies (like Sears) may set their own rules - you have to convince them that you have at least the intelligence of an average carrot and possibly sign a 100+ page document written by too many lawyers. :)

Sources for replacement microwave oven parts

See the document: Major Service Parts Suppliers for some companies that I have used in the past and others that have been recommended. They may include microwave oven parts in their catalog but don't specialize in them.

The following suppliers have web sites with on-line catalogs and list a very extensive selection of microwave oven parts. There is a chance that they may not want to sell to the general public. I suppose this may be due to several factors including the potential liability issues, complaints/attempts to return parts when a repair doesn't work, and the small quantities involved. However, it is definitely worth checking as the public web sites implie a desire to deal with the entire Internet community.

- Global/MPI/All Appliance Parts
  Phone: 1-800-325-8488
  Web: http://www.allapplianceparts.com/

  Their web site includes a very extensive selection of microwave oven parts. For example, nearly 50 different magnetrons are listed along with little photos of each!

- AMI (Appliance Maintenance International)
  U.S. Phone: 1-800-522-1264
  U.S. Fax: 1-800-442-3601
  Int. Phone: 1-515-448-5311
  Int. Fax: 1-515-448-3601
  Email: ami@amiparts.com
  Web: http://www.amiparts.com/

  Distributor of consumer and commercial microwave oven parts. Extensive on-line catalog of microwave oven parts with on-line parts lookup and ordering.

Here is another one:

- Electronix, Corporation
  Web: http://www.electronix.com/

  Magnetrons, interlock switches, lamps, glass trays, diodes, thermal fuses, couplers, latches, rivets, stirrers, fans, waveguides, more... Also: Techweb, $6/month.

The following company will definitely not sell you anything but should be able to provide the name of a local appliance parts distributor.

- QB Products
  Phone: 1-800-323-6856

  Master distributor, they sell only to appliance and electronics parts distributors like Marcone, Tritronics, Johnstone, etc. You can call them to find the nearest distributor.)

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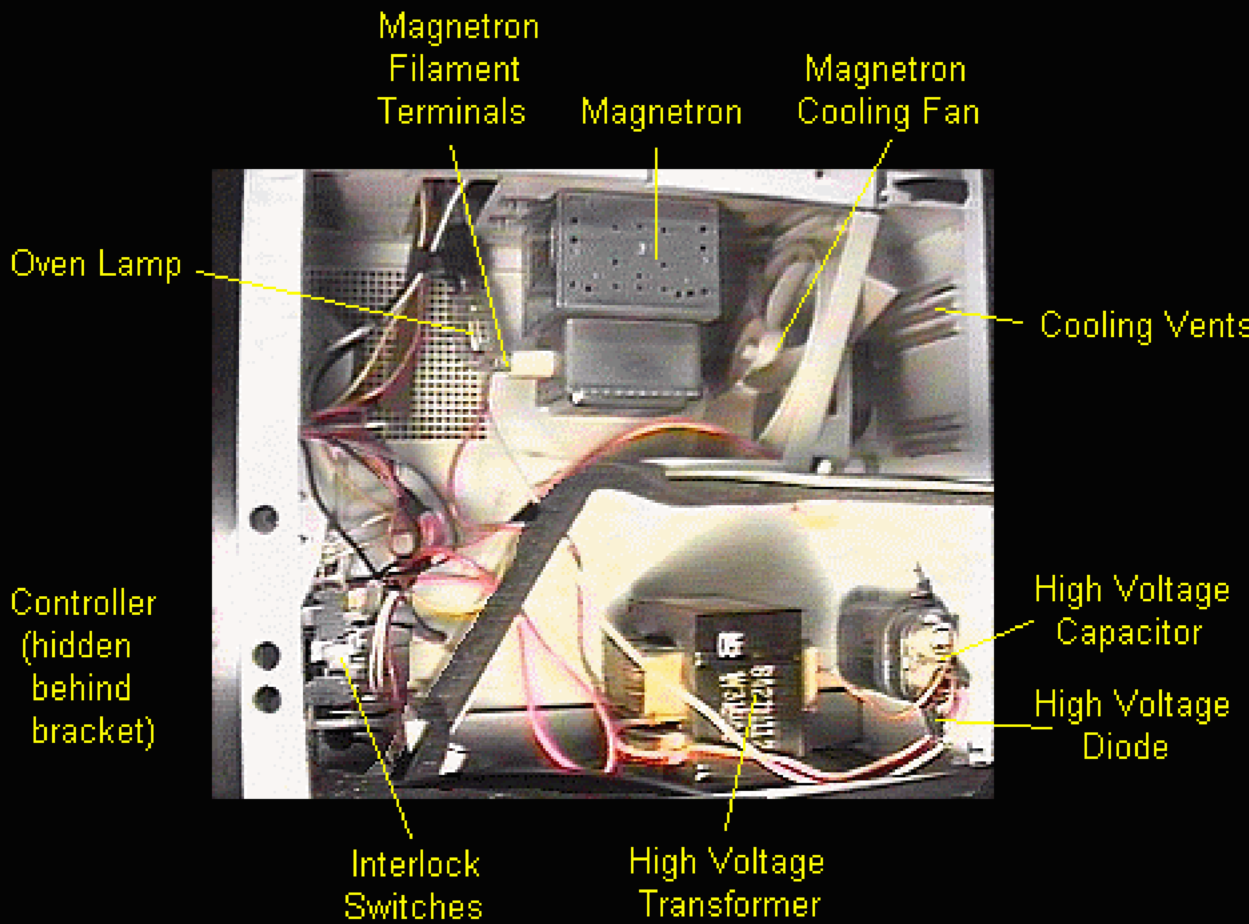
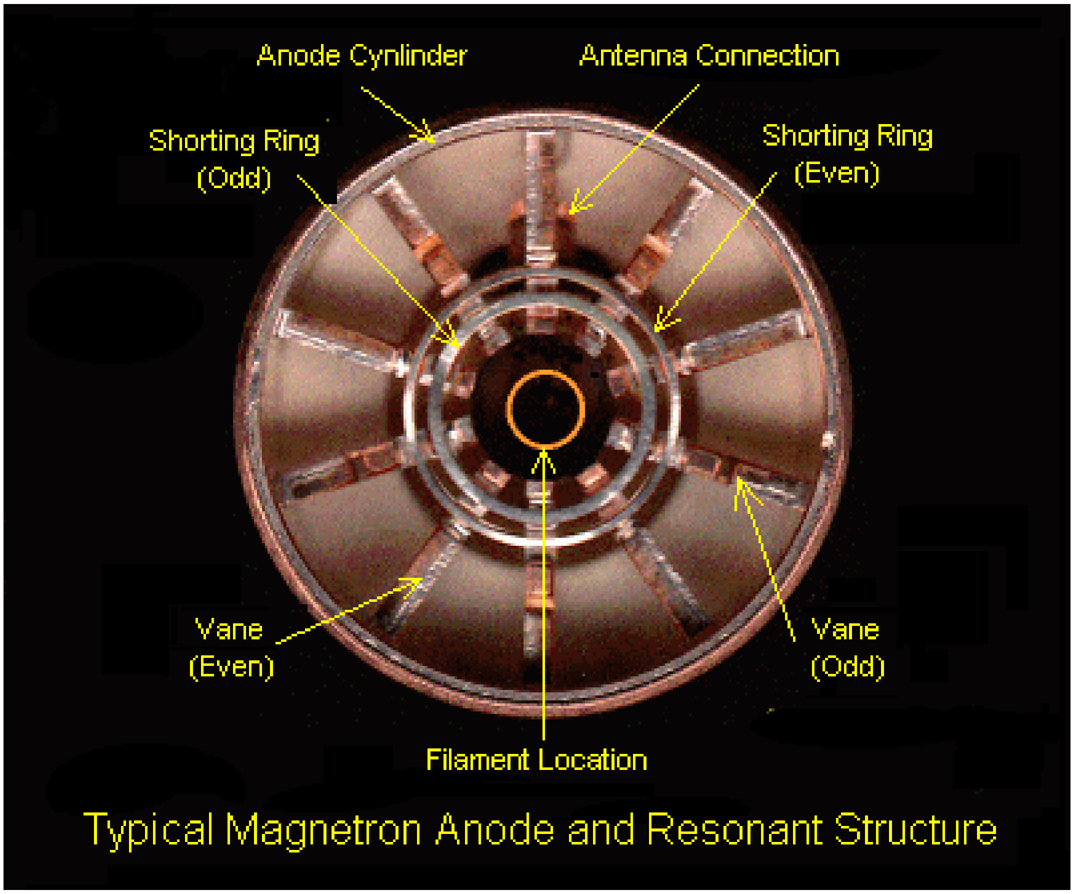
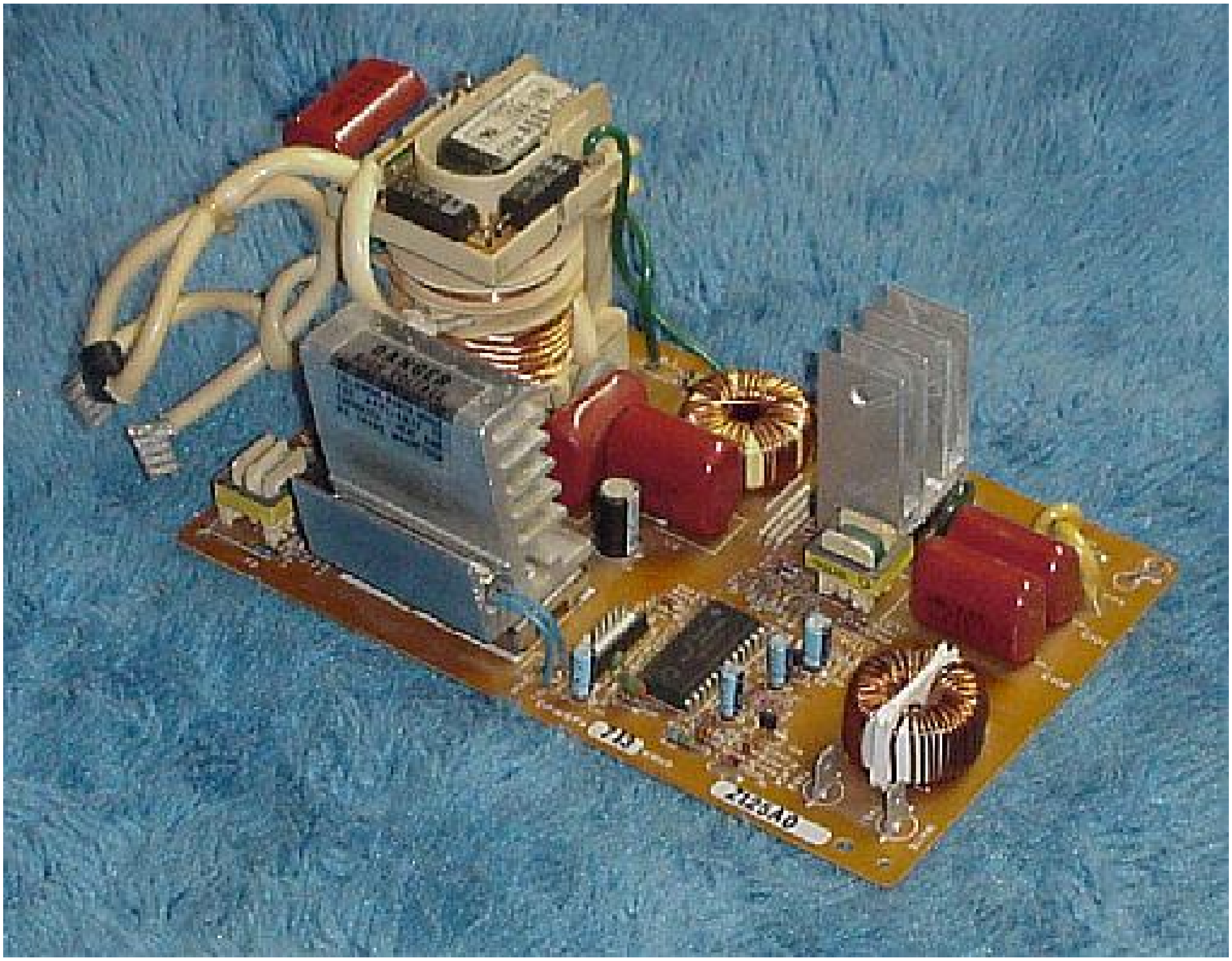
-- end V3.42 --



Typical Microwave Oven Electronics Bay

(Photo Courtesy of John Gallawa (microtech@gallawa.com).)


Anode Cylinder
Antenna Connection
Shorting Ring
(Odd)
Shorting Ring
(Even)
Vane
(Even)
Vane
(Odd)
Filament Location
Typical Magnetron Anode and Resonant Structure



Major Service Parts Suppliers

Version 1.05

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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- Back to Major Service Parts Suppliers Table of Contents.

Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Some of the contact information and summary of products may be out of date as I don't place orders that often. In general, the range of offerings increases with time so it is best to check with the company's Web site and/or request a catalog. However, I won't be responsible if you miss an opportunity to buy your favorite horizontal output transistor because the listing below didn't include HOTs as a line item! Corrections are welcome.

- Back to Major Service Parts Suppliers Table of Contents.

Introduction

Scope of This Document

Note: This document replaces the individual sections in each of major repair guides.

The following sections provide contact info and/or links to companies specializing in service parts (as opposed to general electronics distributors).

For general electronic components like resistors and capacitors, most electronics distributors will have a sufficient variety at reasonable cost. Even Radio Shack can be considered in a pinch.

However, for modern electronic equipment repairs, places like Digikey, Allied, and Newark do not have the a variety of Japanese semiconductors like ICs and transistors or any components like flyback transformers or degauss Posistors.

The companies below are good sources for consumer electronics replacement parts, especially for VCRs, TVs, and other audio and video equipment. For equipment specific parts suppliers, see the individual repair guides.

I have used those in the first section personally. In general, I have been quite satisfied with their quality and reliability. I do not have personal experience with the others but in general, they get listed here as a result of a recommendations from satisfied customers via email or on the USENET newsgroup sci.electronics.repair.

- Back to Major Service Parts Suppliers Table of Contents.

Service Parts Suppliers I (Sam) Have Used

- MCM Electronics
  U.S. Voice: 1-800-543-4330
  U.S. Fax: 1-513-434-6959
  Web: http://www.mcmelectronics.com/

  VCR parts, Japanese semiconductors, tools, test equipment, audio, consumer electronics including microwave oven parts and electric range elements, etc.

- Dalbani
  U.S. Voice: 1-800-325-2264
  Int. Voice: 1-305-716-0947
  U.S. Fax: 1-305-594-6588
  Int. Fax: 1-305-716-9719
  Web: http://www.dalbani.com/

  Excellent Japanese semiconductor source, VCR parts, other consumer electronics, car stereo, CATV).

- Premium Parts
  U.S. Voice: 1-800-558-9572
  U.S. Fax: 1-800-887-2727

Very complete VCR parts, some tools, adapter cables, other replacement parts.

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Other Service Parts Suppliers

These companies have been recommended but I do not have personal experience with them. The following are good sources for consumer electronics replacement parts, especially for VCRs, TVs, and other audio and video equipment. Catalogs are a must. (The first 4 I have used and have been satisfied with service and selection. The others have been recommended by others.)

- Global Micro Parts, 1-800-325-8488, http://www.allapplianceparts.com/.

  They specialize in microwave oven parts, but also carry some other major appliance parts.

- Cititronix/Panson, U.S. Phone: 1-800-846-2484, U.S. Fax: 1-800-726-0142.

  JC Penney, JVC, Kenwood, Maganvox, Service parts for: Fisher, GE, Hitachi, Panasonic, Philco, Philips, Quasar, RCA, Sanyo, Sharp, Sony, Sylvania, Technics, Zenith.

- Electro Dynamics, Inc., 7 Oser Avenue, Hauppauge, NY 11788, Phone: 1-631-951-4922 They also have a sister company that deals with mostly computer parts, "Computer Components" (CCI - I believe) at the same address, phone: 1-631-951-4749. Catalogs are available from both.

- Electronic Parts Center, Phone: 1-800-501-9888, Fax: 1-626-285-6873, Web: http://home.earthlink.net/~epcs/.

  Includes many popular CD pickups at reasonable prices.

- Electronix, 313 W. Main St., Fairborn, OH 45324-5036. Phone: 937-878-1828, Web: http://www.electronix.com/.

- Electronic Warehouse Corp., 1-800-221-0424.

- Fox International, 1-800-321-6993.

- Good Vibes, 1807 S. Neil St., Champaign, IL, Phone: 1-217-351-0909; Rantoul, IL, Phone: 1-217-892-5622; and Bloomington, IL, Phone: 1-309-664-6909. Web: http://www.gvibes.com/partsforsale.html.

  Service parts inventory includes hard-to-find items: Teac reel-to-reel replacement heads, B/W speaker drivers, Sony custom IC chips, etc. They have a wide range of new old stock parts many of which are no longer available from the manufacturer.

- MAT Electronics: 400 Pike Road, Huntingdon Valley, PA 19006-1610, Phone: 1-800-628-1118.

- Parts Express, 340 E. First St, Dayton, OH 45429, Phone: 1-800-338-0531, Fax: 1-513-222-4644, Web: http://www.parts-express.com/.

- RNJ Electronics: 805 Albany Ave., P.O. Box 528, Lindenhurst, New York 11757, Phone: 1-800-645-5833.

- Sears Parts. Replacement parts and accessories for Sears and some other appliances, electronics, and garden and power tools.

- Tritronics: 1306 Continental Drive, Abingdon, MD 21009-2334. Phone: 1-800-638-3328.

Also see the extensive mail order lists at:

- Sam's Neat, Nifty, and Handy Bookmarks under "Electronics Service Parts Sources".
- List of Mail Order Electronics Companies though this is somewhat dated.
- AF4K's List of Parts Suppliers.

Also see the document: "Troubleshooting of Consumer Electronic Equipment" for additional parts sources as well as the equipment specific supplier lists at the end of each Repair Guide. The chapter: "Laser and Parts Sources" of "Sam's Laser FAQ" also includes extensive lists of new and surplus electronics supplies that may be useful.

- Back to Major Service Parts Suppliers Table of Contents.

-- end V1.05 --

Sam's Neat, Nifty, and Handy Bookmarks

Version 4.20f (05-May-04)

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

Introduction

This is a snapshot of the bulk of the primary bookmark file I use with Netscape Communicator 4.8. I strive to keep it up to date but regrettably, this is about as possible as keeping up to date with all the free magazines that come my way. With so many Web sites coming and going and changing it is inevitable that some URLs will result in "404 missing" errors. I am resigned to this for individuals on mom-and-pop ISPs. However, there really is no excuse when large companies change their Web site organization and don't provide an easy way to locate the replacement page for those that have disappeared. Some do but many don't seem to care if you find them or not. Even the U.S. Postal Service will forward your mail for several months. Out of courtesy, Web sites should do this with Web site addresses as well!

The bookmarks, below, are divided into major categories and sometimes further sub-divided but not too deeply. I apologize for the organization (or relative lack thereof). Maybe someday I will reformat this stuff using fancy HTML tables and add meaningful descriptions of each entry. Then again, maybe pigs will fly. :-) This version is pretty clean but I don't guarantee that for the subsequent ones - I 'processed' it mostly by hand (well, OK, I did use a computer!) with some help from GNU EMACS. What is really needed is a SED or PERL script (or something) to do that automatically. I promise get to that first thing after the pigs start flying. :)

Table of Contents

    - Laser amd Optics Information, Tutorials. Software
    - Laser Discussion Groups and Technical Forums
    - Laser Equipment and Parts - New, surplus, mail order
    - Laser Equipment Sales, Rentals, and Service
    - Laser and Optics Sites, Manufacturers, and Suppliers
        - A-F
        - G-L
        - M-P
        - Q-Z
    - Laser and Optics Related Organizations & Publications
    - Laser and Optics On-Line Auctions
    - Light Show Sites and Manufacturers
    - Barcode Scanners
    - Color/Perception/Vision Sites/Information/Links
    - Fiber Lasers
    - Hobbyist/Personal Laser and Optics Sites
    - Holography Sites
    - Miscellaneous Laser and Optics Sites
- Appliances Sites/Information
- Audio Sites
- CD/DVD/LD/MD/Optical Disc Technology Sites
- PC Repair/Upgrade/Maintenance and Datacomm
    - Tech Support Sites
    - Processor Sites
- Printer/Photocopier/Fax Sites/Information
- Small Engines/Equipment Sites/Information
- SMPS Information
- Strobe/Camera Sites/Information
- Television Sites/Information
- VCR Sites/Information/Photos
- Game/Arcade Sites/Information
- Miscellaneous Repair/Info
- Monitor Sites/Information
- Microwave Oven Sites/Information
- Manuals/Schematics
- Parts/Commercial Sites
    - Electronics Distributors
    - Electronics Service Parts Sources
    - Surplus Mail Order
    - Miscellaneous Parts, Kits
- Education and Tutorials

- FCC Information
- Patent Information
- Publishers/Publications
- Science Sites/Information
- Weird Stuff
- Mechanical Adders and Calculators

Sam's Bookmark Links

Sci.Electronics FAQ Sites

Silicon Sam's Technology Resource: (USA-MA)
Sci.Electronics.Repair FAQ (USA-SC,RepairFAQ.org)
Sci.Electronics.Repair FAQ Main ToC (USA-SC,RepairFAQ.org)
Sci.Electronics.Repair FAQ Mirror (USA-PA-E1,SG)
Sci.Electronics.Repair FAQ Mirror (USA-PA-E2,SG)
Sci.Electronics.Repair FAQ Mirror (USA-PA-W,GS)
Sci.Electronics.Repair FAQ Mirror (USA-CA,EIO)
Sci.Electronics.Repair FAQ Mirror (USA-FL,CH)
Sci.Electronics.Repair FAQ Mirror (USA-IL,DG)
Sci.Electronics.Repair FAQ Mirror (USA-NH,TQ)
Sci.Electronics.Repair FAQ Mirror (USA-NY,JA)
Sci.Electronics.Repair FAQ Mirror (DE-1, Germany. DB)
Sci.Electronics.Repair FAQ Mirror (CA-1, Canada)
Sci.Electronics.Repair FAQ (Partial French Translation, France)
Sci.Electronics.Repair FAQ (Italian Translation, Canada)
Sci.Electronics.Repair FAQ (Italian Translation, Italy)
Sci.Electronics.Repair FAQ Snapshots (Circuit Cookbook Archive)
Sci.Electronics.Repair FAQ Snapshots (Circuit Cookbook Archive Mirror)

Major Resources

Google Groups USENET Advanced Search
Google Search Engine
AltaVista: Main Page - Web and Usenet search
AltaVista: Universal Translator
Fight Spam on the Internet!

CircuiTree: The World's Best Source of Information For The Printed Circuit Board Industry
Consumer Product Ssafety Commision Home Page
Consumer Information Center Main Page
Counterexploitation [cexx.org]
Zeal.com - Search. Rate. Review. Discover.
WebEE - The Electrical Engineering Homepage
W3C HTML Validation Service
UXN Spam Combat
TinyURL.com - where tiny is better!
SpamCop - File a spam report
Spam FAQ or "Figuring out the site the Spam came from".
Network Solutions
NetNames USA Home Page
NetNames: Internet Domain Name Registry
CircuitOnline - Links for the Design Engineer
Internet Electronics Manufacturers Resources
Engineering Sources: Citations for Engineering, Science and Technology Information
The Engineers' Club -- Online Service</HEAD>
ETSI - Standardizing Telecommunications Products and Services
EEVL: Edinburgh Engineering Virtual Library | Home Page
EEM On-Line
EEEL - Electronics and Electrical Engineering Laboratory
The Electronic Cookbook Archive
Electronics On Ramp - Electronics FAQ's
Welcome to ExpertCentral
FilePile - Over 1,000,000 FREE Files!
Filez - Search 75M files and 1000s of servers for freeware, shareware, & commercial software
GlobalSpec: Seach for engineering products
InfoSpace - Internet Directory
Inquiry.com - Home Page
Inquiry.com -- Site Overview
International Mfg. Parts & Service Directory.
The Internet Archive Wayback Machine - Web archives
Martindale's 'The Reference Desk: Calculators On-Line'
MetaCrawler
NESDA - Network of Professional Servicers
Oak VSL: Quick Search Form
Oak VSL: Front Desk (oak.oakland.edu)
OAK Software Repository

Publicly Accessible Mailing Lists
Reference.COM - Newsgroup search
sci FAQs By Newsgroup
Switchboard - People and Business Search
Tile.net - Mailing Lists
List of USENET FAQs
Univ. of Wash. Electrical Engineering Circuits Archive
Ultrasurf - Super list of search engines

General Tech Tips/FAQs Sites

AA4DF's Electronics Repair (VCR, TV, Audio, Ham Radio)
Carlsen Electronics - Includes tips on some specific equipment
CSC - Semiconductor Cross Reference Libaray and Electronic Repair Tips
The Unusual Diode FAQ
Electronics On Ramp Pinout & Component ID
ADCC Tech Tips of the Month
ADCC Technical Systems, Inc. Home Page
AnaTek Corp. - FAQ for Electronic Repair Professionals (Search Form)
AnaTek Corp. - Monitor & Terminal Repair Databases
AnaTek Corp.- VCR, TV, Monitor Tech Tips, etc.
Bucks County Tech School AV Technology - Tech-tips
eHow - How-to info from autos to travel
Electrical and Electronic Message Boards (Industry Community)
Electronix Corp. - Repair World - Subscription Tech Tips
Electronix Corp. - VCR, TV, Repair, Parts, Service
Electronic Repair Links (Quality Tuner Service)
Electronics Repair (perm.ru) - info, links, schematics, more
Electronic Repair Tips - elmswood.guernsey.net
Electronicsrepair.net - Electronics repair, service manual and schematics diagram.
Electronics Search FAQ - cera2.com
Electronics Search FAQ - eetoolbox.com
Electronics Search FAQ - eg3.com
Electronics Search FAQ - Pointer
Electronic Servicing Links
Electronics Tech Info, Links, Sony KV-F29 (~nu-lifetv)
Federal Technology Alert - Cover Page
Randy Fromm - Technical Library
Joe's Tech Support - TVs, VCRs, many from S.E.R FAQ
KDTV (Indiana Wholesale Electronics) - Manuals, tech forums, parts database, etc.
I. G. Electronics - CD, LD, Audio, some info

- The Electronic Info Center - TV, VCR tech-tips
- Diverse Devices (UK) - Service manuals, more.
- ALL Technical Tips - Several repair bulletin boards.
- Tandy - Retail Services, Support Library
- Home Theater Hot Links
- Dan Fraser's Schematics
- Manta Electronics - TV, VCR, Audio care. Help via email
- Monitor Repair Info-Center - Some info, per repair charge.
- Physics FAQ
- Quick Service - ESR meter, tech tips, service diskettes
- Sashkin Soft - Downloadable schematics (Russia)
- Service Engineers Forum (UK) - Some tech-tips for TVs, VCRs, other A/V equipment
- Skye's Audio/Video/Computer Tech Tips/Forums
- Sound Specialists - Technician's lament
- TEKINFO - Repair FAQs and tech-tips for nearly everything
- Tony's Freeware Tech-Tips Site
- Troubleshooters.Com - Links to all sorts of repair info
- The TV and VCR Online Fault Finder Site Map
- TV & VCR Symptoms - Links to S.E.R FAQ and Dejanews search strings
- Sprague's Technical Library - Tape: 8 mm, DAT
- WESTEC Electronics (Links, Tech Tips)

Don Klipstein's (and Other) Lighting Technology FAQs

- Don's Light, Lamp and Strobe Site! (Primary)
- Don's Lighting Info Center!
- Don's Light, Lamp and Strobe Site! (Mirror)
- Don's Laser Page - suppliers, miscellaneous laser info
- Don's Xenon Flash and Strobe Page
- Discharge Lamps
- Inverters to power fluorescent lamps from low voltage DC
- Fluorescent Lamps, Ballasts, and Fixtures
- Various High Voltage Generating Circuits!
- Sam's Laser FAQ

Other Lighting Resources

- Carbon Arc Lamps (Charles Brush)
- D.I.Y. Electronic Control Gear - Reusing CFL ballasts
- IESNA - lluminating Engineering Society of North

International Light - Light Measurement, Links
The Internet's Neon Shop
KPCL Lighting Home Page - Information, Links
International Rectifier - Lighting products and applications
JKL Components Corporation - UV, CCFL, FL, lamps and accessories
Just another light bulb nut's LED page
The LED FAQ Pages (Optoeng)
The LED Museum - For the love of LEDs
Ledalite - Articles on various topics related to lighting
The Lighting Resource - The Microwave Sulfur Lamp
Lighting Resource, The Only Source for Illumination You'll Ever Need
Lightning Strikes! - BIG lsmps for special effects
Links on Lighting: The Site for Optical and Illumination Engineering
LRC Research Highlights 1997
National Cathode Corp. - Cold cathode lighting
Neon & Lighting Channel - Neon sign technolog
OSRAM Sylvania Did You Know - Lighting info.
Pure Food: Solar 1000 by Fusion Lighting
Relight News about lighting
The Specialty Bulb Co. Inc.'s Home Page
Sulfur lamp info (Mike Feldman)
The Sulfur Lamp: Home Page
Tomi Engdahl's Lighting Information
The WA Academy's Lighting Links - Sponsored by The Kilowatt Co

Electronics Info, Links, Schematics

Amateur Radio Sites

Amateur Radio.FAQ
Amateur Radio WWW bookmark file (newsvhf)
AmSoft -The World of Ham Radio CD-ROM, Links, etc.
ARRL - American Radio Relay League
B.A.D.A.R.C. Homepage
Bry's Ham Files Page
Bill's Ham Radio WWW Server (Bill, NJ7P)
Bill's Ham Radio WWW Server (Bill, NJ7P)
G3SEK's Amateur Radio Technical Notebook
G4FGQ - Free radio/EE computer programs
GOIER - Ham radio schematics, links, etc.

- HamQuest On-line Auction
- Ham Radio Resources (AF4K/G3XLQ)
- Harry's Homebrew Homepage
- KW Amateur Radio Club Inc.
- Harry's Homebrew Homepage
- Houston Amateur Television Society
- QRP HomeBuilder HomePage
- QSL.Net
- Raymond Sarrio Co. - Full serivce amateur radio site
- Dave Riley - AA1A
- WA2ISE's Home Page of Radios
- The World of Ham Radio's Missing Links

Automotive Electronics

- A Digital Distributorless Ignition System
- EFI332 Project - Engine Management System

CAD

- Calculating Coil Indctance (Harrry's Homebrew))
- The Circuits Portal - EDA programs, links, discussion, etc.
- DesignWorks Home Page
- SchematiCAD FAQ
- Simbología Electrónica / Electronic Symbols
- Wire and Cable Related CAD Programs (Mogami)

Electronically Known (from publications)

- Don Lancaster's GURU'S LAIR home page
- Bob Pease - What's All This Homepage Stuff, Anyhow?

Electronics/Technology Links

- Circuit Central - Circuits, basics, links, more
- Circuits Central - Basics, links, magazines, vendors, etc. (Dark Portal)
- CADI-Search The Radio and Electronic searching engine
- DANA'S Index of Electronic Manufacturers on the Web
- DonTronics - PIC and other electronics links.
- EngResource Electronic Design Engineers Reference

Electronics Links - Computer Technology Lab (~nopporn)
Electronics Links - DIY Electronics
Electronics Links - EOTW Magazine (emags.com)
Electronics Links - Rudi Logghe (club.innet.be/~year2138
Electronics Links - Roy Schmaus (ee.ualberta.ca)
Electronics Info and Links (~jimpy/tronics.html)
Electronics Hotlinks (Mostly repair related, many dead links)
Electronics FAQs Links (ser.fm.uit.no)
Electronic/Ham Radio Link (aade.com)
Electronic Servicing Links
MotionNET.com - Engineering Resources Online
Parallax, Inc. -- Helpful Links
Rom-Rats Homepage - Lots of electronic links
Satcure Electronics Links
Science/Electronics Links
SGT's list of links to elecronics resources

General Electronics Web Pages

John Adams Internet Guide ot Electronics
Bob Alden's Web Page Links
Alex's Electronic Resource Library
Peter Anderson - Mostly BASIC Stamp and related projects
Anthony's RF and Microwave Engineering Sites
The Atari Vector Game Page
Black Crawling Systems - Utilities, electronics projects, etc.
Build Your Own Arcade Controls FAQ
Cathode Corner - home of the Scope Clock
Circuits Central - Basics, links, magazines, vendors, etc. (Dark Portal)
ECMA - Standardizing Information and Communication Systems
EIO Forum Index - Hyper Email discussion groups and more
Electro Tech - Plans, tutorials, schematics, more.
Electronic Gadgets (deanwhite)
Electronics For U - magazine, links, etc.
The Electronic's Page - Circuits, Links (~muldowne)
Electronics 2000 - Baisc info, links, classifieds, etc.
Electronics Hobby (Stephen M. Powell)
Electronics Index Page (Ivsn Ruth)
Electronics-Related Links (Eagel Trader)
Tomi Engdahl - Electronics Info Links Page
John's New Electrical Engineering Page! (~jspatric)

- Russian Electronic - Info, schematics, etc.
- Iguana Labs - Microcontroller and electronic project page
- Mark's Page of Electrical Madness
- MachMat's analogica
- Mike's Electric Stuff
- Jim Lux's Website - High voltage, lightning, radio. nuclear, etc.
- Imagineering (Dave Johnson, P.E.) - Circuits, project ideas, neat stuff.
- Clayton Forresters cover page
- Basic Electronics Info (onestar.texas.net/~diana)
- Hobby Electronics Resources - Parts/search, misc.
- Electronics stuff (geocities.com/BourbonStreet/4589)
- Ray's Electtronics and Tutorial Page
- Science & Technology (G. Weaver)
- John Seney, WD1V, LeCroy Sales Engineer
- Short Circuit - Links, Circuits, WWWBB, Semis
- Steve's Workbench @ RadioShack - Front Page
- Gary Tait's Web Space - Index
- Paul Tayler's Electronics Homepage
- Technick.net - Hardware and software resources
- Telephone History and Information
- Tesla, Edison, etc. Power Electronics Articles (Ignore the Ads)
- Todo Electrónica: página principal (Spanish) - Info, schematics, more.
- Transistor Article (Bruce Carsten)
- Mr. Transistor: Home Page
- Video Animation Hardware
- Seattle Robotics Society
- Richard Steven Walz's WWW Home Page
- Wenzel Associates, Inc. Home Page
- Yahoo! Clubs electronicserviceclub

High Voltage Sites/Info

- Bert Pool - High voltage, Tesla coils, UV laser, etc.
- Brent's High Voltage Page
- Fast Pulse Developement Home Page (LLNL)
- R. E. Beverly III and Associates - HV and other links
- High Voltage Association
- High Voltage Diversions - HV caps, multipliers, misc.
- High Voltage Experimenter's Handbook (Jim Lux)
- High Voltage List Archive (umd.edu)

High Voltage Stuff (Blackburn)
HV, Jacobs Ladder, etc. (~wilyr1)
Jochen's High Voltage Page
Marx Generators (Jim Lux)
Pulse Power Switching Devices (wwl)
SCR coils stuff - solid state Tesla Coil
Tesla, Tesla Coils, Jacob's Ladder, High Voltage
Richie's Tesla Coil Web Page
Snock's High Voltage Page
Tesla Coil Ring
Tesla Coil Mailing List
Tesla Coils Safety Information - (pupman.com)
Tesla Technology Research

Schematics and Circuit Links

AEK Schematics - Simple audio circuits
Analog Innovations - Spice models, circuits
BOMARC Services - Reverse engineered schematics
Bowden's Hobby Circuits
The Circuit Archive - Vintage and antique equipment
Circuit Cookbook Archive (ualberta.ca)
Circuitos Corporation - Assorted schematics
CyberCircuit Home Page
DIBs CIRCATS - Circuits Catalog from DIBs Electronic Design
Eagan Technical Services, Inc. - Reverse engineered schematics, more.
EE Circuits Archive Home Page
Elec.de - Various schematics (German)
Electronic Archive (www.schematica.com)
Electronic Circuits (execulink.com)
Electronic Circuits for the Hobbyist (~antoon)
Electronics Info, circuits, links (~diana)
Electronics Links (Edgar R. Shen)
Electronics On Ramp Circuits and Schematics Page
The Electronic's Page - Schematics (~muldowne)
Electronic Projects (atrobe.edu.au/~djc/)
Electronic Projects (randylinscott)
Electronic Schematics on the Web
Electronic Schematics (pjohnson)
Tomi Engdali's ePanorma.net - Electronics info page
Tomi Engdahl - Neat Electronics, circuits, etc.

- FC's Electronic Circuits
- Dan Fraser's Electronic Schematics - Audio, Monitors, etc.
- Gamesx.com - A/V & Misc Pinouts
- Grant's Electronic Circuits diagrams,schematics, information, links
- Harri7673 - Schematics, Links
- JEM Electronics Downloads Page
- Laurier Gendron's Handy Dandy Little Circuits
- The LSB TechnoFun Web Page - Misc. Circuits
- Mark's Page of Electrical Madness
- MachMat's analogica tube schematics
- Paul Oh - Miscellaneous circuits
- The Radio Design Forum - Circuits, links, etc. (digitron)
- RadioLocman - Schematics links
- Schematics Links (pjohnson)
- Schematics on Demand (KJM@KJM.COM)
- Technick.net - Circuits, pinouts, links, more.
- Wenzel Associates, Inc. - Circuits
- XexorZ's Electronics Page

Test Equipment

- Dan's Home-Built O-Scope Page
- Diemen - Deflection System Simulators
- Diverse Devices (UK) - Test equipment (and other) manuals
- ESR Meter (Bob Parker - Dick Smith Electronics)
- ESR Meter Schematic and Info (Woods)
- ESR Testing (Stephen M. Powell)
- Flyback Tester (Kephart Inc.)
- Gootee Systems - Curve tracer, surplus electronics, antique radios, etc.
- GEKCO - Video test pattern generators
- HP Electronic Test Equipment Parts (Sphere)
- HP T&M Directory
- HP Test Equipment Parts Cross Reference (Sphere)
- Huntron, Inc. Personal Troubleshooting Workstation
- LOPT/FBT Tester (Bob Parker/Dick Smith Electronics)
- Manuals Plus -- Test Equipment Manuals
- Mark Kahrs - Electronics
- Monitortest.net - ESR Meter Page
- The Museum of Tektronix Scopes
- Oscillophone Schematic (LShaping)

Parrot Test Probe Home Page
Phil's Page of Vintage Radios and Electronic Test Equipment
Phil's Tek scope prices on eBay
Quantum Data - Video test equipment
Quick Service - ESR meter, tech tips, service diskettes
Sencore - TV, VCR, etc. Test Equipment
Skutch Electronics Product - Alarm and telephone test equipment
Simpson Electric Co. Homepage
SMS Systems - Used test equipment
Sphere's Used Electronic Test Equipment
Tektronix Resource Site - Reference, forum, classifieds, more
Test Equipment Auction - Wid Industries
TinyScope Page
Used Test and Semiconductor Production Equipment Dealers
VAAC - Flyback tester, CDROM flyback cross reference
ValueTronics International, Inc. - Test equipment
XYZs of Oscilloscopes: Introduction (Tektronix)

Vacuum Tube Stuff

AMPAGE -- Schematics
Antique Electronic Supply Online!
Blue Glow In Tubes
Duncan Amp's - Vacuum tube info, data, links, more.
Fathauer - Antique vacuum tube supplier and links
Frank's electron Tube Data sheets
GEO - the Guitar Effects Oriented Web Page
K4XL's Boat Anchor Manual Archive - Tube equipment manuals
MachMat's analogica tube information
Nostalgia Air - Vintage electronic equipment references
Pat's Tube Schematics
Triode Electronics - Home Page & World HQ
Triode Electronics - Tube Audio Links Page
Tube Amp FAQ 1/20/99 (Frames supported)
Tube Collectors Association
Tube Dude's Webpage of Vacuum Tube Lore!
Vacuum Tube Audio
Virtual Valve Museum

Electronic Components

Componentweb- (Multiple Search Engines)
Electronicsdir.com - Datasheets and electronic component sourcing
Electronic Color Codes (goodolejoe. JAVA)
Free Trade Zone - Component database
JEDEC Semiconductor Standards
PartMiner - Electronics component search program
Semiconductor Links (Tillman)
THE Semiconductor Resource Page

Component Manufacturers Lists.

BOIN´s Semiconductor Linkpage - Wafer, IC, electronics, chip information.
EEM On-Line: The Engineer's Search Engine for Electronic Components
EENet: Semiconductor Directory
Index of Electronic Manufacturers on the Web (netcom.com)
ELISNET - Links: Fugi, Fujitsu, Matsushita, NKK, Rolm, Sanyo, Sony
The Electronics Industry Inforum & Interactive Workplace HomePage
Electronic Components Suppliers (fruchart)
Semiconductor Manufacturers Links (Morten Qvigstad Olsen)
Semiconductor International - Semiconductor manufacturing resources
SuperSite.Net - Semicon. Vendors
A Survey : Semiconductor Manufacturer Directory
WebScope - Electronic Mfg. index

General Semoconductor Information and Datasheets Links

B & D Enterprises Schematics Search Page
Chip directory - Amsterdam
Chip directory - Australia
Chip directory - California
Chip directory - Massachusetts
Chip directory - Pennsylvania
ChipDocs - Datasheets for Electronic Components and Semiconductors
Databook Shelf - Semiconductors (cstron.nl)
Databook Shelf - Semiconductors (uiuc.edu)
Electronic Manufacturer's Databook Links
Electronic Component Datasheets
Electronic Component Database - tds-net.com ($70 - not on-line)
Global Semiconductor Datasheets Library
GlobalSpec.com - Searchable Engineering Catalogs on the Net

IC Master Online - Integrated Circuits
Info Quick - Electronic Component Information
QuestLink Homepage
QuestLink IC Cross Reference
Semiconductor datasheets on the Web - Root page
Semiconductor datasheets on the Web - Complete (amirabbas)
Semiconduttori (Italy but some English datasheets)
Semiconductor Datasheets - From Russia with... (promelec.ru)
SemiDex, Inc. Memory and IC Database
Smt Marking - Design and Development Services
Surface Mount (SMD) Transistors/Diode FAQ
The SMD Code Book - Package/part number lookup
TDS-Net - The Electronic Components Web Database
Transistor Cross Reference Database - ee.washington.edu

Miscellaneous Component Info/Links

Amidon Associates - Iron powder and ferrite, including cores and transformers
Group Arnold - Magnetic Product Group of SPS Technologies
AVX - Capacitors, resistors, etc.
Outline of Capacitor Class Ratings
Capacitor information (eeug.caltech.edu)
The Chip Merchant, Inc.
Counting & display tubes
DEL Electronic Corp. - High Voltage Power Supply Solutions
DuraCap International
Electronic Concepts, Inc. - Capacitors
EMI Suppression Capacitor Explanation
Elm Electronics - ICs for the hobbyist
FCIM Component Identification Tool
General Atomics Energy Products Components and Systems
The Hall Group , Failure Analysis , Destructive Physical Analysis
Hivolt Capacitors Limited - Capacitors for pulsed lasers and similar applications
HV-Diode.com (China) - HV rectifiers, etc.
Leroy's Engineering Web Site: Hardware, Components
Magnetics & Ferromagnetics Materials (Amidon)
PICO - Ultra Miniature DC-DC converters, transformers, etc.
Roll Your Own Power-Transformers!
Safety requirements for EMI Capacitors
Tube Database Search (Bill, NJ7P)
VAC products - Magnets and magnetic components

Vacuum tube 'integrated circuits' links
Vacuum Tubes (Micronetics-trading.com)
Wire - MWS Wire Industries
Wire Gauge Calculations (Mogami)

Other Component Manufacturers

Caddock - High Performance Film Resistors
Duracap (Mallory) Products
Electronic Concepts, Inc. - Manufacturers of Film Capacitors
Ohmcraft -- High voltage resistors.
Thordarson Meissner Home Page
Victoreen
Vishay Intertechnology, Inc.

Semiconductor Component Manufacturers/Datasheets

Allegro, Part Numbers
Analog Devices - Search Engine
Burr-Brown Corporation
Directed Energy - MOSFETs, LD drivers, pulse and digital delay generators
EDI - Standard and custom HV rectifiers
Harris Semiconductor - Product Info/Datasheets
Hitachi Technical Documents Search Page
H.V. Component Associates - HV diodes
iC-Haus: Standard and custom ICs including laser diode drivers
International Rectifier - Keyword Search
KEMET Electronics Home Page
Linear Technology Corporation
Maxim Integrated Products, Inc.
Mitsubishi Semiconductor Group
Mitsubishi Semiconductor Data Sheets
Motorola Semiconductor Products
National Semiconductor Homepage
National Semiconductor Search Tools
NEC - Products/datasheets
Nichia America Corporation
On-Semi.com (Motorola) - ICs, discretes, etc.
Panasonic Semiconductor - Datasheets/search
Philips Semiconductors Home Page

- Philips Semiconductors; Search & Find
- Sanyo data sheets (Audio Labs)
- Samsung Semiconductors
- Sanken Electric Co., Ltd.
- Semelab - Power, RF, Opto
- SGS-THOMSON - Technical Literature
- Sharp DataBook CD-ROM H.P Ver 2.0.1
- Sharp Microelectronics of the Americas -- Camas, Washington
- Supertex - MOSFETs and HV ICs
- Telcom Semiconductor, Inc. - Datasheet0s
- TI Semiconductors
- Toshiba America Electronic Components Datasheets
- Toshiba Semiconductor Document Web Service
- Unitrode Semiconductors
- Unitrode Product Seach and Find
- Vishay Siliconix - MOSFETS, power ICs, optoelectronics, etc.
- Zetex Semiconductors - Linear and Discrete

Universal Semiconductor Replacement Companies

- ECG Electronics
- NTE Electronics, Inc. Web Site, Welcome

Laser/Optics Sites/Information

- Interferometry for Cosmic Measurements - NASA space mission
- Interactive Interferometer - NASA demo of Michelson Interferometer
- The Active Portal Project -- Topic: Science - Technology - Optics
- The Photonics Dictionary
- SciCentral: Best Optics, Photonics, & Laser Science Online Resources
- Sci.Optics FAQ

Sam's Laser FAQs

- Sam's Laser FAQ (USA-SC,RepairFAQ.org)
- Sam's Laser FAQ Mirror (USA-PA-E1,SG)
- Sam's Laser FAQ Mirror (USA-PA-E2,SG)
- Sam's Laser FAQ Mirror (USA-PA-W,DK)
- Sam's Laser FAQ Mirror (USA-CA,EIO)
- Sam's Laser FAQ Mirror (USA-FL,CH)

Sam's Laser FAQ Mirror (USA-IL,DG)
Sam's Laser FAQ Mirror (USA-MD,K3PGP)
Sam's Laser FAQ Mirror (USA-NH,TQ)
Sam's Laser FAQ Mirror (USA-NY,JA)
Sam's Laser FAQ Central (laserfaq.org,DE-2,Germany,LN)
Sam's Laser FAQ Central (laserfaq.net,DE-2,Germany,LN)
Sam's Laser FAQ Central (laserfaq.com,DE-2,Germany,LN)
Sam's Laser FAQ Central (laserfaq.de,DE-2,Germany, LN)
Sam's Laser FAQ Mirror (DE-1, Germany, DB)
Sam's Laser FAQ Mirror (USA,LRL - Obsolete)
Laser Resource Library (Dr. Ed Edmondson and Sam - Inactive)
Sam's Laser FAQ V2.62 (Old, jena.de)
Sam's Laser FAQ V4.35

Amateur Laser Construction Sites/Links

Amateur Laser Constructors (Asselbar)
Articles from SciAm and Light and Its Uses
Society for Amateur Scientists
Tinker's Guild Science Store - SciAm Amateur Scientist Archive CDROM

East Carolina University Glassblowing Services - Information, tutorial
Lasergrowing 1 - Official Homepage (Robin)
Lasergrowing 1 - Original Web Page Cass)
Daniel's Links - Amateur Laser Construction Links:
Sample Laser Signs (University of Illinois at UC)
Danger Sign Request Form (Coherent, Inc.)
CO2 Warning Signs (Robin)
Homegrown CO2 Laser (Altair)
Creative Visual Associates - General and CO2 laser videos
Dewtronics CO2 Laser Project
CO2 Laser Construction (Nathan Ellis)
Emission Technologies - Description, specs, manuals, plans, kits, for CO2 laser
Marc Eichhorn's Home-Built CO2 Laser Page
CO2 Laser Optics Calculator (Tim Goldstein)
Lasers - Home-built CO2, info, links (Tim Goldstein)
Steve Hardy's CO2 laser formulas (Tim Goldstein's copy)
JK Laser Productions Home-Built CO2 Laser
Dave Johnson's CO2 Laser Engraver Page
Construction of Sealed CO2 Laser (David Knapp, Colorado.Edu)
Construction of Sealed CO2 Laser (David Knapp, Colorado.Edu)

Plans for a Sealed CO2 Laser (Sam's copy of David Knapp's paper)
Sarah McNally's Laser Project Page - Home-built CO2 laser
Fester Smyth's Livewire - CO2 laser project status and photos
Wes's CO2 Laser Page - Description, CAD drawings, etc.
JK Laser Productions Home-Built HeNe Laser

Gruber B.'s Laser Construction Page - CuCl/CuBr lasers
Chris Krah - Copper Chloride Laser Technology
Laserist - Copper cloride laser construction and links
Eric M. Stroud's Constructing a Metal-Halide Laser Page
Bob Wilcott's CuCl Laser Page
Copper Vapor Laser Construction - Includes description, diagrams, and photos

Humor - Build your own Nitrogen Laser
Diagrams of the N2 Laser from the Original SciAm Article
The Quest for A 1 MW Pulsed N2 Laser (Univ. of Chicago Student Project)
Jason's Laser Page - Several easily constructed home-built TEA N2 lasers
Jon's Rant About the Scientific American Nitrogen Laser
N2 Laser Project (Not working yet) (Mess1)
Bert Pool's UV Laser - Low cost nitrogen laser construction
Riff 42's N2 Laser I hope! Page - Photos & desc. during construction.
N2 Laser in the Self-s Building (English translation of above)
N2 Laser (German Site) - Includes nice description and photos
Hubert Pissavin's Lasers for Amateurs - N2 laser, laser using disposable flashes, more
Hubert Pissavin's N2 Laser Links Page

Daniel's Oxygen/PMG and Other Laser Projects

The Peddie Dye Laser

Chuck Adams' M-60 Tank Rangefinder Ruby Laser Project
Chris's Ruby Laser Homepage
Doug's Monster Laser Hardware Page - M60 and Chieftain rangefiners, more.
Rotorwave, Inc. - MOPA for high speed holography based on M-60 ruby laser
Hubert's Lasers for the Amateur - Links, camera flash pumped Nd:YAG, N2 laser
Information on Building Capacitors (Tesla Coil Mailing List)
Pulsed power- Marx generators

Elmar's Home-Built DPSS Laser
Robin's Mounting Bare Laser Diodes Page - Complete procedure with photos

Jon's Home-Built Lasers - N2, CO2, ion, SS, other laser and HV related photos and info, more.
Milan Karakas's Experiences with Lasers Page - N2, others
Mark Csele's Homebuilt Lasers Page - N2, dye, misc.
Massild's Laser projects
Massimiliano Cosmelli's Amateur Laser Construction Pages
Renato's Home-Built Lasers Page - N2 and dye laser projects
Rich's Laser Page - Nitrogen and dye laser info and photos
Tom Stock's Laser Projects - CO2, N2

Vacuum Technology

The Electronic Bell Jar - Vacuum technology for the amateur
Vacuum History & Technology
Vacuum Technology (ECE Department, University of Alberta)
Vacuum Systems (EE-527, CAM. Univ. of Wash.,)
Building my eight inch Bino-Scope (includes vacuum aluminizing)

Parts Suppliers for Home-Built Lasers

Ace Glass Incorporated
Adams & Chittenden Scientific Glass
Airgas, Inc.
A-Vac Industries - Vacuum pumps. parts, service
BOC Edwards - Vacuum equipment and accessories
BOC Gases: Special Gases
Capitol Vacuum - Vacuum equipment repair parts and turbopump repair
Cole-Parmer - Scientific and Lab Equipment
Duniway Supply - Vacuum pumps and more
Ed Fagan, Inc. - Glass-to-Metal Seals - Properties of materials
EGL Neon - Glass, electrodes, gases, pumping ssytems, accessories, more
Eurocom, Inc. - Neon sign equipment and parts.
Evertron - Flyback based HV neon power supplies
G. Finkenbeiner Inc. - Quartz products (optics and scientific)
France Transfirners - Neon sign transformers, etc.
Friedrich & Dimmock, Inc. - Glass tube and rod.
Glasscraft, Inc.
Glasscrafter Borosilicate Tubing Info
Helix Technology (Granville-Phillips and CTI-Cryonics - Vacuum equipment

- Hytek Microsystems - LD drivers and TEC controllers, more.
- HyVac Producst, Inc. - Vacuum pumps and high vacuum equiptment
- Kimble/Kontes Glass - Scientific, specialty, and custom glassware
- LakeShore Cryotronics - TEC controllers, indium foil, low temp solder, etc.
- LDS Vacuum Products, Inc. - All sorts of vacuum items
- Kurt J. Lesker Company - Vacuum systems and vacuum components
- Lightwriters Glass Warehouse - Books and videos, toches, eyeware.
- Marlow Industries - Thermoelectric cooler systems
- MDC Vacuum Products Corporation - Vacuum components
- Melcor Thermal Solutions - TECs, controllers, low temp solder, etc.
- MKS Instruments - Components for vacuum and gas based processes
- Myers Vacuum - Molecular distillation equipment and gauges. CVC
- NeonCentral - Everything for neon signs
- Neon & Lighting Channel - Neon sign technolog
- OE Technology - High Vacuum Equipment
- Pfeiffer Vacuum - Pumps, systems, accessories
- Precision Plus Vacuum Parts, Inc. - Vacuum pump repair parts and supplies
- Precision Scientific - Scientific laboratory equipment
- PTB - Used vacuum equipment
- SmallParts.com - Tiny hardware thingies of all types
- Spectra Gases - Laser gases and equipment
- SPI Supplies - Vacuum equipment and supplies
- Teledyne Hastings - Vacuum gauges, flow meters, etc.
- Thermionics Vacuum Products - High vacuum pumps, gauges, components, more.
- Thermoptics - TEC Controllers, more.
- Vacuum Industry, Science and Technology Links (Sansalone)
- Vacuum Technology and Vacuum Coating (Alex Yuan)
- Vacuum Technologies Co. - Pumps, rebuild kits, etc.
- Victor Equipment Company - Torches, regulators, related equipment.
- Visual Spectrum - Hastings vacuum products distributor
- Wale Apparatus - Scientific Glassblowing, Lampworking, Flameworking
- Welch Vacuum Pumps

Amateur Laser Communications

- VK2ZTO's Experimentation Web Site - Amateur laser communications.
- WB9AJZ's Laser Links Page
- WB9AJZ's Laser Communications/Project Page
- Optical Through the Air Communications (David Johnson, P.E.)
- N3RTR's Laser Experiments Page (nothing much yet)
- N1BUG's Basics of Laser Com DX

Mousehole.com - KB2TCQ's Lasers and Laser Comm and Other Projects
K3PGP's Experimenter's Corner
Tomi Engdahl's Experimental Laser Data Link
Derek's Laser and Optical Communication Links
Laser Reflector - Archive directory
Laser Reflector - Amateur Radio Laser Communications
The KB2TCQ Weak Signal and Contest Page

Laser Related Schematics/Plans

Coherent CR52 Laser Photos and Schematics
Digitally Controlled Laser Diode Driver (from Electronic Design)
The Electronic Cookbook Archive - Optical Department
HeNe Laser Power Supply (JEM Electronics Downloads {Page)
HeNe Laser Power Supply (bad design - do not use)
HeNe Laser Power Supply (ee.washington.edu)
K3PGP's Biasing & Modulating Laser Diodes Safely!
Laser Diode Driver (Cookbook Archive)
Laser Link Communicator (Peter Philips, Electronics Australia, July 1997)
Laser Listening Device Plans (thecodex.com)
Laser Power Supply and Starting Circuit - Some errors (Dark Portal)
Oatley K002 HeNe Laser Power Supply
Oatley K002 HeNe Laser Power Supply (Local Copy)
Radio Shack 63-1040 Laser Pointer (Walter Gray)
Adam Smith's Homemade Laser Light Show
SANYO Laser Diode (Includes driver circuit)
Sony Laser Diode Operation (Includes APC and ACC circuits)
Thermoelectric Cooler Controller Schematic (Billock and Xie)
UPN Laser Transceiver (Derek Weston)
WL's Switchmode Argon PS

Laser Safety Sites and Links

University of Waterloo - Laser Safety Manual
CDRH - Center for Devices and Radiological Health (USA)
CDRH - Good Guidance Practices Search Page
CDRH - Electronic Product Radiation Control Page
CDRH - Laser Products, Including Laser Light Shows and Displays
Danger Sign Request Form (Coherent, Inc.)
Directed Light, Inc. Laser Safety Bulletin

- ISHN - Comments on Laser Pointer Safety
- Laser Institute of America - Safety, applications, etc.
- LaserFX.com - Basic Laser Safety
- Laser Pointers - NRPB Information Sheet 1/98
- Laser Institute of America - Laser and laser pointer safey bulletins
- LBNL Health and Safety Manual - Chapter 16: Laser Safety
- LIA - Laser Area Warning Signs and Equipment Labels
- LIA - Laser Safety Information Bulletin
- Office of Environment, Safety and Health
- OSHA - Laser Hazards (Standards, compliance, and training manuals, links)
- Navy Laser Safety
- NIH - Summary of Laser Classes (part of Radiation Safety Manual)
- NRPB - National Radiological Protection Board (UK)
- RLI LaserNet - LaserNet Homepage
- RLI LaserNet - Safety recommendations for laser pointers
- RPB - Radiation Protection Bureau (Canada)
- University of Alabama at Birmingham - Laser Safety Manual
- University of Illinois at UC- Laser Safety Manual, Tutorial, Warning Signs
- University of Missouri at Rolla - Laser Safety Program
- University of Pennsylvania - Laser Safety Manual
- USACHPPM - Laser and Optical Radiation Hazards Program

High Power Laser and Laser Research Sites

- Adelaide University (Optics Group) - MOPA DPSS 150 watt laser.
- Argonne National Laboratory - LAL
- Advanced Technology Center Airborne Laser (ABL)
- Airborne Laser Home Page
- Airborne Laser (ABL) - Description
- Brookaven National Labs ATF - CO2 and YAG Laser Projects
- Central Laser Facility - European high power laser research
- Chemical Oxygen-Iodine Laser (COIL)
- Institute of Applied Physics, U. Jena (Germany) - Fiber Lasers
- Laser Propulsion Research Projects
- Laser Star Astrophysics (John Talbot)
- Lawrence Livermore National Laboratory - Laser Programs
- Lawrence Livermore National Laboratory - National Ignition Facility
- Lawrence Livermore National Laboratory - Nova Operations
- Lawrence Livermore National Laboratory - Table Top X-Ray Laser
- Mid-Infrared Advanced Chemical Laser (MIRACL)
- NCLR Laser Projects - excimer, solid state, free electron

Centre for Optoelectronics, Ngee Ann Polytechnic, SINGAPORE
RPI - Laser Propulsion Research Projects
Sandia National Labs - Lasers, Optics, & Remote Sensing
UCSB Free Electron Laser Link Page
University of St Andrews Ultra-Short Pulse Laser Research Group

Laser and Optics Link Sites

Laser, Optics, and Holography Ring Homepage
Salmah Abdullah Laser Links, Links Page
Accu-Right's Laser Links - Industrial, academic, gov, art, more.
Chris Cooney's Laser, Light Show, and Holography Links
Tomi Engdahl - Laser and light effects page - Much info
Laser Material Processing at Gintic - Company and research links
Laser Links (David Carey) - Some specific supplier info, misc.
Laser Technologies and Applications - Links
LaserFX Links Page
LaserLinks - Stony Brook Laser Teaching Center
LaserNet Homepage
Lasers & Optics - USA & UK, Laser Tutorial
Laser and Optical Communication Links (derekw, UPN)
Lasers & Optronics Online - Industry Links
Lasers & Optronics' 1997 Buyer's Guide Online
LEOMA - Laser Links
LEOMA - Laser & Electro-optics Mfgr's Assoc.
Links to Laser Safety Web Sites (nswc.navy.mil)
Jim Moss's Bookmarks for Laser Stuff
MotionNET.com - Engineering Resources Online
NASA Langley Photonics Group - Laser/optics links
NASA Langley Photonics Group - Laser diode manufacturers database
Newsight - Laser and Electro-Optics Information Center
Optical Links (Ingenieurbüro Vingerling)
OpticsNotes.Com A Resource for Optics and Photonics Information
Optics Physics Links (cbell.com)
Opto & Laser Europe
Optoelectronics World
The Photonics Directory
Photonics Yellow Pages
Q-Peak Applied Photonic Systems - Laser and optics links
Robin's Laser Company Links - Very extensive list.

Skywiise's Lasers and Optics Page - Links and more.
Spectra Physics Lasers Web Site Hyperlink
Nelson Wallace's FAQs Page - References to optics, scientific, and business resources
Andreas Wappelt - Photonics Direct

Laser amd Optics Information, Tutorials. Software

A Brief Introduction to Laser Diodes (University of Washington)
ACME Optics - Roadrunner optical design software (formerly KDP)
Animations of Physical Processes (infoline.ru)
Animations of Physical Processes - Includes physics, optics, waves.
Antony's HeNe Laser Page - Demo laser of sorts
Archives - Pinouts Listing (LaserFX)
Rami Arieli: The Laser Adventure
Rami Arieli - Laser Types
Rami Arieli - Laser Applications
Rami Arieli - Laser Experiments
Rami Arieli:- Schawlow: Measuring wavelength with a ruler
Aspheric surfaces and conic sections (LBP)
Ben's Laser Page - Argon laser power supply, DPSS laser
The Blue Laser Diode - Gallium Nitride (GaN) based LEDs and Lasers
Breault Research Organization, Inc. - Optical Eng. Software/Services
Cable U. - Laser Types: VCSELs vs Fabry-Perot Diode Lasers
University of Cincinnati ECE614 - Include optics primers
Cleaning Laser Optics (Directed Light, Inc.)
Cleaning of lenses and mirrors (LBP)
Collodium Optics Cleaning Technique (ATS)
CORD Communications - Electro-Optics Courses
CORD Communications - Electro-Optics Course Directory
Dewtronics LEOT Tutorial on Lasers - Copy of CORD Courses
Sam's Local Copy of CORD LEOT Courses
Creative Visual Associates - General and CO2 laser videos
Photos of Directed Energy 30 W CO2 Laser and Power Supply
DOC Online Papers
Don's Laser Page - suppliers, miscellaneous laser info
DPSS YAG Laser at 532 nm - Diagram and description (dolbye)
Easy explanation of lasers (jimb3d)
Edmund Industrial Optics: Technical Support
Ed.Sci. Laser Primers: LD modules, beam expdrs., spatial filters.
EG&G (now Perkin-Elmer) Technical Papers

EIO - Laser Information and Technical Forum
Fiat Lux - Interactive educational light nfo
FOTEC Fiber Optic Testing FAQs
Frequently Asked Questions about CO2 lasers (Parallax)
Glossary of Laser Terminology (Acuu-Right)
Glossary of Laser Terminology (uiuc.edu)
Glossary of Fiber Optic Terms - (LISTCo, Inc.)
Selman Hershfield's Optics Lecture
The Helium-Neon Laser (Dept. of Phys., Middlebury College)
The HeNe Laser and PS by Elden Peterson of Vortex, Inc.
Andreas Hotovy's Laser Page (German)
HowStuffWorks.com's "How Lasers Work"
Hydrogen Laser Info (Hylaco Analytical Services)
Ibelings.com World - Photos of inside of small DPSS laser module, more
Information on Nd:LSB (Digi-Art)
International Light, Inc. Light Measurement Handbook Page
The Invention of the LASER at Bell Labs: 1958 - 1998
ILX Technical and Application Notes - Laser diodes
K3PGP's Cryo-Cooling of Laser Diodes (from: The Laser Cookbook)
K3PGP's Laser Diode Manufacturers
K3PGP's Laser Diode Specifications
KDP, free Optical Design Program
Kentech's Tutorials - Transmision lines (inc. Blumlein), pulsars, etc.
Laser Applications (Laser On-Line Guide)
Laser Helpers (Kentek) - Useful formulas, conversions, glossary, etc.
Laser On-Line Guide - Links, Q&A, services. more
LaserFX.com Backstage - Archives: tech papers
LaserFX.com - Laser Science Projects
Lasers - Comments & Links (~gmt)
Laser Diode Search (Thorlabs) - Laser diode database
Lasers - General Information (nwu.edu)
Lasers and Optoelectronics - Course outline (Oregon State University)
Lasers & Optics - Laser tutorial (Web Science Resources)
Laser Propulsion Research Projects
Laser Science Project - HeNe plans (hooking up tube and PS)
Laser Stars - Laser History
Laser Stars - Plasma Laser Astrophysics
Laser Stars - Spectra of Gas Discharges
Laser Tutorials (RLI)
Laser Turorials (RLI) - Argon Gas Laser System
Lasers Tutorial (University of Aberdeen, UK)

Lawrence Livermore National Laboratory - All About Lasers
Ledalite - Articles on various topics related to lighting
LEOMA Short Course - Understanding Laser Technology (fee)
LiCONiX Lasers - HeCd mirror adjustment procedure
Lighting Design and Simulation Glossary (Georg Mischler)
Lumex Info Page - Includes "Leddy's Latest" laser and optics notes
Lumex Tech Notes - Laser diodes, LCDs, solid state and other lamps
Marc's Laser Pages (German) - Laser show, gallery, education; downloads, links, chat, etc.
Meadowlark Optics - Principles of Retarders
Melles Griot - Application Notes
Melles Griot - Lasers and Laser Tutorials
Melles Griot - Optics Tutorials
Melles Griot Laser Laboratories (Oregon State University)
MEOS GmbH - Manufacturer of experimental laser kits and systems
MEOS GmbH Download Page - Laser experiment manuals
Metrologic - More Than 101 Ways to Use a Laser
Metrologic - Fun Ideas Using a Laser - Humor
Mikos - Twyman-Green Interferometer - PSI 4.1
Molecular Technology GmbH - Info on laser/non-linear crystals, other optical materials
NASA LaRC LSB Database Lasers - Materials info
NASA LaRC LSB Laser Tutorial
Newport - Support and Application Notes
Nightlase Technologies (Flavio Spedalieri) - Laser and optics tutorials
Nortel - The Educative Uses of Laser Technology
Optlectra - The Laser Company: Product Search (.com)
Optlectra - The Laser Company: Product Search (.de)
Optlectra - The Laser Company: Product Search (.net)
Optlectra - Laser power supplies (includes some pinouts) (.com)
Optlectra - Laser power supplies (includes some pinouts) (.de)
Optical Measurement and Scanning (Inhalt)
Optical Networks - Educational information (Sonet.com)
Optical Research Associates - Optical design software
Optical Research Associates - Optics for Kids
Optics 513 Chapter Notes (University of Arizona)
Optics Cleaning Methods (Coherent, Inc.)
The Optics Of Spectroscopy (Horiba Group)
Optics2001 - Optical Library - Optics - Photonics - Laser - Imaging - Fiber optics
Optics Tutorials - Refl, refr, color, polarization, etc. (Siltec)
Paraxial Design System - Java based lens design applet (CEMS)

PerkinElmer Optoelectronics | Technical Library | Technical Papers
The Phasmatron Spectroscope - Ultra-high resolution
Physics 2000 (University of Colorado)
Physics Lecture Notes (mcmaster.ca)
Photometry and Radiometry (Ledalite Library)
Potassium-gadolinium tungstate single crystals KGd(WO4)2, KGW
Power Technology Inc.Technical Library- Info on diode lasers
PTI Manuals Online - N2, dye, and frequency doubler
Pulse Forming Networks (Plastic Capacitors, Inc.)
Q-Peak Applied Photonic Systems - Recent Technical Papers
Radiometry vs. Photometry FAQ (James M. Palmer)
SCIOPT Enterprises - Optics and laser design softare
SDL high power fibre coupled laser diode
Prof. A. E. Siegman: Home Page
Skywise's Lasers & Optics - Includes laser spectrum chart
SNLO - Select Non-Linear Optics program
Spectra of Gas Discharges (Laser Stars)
Stephen's Laser Light: How'zit Work? - Stimulated Emission Laser Tutorial
Super Laser pages - Compact high power CO2 laser - maybe
Three-Colour, Solid-State, Three-Dimensional Display
TML Laser - (Dutch) Cyonics 2201, software, photos, animations, more.
Understanding C02 Lasers (Whitehouse)
The Unusual Diode FAQ - IV.16 - Blue-Green-Violet Laser Diodes
The Unusual Diode FAQ - IV.24 - Laser diodes
VCSEL (Verical Cavity Surface Emitting Laser)
Nelson Wallace's Optics Site - Geometric and physical optics tutorials, software, FAQs, more
Warren Vidrine's Optics Tables (IR, etc.)
World Laser Optics - Papers related to high power lasers
Xueqing Liu'sThe aberration correction of a Diode Laser
David Zurchar's Lexel 88 and Other Lasers Page

Laser Discussion Groups and Technical Forums

EIO - Laser Hyper-Email Discussion Group
GoPhotonic.com - Photonics related discussion groups, news, etc.
LaserFX - Ads Forum
LaserFX - Graphics and Images Forum
LaserFX - Hobby Forum
LaserFX - Laser and Projectors Forum
Laser Focus World Industry Talk

MyForum - Ruby Laser Message Board
Photonics Online Discussion Forums

Laser Equipment and Parts - New, surplus, mail order

All Electronics - New/surplus, occasional laser bargains
ALPEC Team, Inc. - Laser pointers, modules, sights
American Science & Surplus
Anchor Optical Surplus
Arbor Scientific - Kits and demos, parts and equipment.
Bid-Service LLC Lasers - Systems related to semiconductor processing
BMI Surplus Equipment Brokers - Includes lasers and optical equipment
BSC Optics - High quailty optics and optical equipment
Bull Electrical (UK) - Lasers page.
C and H Sales Company - Electronic surplus
Carl's Electronics - Plans for 40W CO2 laser, more.
Cascade Laser Corp. - Laser repair and components
Casix - Laser optics (China) - Optical and laser components and kits
C and H Sales Company - Electronics Surplus
CTR Surplus - Electrical, PSs, RF, Optics, more
DeHarpporte Trading Company - Laser pointers, DPSS lasers and modules
Dfreshh Laser lighting and sound: Some laser rental/surplus sales
DIY Electronics (Kitsrus) - Diode laser modules
Edmund Scientific - Optics, lasers, electronics, kits, etc.
EIO - Surplus electronics, some laser. and computer parts
Electronic Surplus Online! - Includes some laser equipment
Enlight Technologies, Inc.- DPSS lasers, modules, and pointers
Europe Laser Exchange - Lasers and laser systems (mostly large but some small)
Future Horizons - Werid stuff probably to be avoided
HB-Laserkomponenten - HeNe, Ar/Kr ion, Co2, Nd:YAG, new/used
Herbach and Rademan - Electronic surplus, HeNe lasers/PSs, more.
Hi-Tech Electronic Surplus
H.V. Component Associates (HV diodes)
Holland Laser Products - Surplus lasers, test equipment, vacuum systems, etc.
Holograms and Lasers International
Hosfelt (Specials include laser pointers, etc.)
HSC Electronic Supply (Halted Specialties) - Electronics and some lasers
Images SI, Inc. - Parts and kits for many types of projects
Information Unlimited - Sci. Proj, Kits, Lasers, HV, Plans, Books, Parts
Intelite, Inc. - Lasers and electro optics products

Kentek Corporation - Laser replacement parts, accessories, etc.
KERN laser systems, etching, and profiling
Labtrader - Laser/Optics for Sale
Laseramazers.com - Laser show equipment inc. diode, DPSS, HeNE, and Ion lasers
Laser Laser Productions - Laser equipment and parts for sale
Laser Pointers and Modules (arcos.org)
Laser Pointers (hut.fi/~mkallio/sivut)
Laser Resale, Inc. - Surplus, buy, sell, lasers and components
Lasershop - New and used lasers, optics, plans, more.
Laser Surplus Inc. - New and Used Laser Equipment
Laser Surplus Sales - Lasers, PSs, Optics, Test/Mesaurement
Laser Technical Instruments - Laser line generators
Laserworks - Laser entertainment hardware
LasPro - DPSS laser kit
Latronix (Sweden) - laser and optics
Lauritsen Laser Labs - Laser trade/swap/service club
LMDC - Optics, motion control, lasers. Sales, integration, consulting.
Main Line Optical Instruments
Marlen P. Jones - Electronics, lasers, optics, more.
MediaLas Laserproducts GmbH (Germany) - Showlaser-components
Meredith Instruments - All sorts of laser surplus
Midwest Laser Products - New and surplus lasers and components
MWK Laser Products - Laser Parts and Equipment
Musser & Associates - Optical tables, breadboards, components, more.
Neodymium Glass - Surplus rods, slabs, and other optics from LLNL
NVG, Inc. - Diode lasers, laser diodes, drivers, optics, more.
OATLEY Electronics (Australia) - HeNe and diode lasers, kits.
OE Technologies - High voltage components, optics, PM tubes, more.
OptoSigma - Optic and optical components
PEMED Surgical Lasers - Surplus CO2 and YAG laser systems
Pendex Corporation - Refurbished laser and optics equipment
Plans and Kits Unlimited - Amusing site, but very negative reviews.
RedLine 115 Laser Modems.
Resources Un-LTD
Second Hand Laser - Surplus from HB-Laserkomponenten GmbH
SICK, Inc. - Laser measurement systems
Sterling Resale Optics - Surplus optics
Surplus Shack - Optics, instruments, equipment
SVBx High Tech Labs - Plans, parts, circuits, bbs, chat, more.
SVSKITS.com - Laser show and robotics kits and parts
TECNET - Used Equipment Database of Surplus Assets

Ted's High Voltage & Other Items For Sale
University of Utah Surplus Property
Used-Lasers.com - Photos and links not clear if anything for sale
Used Line - Ads for used scientific equipment, some lasers
Wacky Willy's Surplus Stores

Laser Equipment Sales, Rentals, and Service

Anderson Lasers, Inc. - Industrial, scientific, light show lasers, more.
Cambridge Lasers Laboratories, Inc. - Ion laser repair, upgrade, rental.
Cascade Laser Corp. - Laser repair and components.
CASIX - China based supplier of laser optics, components, and kits
Control Laser Corporation - Laser Marking Systems
Creative Technology - Laser pointers, diode/DPSS modules, consulting
Directed Light, Inc. - Laser equipment for industry
DZ Laser Service - Specializing in ILT laser repair
Edmund Scientific - HeNe, diode, Argon lasers, optics, kits
EK Photonics - SS laser parts, accessories, repair
Ellison Research Labs - Electronics consulting including laser repair
Evergreen Laser Corporation - Ion laser service and refurb.
Excitek, Inc. - Ion laser sales and service, CO2 tube regassing
G.L. Services - Laser safety, display, service, refurb, more.
Grapevine Laser - Sales and service of Ar/Kr ion lasers.
HB-Laserkomponenten - HeNe, CO2, Nd:YAG laser sales and service
Holo-Spectra - Laser resale, repair & refurb, lightshows, more
HGM Medical Lasers Inc. - DPSS and other medical/surgical laser systems
H&H Research - Ion laser sales and service
H&H Research (alternate site) - Ion laser sales and service
Laser Components (USA), Inc. - Importer/distributer of laser diodes/modules, optics, detectors, more.
Laser Components (DE) GmbH- Far IR diode lasers, other electrooptics, more.
Laser Components (UK) Ltd. - Far IR diode lasers, other electrooptics, more.
LaserDealer.Com - Laser Engravers for Signage and Industry
Laser Devices, Inc - Laser gun sights, laser pointers, laser diodes and drivers
Laser Electronics Ltd. - Lasers. controllers, rentals, reprocessing
Laser Electronics (Operations) Pty Ltd (Austrialia) - Supplier
Laser Innovations - Ion laser sales, service, and support
Laser Labs, Inc. - Medical, surgical, scientific lasers, laser tubes
Laser Labs, Inc. - Light show equipment and sorfware
LaserNexus. - Scientific, Industrial & Medical Lasers Components & Optics
Laseroptronix (Sweden) - Lasers, laser and other optical equipment

[Lasers Now - Ion, CO2,, Cu vapor, HeCd laser systems]
[Laser Tune - Sales of remanufactured CO2 and YAG lasers, repair, parts]
[LG Laser Graphics GmbH - Ar ion, HeNe, Hd:YAG, diode lasers]
[MediaLas Laserproducts GmbH - Lasershow-components]
[Photovac Laser Corporation, Inc. - CO2 laser tube reprocessing, service, more.]
[Polytec PI - Lasers and optics equipment]
[Powerlink Lasers Ltd. (UK) - Ion laser repair, reprocessing, mfgr, and design.]
[Usedlasers.com - Used laser engravers]

Laser and Optics Sites, Manufacturers, and Suppliers

A-F

[Advanced Engineering Solutions. Inc. - CO2, Diode, Ar ion, Ti:Sa lasers.]
[Aerotech, Inc. - Motion control systems (formerly HeNe lasers)]
[Alkor Technologies - Optical elements and coatings (Russia)]
[Almaz Optics, Inc. - Optical materials, components, nonlinear crystals, more.]
[ALPEC TEAM, INC. - Laser modules, pointers, sites]
[ALPHALAS GmbH - Lasers, optics, electronics]
[American Laser Corporation - Ar/Kr Ion lasers, power supplies, accessories.]
[Analog Modules, Inc. - Laser power supplies, amps, drivers, more]
[Analog Products -- AD9660]
[Analog Technologies, Inc. - LD and TE drivers, mode hop free lasers, PD amps/preamps]
[Applied Optronics Corporation - High power laser dodes, modules, systems.]
[Avalon Photonics - VCSEL, VCSELs, Optical Data Communication,]
[B&W Tek, Inc. - Fiber coupled laser diodes, laser diodes, and systems, more.]
[Balzers Thin Films - Optical coatings]
[BE MEyers and Co. Inc.- Lasers, night vision, cameras, integrated systems]
[Big Sky Laser Technologies, Inc. Home Page]
[Blue Sky Research - Electro-Optic Manufacturer of Laser Diodes and Instruments]
[Bonneville Technologies - LDs, pin PDs, DPSS lasers]
[Boston Lasers, Inc. - High power laser diodes, drivers, DPSS lasers, more.]
[Burleigh Instruments, Inc. - Laser test and measurement]
[CASIX (China) - Laser, non-linear, and electrooptic crystals, optics, more.]
[Castech (China) - Advanced laser crystals, optics, Si APDs]
[Cambridge Technology - Galvo based scanners and systems.]

Clark-MXR, Inc. - Femtosecond lasers for micromachining and spectroscopy
Cleveland Crystals, Inc. - Nonlinear and electro-optic crystals and devices.
Coherent, Inc. - CO2, dye, YAG, YLF, diode, DPSSLs
Coherent Technologies, Inc - Tunable 2 um lasers, doppler radar, more.
Continuum - Solid state lasers for science, industry, and medicine
Control Optics Corporation - Optical engr. supplies and services.
Convergent Energy - Industrial lasers and systems
The Cooke Corporation - Fiber optics, imaging, white light HeCd laser, more
Crystal Associates - Laser and non-linear crystals and optics
CrystaLaser (Diode Pumped Crystal Lasers)
Cutting Edge Optronics - Diode-Pumped Lasers
CVI Laser Corporation - High damage threshold optics.
DEL Electronic Corp. - HV power supplies includeing HeNe and CO2 lasers
DEOS - Sealed CO2 RF excited waveguide lasers
Diffraction International - CGH and binary optics, aspheric mtrology, design.
Digital Optics Corporation (DOC) - Diffractive optics
Directed Energy, Inc. (DEI) - Pulse generators, LD drivers, more.
DPSS Lasers, Inc.
EG&G (now a division of Perkin Elmer) - Flashlamps, sensor, etc.
EG&G Product Data and Tech Notes via Polytec PI France - Département Electro-Optique -
Edinburgh Instruments - CO2, CO, far-IR lasers, more
Exciton - Dye laser dyes
Electro-Optical Products Corp. - Modulators, Defl, Scanrs., Shutrs, etc..
Emco DC-DC High Voltage Power Supplies
Enlight Technologies, Inc. - IR and green DPSS lasers, green laser pointers.
EOSI - Tunable diode lasers. laser amplifiers, accessories, LabView
Equilasers, Inc. - Solid state lasers for medical, microwelding, other.
ESC Medical, Ltd. - Medical/surgical lasers
Esco Products - Standard and custom optics
EXFO Electro Optical Engineering - Optical and fiber optic test systems.
Fermionics - InGaAs PDs, InGaAsP LDs, HgCdTe detectors
Foctek Photonics, Inc. (China) - Laser and NL/EO crystals and optics
FOCUS, Inc. (Russia) - Custom optics

G-L

GEOLA (General Optics Laboratory) - Nd lasers and holography systems

Gigahertz-Optik, Inc. - Light measurement systems
GSI Lumonics - Laser Systems, Components, Instrumentation, Life Science and Metrology
Hamamatsu - PMTs, PDs, LEDs, sensors, light sources, more.
Hankwang - CO2 and YAG lasers (Koria)
Heraeus Noblelight, Inc. - Flashlamps, arc lamps, and other specialty lamps
Hewlett Packard - Laser Interferometer Positioning Systems
High Brightness Solutions - Laser diodes, modules, DPSSLs, photodiodes.
High End Systems On Line - Lighting control including Laser Chorus
II-VI Incorporated - Laser optics, components, detectors, more.
ILX Lightwave - Fiber optics and diode laser instrumentation
Industrial Microphotonics Company - Diode Array and Diode Bar Manufacturer
Infineon Technologies - High power CW and pulsed laser diodes and other semis.
Institute of Inorganic Chemistry (Russia) - Laser and optoelectronic crystals
International Light - Light Measurement Systems, Instruments, Detectors, etc.
ISP Optics - IR and UV optical materials and components
ITI Electrooptics - Laserr and non-linear crystals
Janos Technology, Inc. - Precision optics from exotic materials
JDS Uniphase Corporation - Lasers and subsystems, more
JMAR Technologies, Inc. - Picosecond lasers. more.
Jodon, Inc. - HeNe lasers and tubes, non-contact gauging, more.
JSL (Joachim Sacher Lasertechnik) - Laser diodes, external cavity diode lasers, accessories
Kaiser Systems, Inc. - HV power suppiles, cap chargers, more.
Keon Optics - Optical polishing and thin films coating
Kigre, Inc: - Solid state laser components and systems
Koito Manufacturing Company, Ltd. - HeCd whitelight laser
Lambda Physik - Excimer and dye lasers and dyes
LASAG Industrial Lasers - Nd:YAG pulsed lasers for welding, cutting, drilling
Laser 2000 International - Lasers, optics and fibre optic equipment.
Laser Analytics - Lead-salt tunable diode lasers
Laser Beam Products - CO2 and other high power laser optics
Laser Crystal Ltd.: Non-linear optical elements, LBO, BBO, KTP. more
Laser Diode, Inc. - FO TX/RX, GaAs lasers
Laser Diode Array, Inc. - Large multi-bar laser diode arrays
Laser Drive, Inc. - PSs for HeNe, Ar+, CO2, lasers, tungsten & discharge lamps

Laser Drivers - iC-Haus laser diode drivers
Laser Kinetics Inc. - CO2 laser systems
LaserMax - Diode laser modules
Laser Physics - Air Cooled Argon Ion Lasers
Laser Power Corp. - CO2 laser optics, IR coatings and DPSS ulasers
Laser Quantum Ltd - Diode Pumped Solid State Lasers and accessoris
Laser Research Optics - CO2 laser optics
Laser Science, Inc. - N2, CO2, and N2 pumped dye lasers, more.
Laserscope - Turn-key medical/surgical laser systems
Laser SOS USA. Inc. - laser parts, consumables, oem light sources, more
Lasermate Corp. - LD modules, drivers, pointers, optics, DPSSLs
Lasever, Inc. (China) - DPSS lasers - IR, green, blue
Lasiris, Inc. - Lasers and accessories for structured lighting
LASOS Laser-Fertigung GmbH
LASTEK - Photonics products for research
Latronix AB - Laser and optics systems and components
Leadlight technology, Inc. - Green laser pointers and DPSs modules, more.
Lee Laser- High power Ng:YAG lasers
LiCONiX Lasers - HeCd lasers (now part of Melles Griot)
Light Solutions Corporation - DPSS lasers.
Lightwave Electronics - DPSS lasers
LIMO - Micro-Optics & Laser Systems
Litton Airtron - Synthetic solid state laser rods and slabs
Logic Systems, Inc. - Includes PSU for large frame ion lasers
Lumex - Vsible and IR laser diodes, LEDs, LCDs, more.
LUMITEK International, Inc. - Sensors, viewers, detectors, safety gear.
LumrnX Technologies, Inc. -- Coaxial flashlamp pumped dye lasers
Lumonics, Inc. - See GSI Lumonics
Lynton Lasers - Medical, surgical, conservation, cleaning.

M-P

Macken Instruments, Inc. - Laser beam power and measrement.
Maier Photonics - Thin film optical filters
Meadowlark Optics, Inc. - Polarization control devices
Mektec Seiwa-DPSS Lasers (China) - DPSS lasers (alternate site: www.dpssl.com)
Melles Griot - Lasers, Optics, Instruments
Melles Griot - Laser Group
Melles Griot Laser Products - HeNe, HeCd, Ion, Diode

MEMS Optical, Inc. - Diffractive optics, MEMS systems, more.
Metrologic Lasers - HeNe, diode, educ./kits, bar code scanners
Micro Laser Systems (uLS) - High performance diode lasers
MJL Crystek, Inc. (Koria) - Laser and non-linear crystals
MK Photonics - Optics, optics instrumentation
Molecular Technology GmbH - Laser/non-linear crystals, other optical materials
Moose Hill Enterprises - Imports include laser crystals
Morton: Advanced Materials - CVD SiC, ZiSe, ZiS, for optics.
Nanolase - DPSS passive Q-switched lasers
National Laser - Ion and replacement tubes, diode lasers
New Focus, Inc. - Tunable diode lasers, optics and components.
New Wave Laser Products - Compact precision solid state lasers.
Newport - Precision optical components and systems
Nichia America Corporation
NEXEX - Excimer lasers and micromachining workstations
Nichia Chemical Industries, Japan
NEOS Technologies - AO components including AOMs and PCAOMs
Nova Phase Inc. - Standard and custom optics and crystals
NSG America's Home Page
Nu Light Systems - Laser displays, Airoamer, lighting and control systems.
NVG, Inc. - Diode lasers, laser diodes, drivers, optics, more.
Optical Coating Laboratory, Inc. - Optical thin film coatings and components
OPOTEK - Tunable Laser Systems
Opticon Corporation - UV-VIS-IR optical components.
Optima Precision, Inc.- Laser Diodes, Optics, Related Components
Optlectra GmbH - Ion, HeNe, diode lasers, power supplies, components.
Opto Power Corporation - High Power Diode Lasers, Accessories
Optometrics USA, Inc. - Optical components and instruments
Oriel Instruments - Equipment to make, move, and measure light.
OSRAM Opto Semiconductors - LEDs, laser diodes, other lighting devices
Oxford Lasers, Inc. - Copper Vapor Lasers
Oxford Lasers - Systems for high speed imaging and precision micromachining.
Pangolin Laser Systems - Laser manufacturers., links
Parallax Technology, Inc. - CO2 laser tubes sales and service.
Pathfinder Laser Products, Inc. - IR beam locators
pb-laser.com (China) - High beam quality CO2 lasers
PD-LD, Inc. - Laser diodes, LEDs, detectors, collimators, more
Photon, Inc. - Laser beam profiling

Photon Technology International - Photonics components, instruments
Photonic Systems Inc. (Optical processing consulting)
PicoQuant GmbH - Pulsed diode lasers, LED sources, more.
PLT Technology, Inc. - High power laser diodes
Polaroid Laser Diodes
Polytec PI - Piezo stages, SS, excimer, dye lasers.
Positive Light, Inc. - UV, DPSS Nd:YLF, Ti:Sapph, more.
Power Technology Inc. - Laser Diodes/Modules/HeNe PSs/more
Precision Projection Systems - Components for Light Effects/Shows
Pulslight Company (Bulgaria) - Copper bromide lasers for industry and medicine

Q-Z

QED (Quality Electro-optical Devices) - DPSS lasers
Q-Peak Applied Photonic Systems, Inc. - DPSS lasers, contract R&D
Quantronix Corporation - High power solid state lasers.
Quantum Technology, Inc. -- NL optics, EO, HV drivers, etc.
Radiant Dyes - Dye lasers, accessories, more.
Quarton, Inc. - Laser pointers, laser sights, laser tools. more.
Raicol -- Nonlinear and electrooptic crystals and elements
Rainbow Photonics AG (Switzerland) - DPSS lasers, more.
Rocky Mountain Instrument - Electro-optics system design, dev., mfg.
Rofin-Sinar Technologies - High power CO2, Nd:YAG, diode lasers, markers
Reaserch Electro-Optics (REO) - Optical coatings, tunable HeNe lasers, more.
Roithner-Lasertechnik (Austria) - Diode lasers, LEDs, laser components, more
Rolyn Optics California - Optics for Industry
Ross Optical Industries - Optics of all kinds
Semiconductor Lasers International Corporation - Laser diodes.
SDL, Inc. -- High power laser diodes, subsystems, and accessories.
SensorPhysics - Laser beam diagnostics instruments
Science and Technology Center FIRN (Russia) - LSB DPSS microchip lasers, modules, systems.
Sensors Unlimited, Inc.
Shanghai Uniwave Technology (China) - DPSS Lasers, optics, crystals
Sharp Microelectronics of the Americas - Optoelectronic Components
Sony Laser Diodes
SOPRA, Inc. - High energy excimer lasers and optical instruments

Spectragen, Inc. - Laser crystals, IR and UV optics, more.
Spectracom Inc. 980nm Laser Products
Spectra-Physics Lasers - Lasers and laser systems, optics, etc.
Spectronika Ltd. - CV lasers and systems
Spectron Laser Systems - Nd:YAG and sealed tube CO2 lasers
SPECTRAL laser - High power HeNe, sealed CO2 lasers, power supplies
StockerYale Inc. (formerly Lasiris, Inc.) - Lasers for structured lighting, more.
Sunlit Systems Co. (Taiwan) - Green laser modules & pointers, laser projectors
Superconix, Inc. - Laser crystals, non-linear crystals, more
Synrad - CO2 Laser Manufacturer
Litton/Airtron/Synoptix - Laser and non-linear crystals
Thorlabs, Inc. - Optics, laser diodes and drivers, LD database
Thomson-CSF Laser - Lasers for science and industry
Thomson-CSF Laser Diodes
TOPTICA Photonics AG - Tunable laser systems, laser diodes, optical disk testers, more.
Toshiba Optoelectronics -- Visible Laser Diodes
Transverse Industries Co., Ltd. - Green DPSS laser modules, other laser products
TuiOptics GmbH (Germany) - Tunable and other diode lasers
U-Oplaz Technolgies, Inc. - Non-linear crystals, optics. Distributor for CASIX
Unique-m.o.d.e. - Customized high power diode laser systems
Universal Laser Systems, Inc. - Sealed RF excited air-cooled CO2 lasers
Uniwave Technology - DPSS, non-linear optics, CASIX dist.
ValpeyFisher - Ultrasonics and Optics
Vector Technology Limited (UK) - Diode laser modules, sensors, comm. systems.
VLOC - Laser and non-linear crystals and optics
VLOC - Laser crystals, doublers, polarizers, and other optics
Wavelength Electronics - Laser diode drivers, TE coolers, heaters
World Laser Optics - High power DOEs, laser pwr meter, software, more.

Laser and Optics Related Organizations & Publications

CORD - Center for Occupational Research and Development
CRC Press - Electro-Optics/Lasers
CVRL Color & Vision database

EIO - Laser Information and Technical Forum
Industrial Laser Solutions
Lasers & Optronics Magazine
Lasers & Optics - Web Science Resources
Laser Focus World - Magazine and services
Laser Institute of America - Laser Safety
LEOS - IEEE Lasers & Electro-Optics Society
Optical Society of America
Optics.org - The Photonics Resource Center
Optoelectronics World
Opto & Laser Europe
OSA U. of Ill. Stu. Chap. INet Educ. Initiative - Optics Breadboard
Optics and Epics, Physics and Fiction
Photonics Online - Info on laser, photonics, optronics industries
Photonics Online Online Discussion Forums
Photonics Tech Briefs
Photonics Spectra Online - Photonics.com
SPIE - The International Society for Optical Engineering -- The Optics, Photonics, and Lasers Resource
UKLEO - UK Laser and Electro-Optics Association

Laser and Optics On-Line Auctions

" ADD_DATE="932911631" LAST_VISIT="1023449855" LAST_MODIFIED="932911616">eBay Auction Search: Laser Equipment by Type

LabX Magazine: Auction Page
eBay Auction: Main Page
eBay Auction Search - Laser Equipment by Type
eBay Auction Search: Laser and Related Stuff
eBay Auction Search: Laser Power Supply and Exciter
eBay Auction Search: Specific Manufacturers' Lasers (Includes Ion,HeCd,CO2,other)
eBay Auction Search: Specific Manufacturers' Lasers (Mostly HeNe)
eBay Auction Search: Interesting, Strange, Old, Vintage Lasers
eBay Auction Search: Laser Light Show Items
eBay Auction Search: Transformer and Vacuum Equipment
Tradinglounge.co.uk - The UK fibre optics auction site

Light Show Sites and Manufacturers

Argon Attraction's (Philippines) - Laser show design, presentation, rentals, sales.
Arrow Sound, Light, and Laser (Swiss)
Cambridge Technology Home Page
Cosmic Laser Light Entertainment's Home Page
Digi_Art Lasershow und Multimedia
EIO - Laser Light Show Hyper-Email Discussion Group
EIO - Laser Light Show Information and Technical Forum
ES Lasersysteme (Germany) - Laser show components and software
The Entertainment Laser Association (E-L-A, UK)
G-Beam - Equipment for small laser show
How Laser Shows Work - Laser F/X International
International Laser Display Association (ILDA)
International Laser Productions (Indonesia) - Includes DPSS modules
IRIS - Laser Systems and Entertainment
J and K Laser Productions - Laser light shows
Jason Lavoie's Laser Show Lasers Page
JM Laser Display - Catweazle system and DPSS laser
Laserdisplay - CATWEAZLE Pro (jmlaser.com)
Laser Electronics Ltd. - Laser shows and displays
Laser F/X International - Home Page
Laser Lightshows Watching and Making (Excite)
Laserforum - Audio-Visual Laser Presentations
Laser Images, Inc. Laserium - Light show equipment
Laserist Magazine/ILDA news, tech focus, links, photos
Laser Laser Production - Laser light show productions
LazerMagic - Laser shows & equipment
Laser Show Technology (laser.shows.org) - Inside a galvo scanner.
Lasers.org - General purpose laser and light show portal
Laser Spectacles, Inc. - Laser light shows production
Lasertronics - Laser shows, holographic projections, etc.
LasPro Lasertecknik -Show laser systems and laser show production
Leintz- Laserskanner
LOBO Lasersysteme - Light show equipment
LPD - Laser Products Development - Light show equipment and software
Make your own laser show! (Silicon Valley Services)
Mobolazer - Light show equipment
MVS Lasertechnik - Laser display systems, software
Nitelite Lasers Products & Services
NML - Laser Light show equipment, software
Oracle Laser Productions (Australia and Singapore)
Pangolin Laser Systems - Laser show software

Hubert Pissavin'a Mural Display by Laser (French)
Precision Projection Systems - Laser show systems, components, software
Redline Lasers - Laser show equipment
R.M. Engineering - Light show equipment
Showlasers - Laser light shows and equipment
Star Light & Magic - Light show equipment, parts, supplies
Technological Artisans - Laser show rental, purchase, components.

Barcode Scanners

BarCode 1 WebSource Finder (Russ Adams)
TAL Technologies - serial data acquisition including barcode

Color/Perception/Vision Sites/Information/Links

Color FAQ - (poynton)
Color Representation (udayton.edu)
Color Science (Bruton)
Color Space Definitions (Barco USA)
Color Spaces (John R. Smith)
Color Theory (ukans.edu)
efg's Palettes and Colors Lab Reports
Film Color Space and Other White Papers (Puffin Design)
Gamma FAQ - (poynton)
LAB Color Space (linecolor)
Light and Color (Phys 1230) (U. Colorodo)
Painting by Numbers - How we see the colour spectrum
The Representation of Color Metrics and Mappings in Perceptual Color Space (Steve Boker)
Vision Science Links - Lighting Research Center (RPI)
Where's purple or How to Plot Colors on a Computer Screen

Fiber Lasers

IAP R&D topics of the research group fiberlasers
IRE-POLUS Group - Fiber lasers

Hobbyist/Personal Laser and Optics Sites

Argon Laser - Miscellaneous ALC-60X photos

Buffo's Laser Site - Description/photos laser/optics
Cyberimage's Hobby Page (Aaron Henry)
Doug Dulmage's Pages - Includes laser display, engraving, etc.
Richard Everett's TCB50 CO2 Laser Photos
Gento's Laser Page (German)
Ivan Gomez's Laser Show Page
Ivan Gomez's Coherent I-90 Photo Gallery
JK Laser Productions Technology Page - Home-built lasers, CR-52, projector, more.
Kevin's Uniphase DPSS Laser Disassembly Page
Martijn's Laser Pics - ALC68, TIM622, more
Matthijs Amelink's Laser Page - Home-built laser scanning systems
Mazz's Laser Photo Gallery - 50 mW and TIM622., and ALC68
Mike's Argon Laser Switchmode PSU Hacking
Mitch's Sharplan 3000 YAG Laser Conversion Project - Improving beam quality
Poul's CLM 4 Cambridge Argon Laser Page - photos. description, request
Pasi's Laser Page - HeNe, Argon ion, etc.
Eric Reiter - Includes external cavity stabilized diode laser project
Scott's Tesla Coil, Lasers, and Other Stuff
Tele Monster's Homepage > Hobbies > Lasers
TMLaser Pro Systems - Includes ALC68, GM20, Colorbox, and optical bench pics, more
WL's Laser Project Page - Home-built SMPS ion laser PSU and more

Holography Sites

Amateur Holography (Mirror of SAS Holography Page) - Much info
Yohoo - Holography Sites
3D Imagery - A Hologram Production Site
3D Imagery - Laser pointer holograms
EIO - Holography Hyper-Email Discussion Group
EIO - Holography Information and Technical Forum
Holocom, Inc. - Holography informatiion
Holografie - Do it yourself - So einfach wie noch nie !
Holograms and 3D Films - Simple descriptions
Holophile , Inc. - Hologram displays for marketing.
Holostar - Courses, forum, gallery, links
Holoworld - Laser pointer holography
Holoworld - The Internet Webseum of Holography
Jon's Holography Page - Description, setup, books, and many links
MIT Media Lab - Spatial Imaging Group

Royal Holographic Art Gallery - Includes holography FAQ
VOXEL - Medical Imaging: Holograms from CT and MRI data

Miscellaneous Laser and Optics Sites

3D Digitizer - Diff Scan - Laser + diffraction grating triangulation
3D Laser Art Co. (3D Engraving in Glass and Quartz)
Accu-Right Corporation - Materials fabrication using Mistubishi CO2 lasers
Aculux - Optical triangulation laser rangefinders.
Almaz Optics, Inc. - Optical materials, components, nonlinear crystals, more.
The Amateur Interferometer Group
The Amateur Telescope MakingPage
American LaserWare - Laser marking software
Cable U. - Everything you ever wanted to know about fiber optic cabling
Canterbury Ring Laser Project
Center for X-Ray Optics - CXRO
Coherent Technologies, Inc - Eye safe laser based remote sensing systems
Control Laser Corp. Diode Pumped YAG Pics
Dakotatrk21's Lasers Page - Argon and light show stuff
DigiLens - Electrically Switchable Optical Technology
Digiscape VR - Laser rangefinders and laser mapping products
DN Labs Dye Laser Technology- Solid state dye laser R&D
EdgeWISE Tools, Inc. - Laser cutters for fabric, textile and airbags
Elprocom - High voltage devices and systems
E-O Devices - Pulsed laser diode driver, optical receiver, laser rangefinder
Fiat Lux - Student project dealing with light
Fiber Optic Fabry-Perot Interferometer Page
FT-300 Night Vision Scope Exposed
The Garching Frequency Chain - Precise optical frequency measurements
GSCI-IR Optics - Night vision optics
Holoverse - 3D Displays
IEEE ToonTime February 1999 - High power laser pointer
J.K. Erwin Corporation - Small Beam Shear Interferometer
KB2TCQ (Eric M. Stroud) Laser Page (Includes homebuilt lasers)
K-Space Associates - Laser based thin film strain monitor
Laser 1, Ltd, - Laser cutting
Laser-Based System Achieves Cinematic-Quality Projection (Photonics Online)
LaserWorld - Laser selection consulting
Linden Laser Systems - Large screen laser projector
LMI - Non-contact measurement and control

McShane, Inc. - Temperature and other process controllers
MetroLaser, Inc. - Holographic non-desctructive testing, themometry, more.
NASA Langley Photonics Group Databases - Lasers/fiber/etc
NEC Laser Specifications - HeNe and argon ion
Newton Research Labs, Inc - Vision systems, laser trackers, more
Optical Coating Library (JK Consulting)
Types of Optical Media Used in the Comm Industry (Testmark.com)
Optics for Research - Custom optics
Paul's OptoInfo Pages
Photonics Jobs Inc.: Placing professionals in the Lasers, Optics and Photonics Industry
Photonics Online: Virtual community for the imaging industry
P.T.G. Precision Technology Center Laser Glass Cutting Systems
REFLA CO2 Laser (Gil Teva)
Richard's Laser Photos Page - Laakmann TCB-50-II 90 W waveguide CO2 laser
Siltec - Fiber Optic Sensors
Tele Monstor's Laser Show Site - FAQ, photos, manuals, forums, links, software
Transimpedance Photodiode Circuit Spreadsheet Modeling
Zech Laser - Cutting systems including laser, water jet, plasma; laser shows, 2nd hand.

Appliances Sites/Information

A-1 Appliance Parts - Includes repair forum
A Two-into-one Homemade Neon Dimmer
All Appliance-Parts.Com - Parts, on-line chat, email help
All Appliance Parts Inc. - Parts, on-line chat, email help (same as above)
American Induction Heating Corp. - Includes some technical info.
Appliance411 - Appliance purchasing, service, repair, links, forum, more
Appliance Aid - Large appliance info, repair, links, parts/mfgs, email help, more.
Appliance Clinic - Washers, Dryers, Refrigerators
Appliance Service Center
Appliance Repair Forum
Appliance Repair Net - EB Large appliance repair manuals for sale
Battery Technology Inc. Home Page
Cagle's Secure on-line sales of JennAir, Kitchenaid, Appliances and Parts
Cadex - Battery and charger FAQs
Calrad Inc. World Wide Web Site
COLIN Electric Motor Service
DALE Electric Supply
Fixitnow.com - Large appliance repair info/forum/email help

Garrell's Appliance Center / Service, Repair, Parts
Gracie Appliance - Htg & Clg Home Page
Gracie Appliance - The Fix it List
Grainger - Equipment and supplies
Guide to Worldwide Plug/Socket Patterns & Power Mains (Panel Components)
How A Dimmer Switch Works (swbell.net)
Mike's Clock Clinic's Web & FTP Pages
Point and Click Appliance Repair - Appliance parts and free repair help
Power Factor Article (Microconsultants)
Probe 100 Plus Power Monitor
RepairClinic.com - Large appliances includes tips, email help
Reversing and Repair of Electric Motors
Sears PartsDirect - On-line store
Single to Three Phase Convertor Info (mwn)
Specialised Electro Motion - Some motor info
TAS Appliance Parts
The Fridge Doctor - Operation/maintenance/repair of refrigerators/freezers
The Old Appliance Club
The Toaster Museum Foundation
Therm-O-Disc Home Page
The Virtual Repairman - Some basic info, free email repair advice
World Electric Power Guide

Audio Sites

8-Track Heaven -- 8 Track Tapes, Players, Eight Track Tape Collecting, and 8-Track Mind Zine
Angela Instruments - Audio components and kits
Antique Electronic Supply Online!
Audio Analogue(tm) Unofficial WWW page
Audio Electronics Page (Claudio Bonavolta)
Audio Service Manuals - A. G. Tannenbaum
Audio Service and User Manuals - Marty Gasman
Steven L. Bender's Home Page
BKB Labs - Technical/service literature for vintage audio equipment
DMZ Schematics
Duncan's Amp Pages - Guitar amps, tube info, design tools
Duncan Amp's - Vacuum tube data locator
Steve Ekblad's Audio Related Internet World Wide Web & FTP Sites ©
GEO - the Guitar Effects Oriented Web Page

GM's Hi-Fi page - Audio Mfgs. Links and more
Harman Kardon Service Manuals
HeadWize - A NonProfit Resource Site for Headphones and Headphone Listening.
HeadWize - Library (Audio Projects)
Milbert Amplifiers, Inc.
Musical Instrument Technicians Association - Specialize parts sources
Nauck's Vintage Records Turntable Stroboscope Disc
Peavey Electronics Corporation Internet Site
Peavey Electronics Support Center
Stork Audio's Home Page
Tube Amp FAQ (~keen)
Tube Amp Troubleshooting (~keen)
Tube Asylum - Vacuum tube amp, etc., BBS
Tube Audio Construction - The Engineering Musician Web Magazine
Unique Audio Products (Humor, really!)
Valve Radio Repair and Restoration

CD/DVD/LD/MD/Optical Disc Technology Sites

Adding a Digital Audio I/O to the Sony D141
ANEX Electronics (Poland) - CD optical pickup photos
Audio Compact Disk - An Introduction (University of Washington)
CD/DVD-System Solutions - Philips Laser Optics
CD/DVD Technology - Specification 'color' books
CD Media World - All sorts of CD and DVD information
CD Page - General info
CDROM - Philips
CD-R FAQ (Andy McFadden)
CED Magic (Obsolete RCA system)
Cinram International Inc. - CD/DVD manufacturing
Compact Disc Technology (University of Washington)
DVD - CD Technology at a glance - Welcome to Philips Laser Optics
DVD Central @ E/Town: The Home Electronics Guide
DVD Demystified
DVD FAQ
A Home Built (almost) Panasonic/MKE/CR56x CD-ROM Interface
HP SureStore CD-Writer Technical Intro
I.G. Electronics - LD and some model specific info.
Interface Standards - CDROM, ATAPI, PCI, more (fission.dt.wdc.com)
Leopold's Laserdisc page
MD Community Page: User and Service Manuals

- [MD Community Page: Homepage]
- [Metropoli files - CDROM info and drivers]
- [The MiniDisc Community Page]
- [The MiniDisc Page]
- [NEC CDROM information]
- [OSTA Home Page]
- [Philips Sound & Vision: New technologies - CD, CDI, LD, DVD, etc.]
- [RadioPro Compact Disc Page]
- [Repairing your PSX laser and other faults.]
- [Sony Playstation Inside Unveiled - Photos, block diagram, etc.]
- [Sony Playstation - PSX controllers/pinouts/etc.(Modstation)]
- [S/PDIF Interface Standards]
- [Tandy - Portable CD/Cassette Players]
- [TVI TAFE - Electronics - Computer Peripherals : CD-Rom technology]
- [VIDCAM Video for Sony Playstation parts, electronic kits, more.]

PC Repair/Upgrade/Maintenance and Datacomm

- [Focus on PC Support from About.com]
- [The PC Technology Guide]
- [ATA-ATAPI.COM -- ATA ATAPI IDE EIDE -- by Hale Landis]
- [CCC - Conectors and Standards: voice, data, and video]
- [Computercraft - THE PC repair/upgrade info site]
- [Peter den Haan's EIDE/Ultra-ATA storage page]
- [HardSeek - Hardware mfgs complete web list.]
- [HP Drivers, etc., ftp directory]
- [The Hardware Book - Circuits, pinouts, cable and adapter descriptions, more.]
- [Interface Standards - CDROM, ATAPI, PCI, more (fission.dt.wdc.com)]
- [Metropoli files - CDROM info and drivers]
- [Mauritron Tech. Services - Service Info: VCR, TV, PC Repair]
- [Nick's Pinouts Collection]
- [PC-DISK - Hard Disks, Layouts, Jumpersettings]
- [PeteWeb - PC Refurbishing, old card info]
- [Ray's Packard Bell Web Site]
- [Solid-State Optical Mouse Sensor with PS/2 and Quadrature Outputs]
- [Superput's Hardware Page - PC pinouts, monitor test patterns, links.]
- [The PC Guide! - Config., upgrade, troubleshooting, repair]
- [Troubleshooters.Com: PCs, Win95, Internet, etc.]
- [VESA Home Page - Video Standards Association]
- [VGA timing information]

PC Video FAQ : Circuits for Fixed Frequency Monitors
The RAM Guide
Sandy Bay Software's PC Webopaedia - WELCOME!
Communications cables (David Barnett)
Georg Schwarz's hardware reference page
SOHO DataCom - Telephone, datacomm, other
Sutton Designs Network Power Protection Products
Trish's Escape from Hardware Hell Computer Help
Ultra Spec Cables - Cables, adapters, PCI FF monitor card.
The Tech Page - Hard drive info

Tech Support Sites

Apple Tech Info Library - Search
Apple Service Manuals
Aztech Tech Support Page
Creative FTP Index: /pub/creative/drivers/sb+sbp
Epson FTP File Download Help for Zipped Driver
E-MAC - Apple Archives
Logitech Customer Support
NEC Technical Support
Outbound Service & Support

Processor Sites

ATX Motherboard Specification
Cyrix Online - Cyrix Legacy Products
Intel - Microprocessor Quick Reference
Intel Motherboards
Intel Secrets -- What Intel Doesn't Want You To Know
MCU/MPU Internet Resource List

Printer/Photocopier/Fax Sites/Information

Links to fax machine manufacturers sites
Affordable Photocopy, Inc. - Wholesale Copiers, Parts & Supplies
Affordable Corp. - Copiers - Maintenance Guide
All Laser Service - Laser printer error code/troubleshooting info
Ames Supply Company - Copier service tools, parts, etc.
Apple Service Manuals

- [Bell Copiers (UK) - Parts, accessories, consumables, spares., advice.]
- [BrokenFax.com - FAX machine repair, info, links, consulting]
- [The Copier Network - Copier Forum]
- [The copier, printer and fax network for dealers and suppliers - (Asay Publishing)]
- [Do-It-Yourself InkJet and Laser Printer Repair - fixyourownprinter.com]
- [HP LJ Error Codes and Remedies (ftp://ftp.printerworks....b/printers/)]
- [HP - Service Parts Information]
- [HP - PartSurfer]
- [I.E.S.G. - UCB: Laser Printer Trouble Shooting (jjardine)]
- [A Laser Printer Book by Steven Burrows]
- [Copier Info and Llinks (Smarka)]
- [Image Control - All about inkjet inks and more]
- [Inkjet Printer Tips and Cartridge Care]
- [Inkjet Printers And Refilling Cartridges - Money Saving Hints]
- [Laser Wizard - Including laser printer test equipment]
- [Parts Now! - Parts and service, info]
- [Parts Now! - Print engine information]
- [PrinterCartridgeInk.com - Includes the S.E.R Printer Repair FAQ]
- [The Printer Works - Laser Printers]

Small Engines/Equipment Sites/Information

- [Doc Systems-Small Engine & Power Equipment Resource Center]
- [Lawn Mowers and Tractors Forum]
- [Manufacturer's Supply - Small Engine and Lawn Mower Parts]
- [M & D Mower Repair]
- [Neil's Tecumseh Throttle and Carburetor Linkage]
- [Oscar Wilson Engines & Parts Inc]
- [Small Engines Discussion List - Signup]
- [The Small Tractor FAQ - Homepage]
- [Tower Hobbies - Radio Controlled Engines Made Easy!]
- [Transistor ignition circuit patent (4163437)]

SMPS Information

- [ATX Power Supply Repair - Nuts and Volts Magazine]
- [IR, Corp. - Electronic Ballasts using IR215X Devices (AN995a)]
- [IR, Corp - Electronic Ballast. Compact Fluorescent (irplcfl1.pdf)]
- [IR, Corp - Electronic Ballast. Linear Fluorescent Tube (irpllnr1.pdf)]
- [IR. Corp - Ultra-Compact F-lamp Ballasts using IR51 (DT95-3)]

International Rectifier - Lighting products and applications
International Rectifier Corporation
Lambda Electronics Inc./ Main Menu
Maxim Pirate Applications Web Site
Powersupplies.net - Info, links, free software, more.
Power Inverter Schematics (JEM Electronics Downloads Page)
Power Integrations - Reference SMPS Designs
Ridley Engineering, Inc. - Switching Power Supply Products and Services
Simple Inverter (Aaron Cake)
Superput's Electronics Page - Inverters, SMPSs, PICs, glossary, links
Switching-Mode Power Supply Design (cyberg8t.com)
Switching-Mode Power Supply Website Links
Easy Design of the Optimum Topology Boostbuck (Cuk) Family of Power Converters
200W ATX PC POWER SUPPLY
TI Off-Line SPMS Failure Modes PWM Switchers and DC-DC Converters
Zetex - Application notes.

Strobe/Camera Sites/Information

Don's Xenon Flash and Strobe Page
EG&G (now Perkin-Elmer) Technical Papers
The Hacker's Guide to the SX-70 (SX-70-FAQ)
Prototype Studio Flash - built from decommissioned photocopiers
Strobe Light Schematic (execulink.com)
Surf Point - Business:Companies/Industries:Photography
WJ's Infrared & Photography Homepage
Wolf Camera & Video Home Page
Xenon Corporation - High performance Xe Products

Television Sites/Information

AnaTek Corp.- VCR, TV, Monitor Tech Tips, etc.
B.A.D.A.R.C. TV Fault Database - Mostly UK models
Basic Principles
Blue Ribbon TV Service (Links to suppliers)
Broadcast TV - Tutorial (arrakis.com.au)
CRT Emission Tester and Rejuvenator
Curt's TV Repair Tips
DBS DISH Satellite News and Information
Degaussers - Data Devices International

Display Technologies
The Electronic Info Center - TV, VCR tech-tips
Electronique Grand Public (French) - TV site
Electronix Corp. - VCR, TV, Repair, Parts, Service
Electronics Repair (perm.ru) - info, links, schematics, more
FCC TV Interference Handbook (copy on Kyes TV Web site)
Colin's TV Interference Handbook (Portions of FCC doc/more)
GEKCO - Video test pattern generators
High Tech Tubes (CRTs and PPs) - Popular Mechanics
Houston Amateur Television Society, Inc.
Mauritron Tech. Services - Service Info: VCR, TV, PC Repair
Mitsubishi TV Service Modes
NTSC Television Tutorials (Williamson Labs)
PAL TV and video faults advice (Martin Gumbrecht)
PALsite - The home of the PAL video system
Panasonic TV Service Modes
PTS Electronics Corp. - Refurbished TV Parts
Quick Clip(tm) - In circuit RCA/GE/Proscan EEPROM prgr.
Sams Technical Publishing (formerly Howard Sams)
Sams' Photofacts
Satellite Reception (Magnavox)
Satellite TV Information and FAQs
Samsung Display Devices(korea tube lcd sdd brown tube picture tube samsung)
Schematy Tv - Television Schematics - A few at least
SGS-THOMSON | TV, Monitor & VCR
Solara (and I assume other) Shematics - Need specific file name
Sony TV model KV-F29, Chs G3F Service Page (~nu-lifetv)
AWH: SONY Service Mode (NTSC)
James Sweet's Sony/Trinitron aperture grille/dropped monitor photos
RadioShack Product Support
TenLab International TV Format info
TenLab Multisystem Digital Video & TV Converters PAL SECAM NTSC
Ten Pin Video Camera Pinout
Tru-line Video TECHnologies - Video adjustment FAQs
TV, Audio and Video Repair (Spanish)
The TV Set (Magnavox)
TV Technical Assistance (Dennis Viereck)
UK Satellite TV Spares & Repairs
Video Standards (AMRS)
Video Standards Overview (Tektronix)

VCR Sites/Information/Photos

- AnaTek Corp.- VCR, TV, Monitor Tech Tips, etc.
- The Camcorder (Magnavox)
- Certified Electronics - Camcorders, Beta and VHS VCRs. and TVs
- Disassembly and Inspection of a VCR - EE498 Final Project
- DIY Article - DIY Cleaning your VCR (Secrets of Home Theater)
- The Electronic Info Center - TV, VCR tech-tips
- Electronics Repair (perm.ru) - info, links, schematics, more
- Electronix Corp. - VCR, TV, Repair, Parts, Service
- Howstuffworks - How VCRs Work
- Leopold's Home Video Formats Page
- Macrovision
- Mauritron Tech. Services - Service Info: VCR, TV, PC Repair
- PAL TV and video faults advice (Martin Gumbrecht)
- RadioShack Product Support
- Ronald's VCR Knowledge Page - Basics including diagrams and photos of signals
- SGS-THOMSON | TV, Monitor & VCR
- Studio Sound Service VCR Parts - Frank Fendley
- VCR Parts and Help for the Do-It-Yourself Technician
- VCR Repair Database (vidcam.com.au)
- VCR Repair Database (fixer.com).
- VCR Repair Instruction (fixer.com) - Good stuff!
- Videotape Systems Theory
- Video recording formats - analog and digital (Tomi Engdali)
- An introduction to VCRs (Kuhn, EE Wash)
- VCR Q & A - consumer oriented (bradley.edu)
- VIDCAM Video Repair Page - Basic camcorder maintenance
- The Video Cassette Recorder (VCR) (Magnavox)
- Video University On-A-Disk

Game/Arcade Sites/Information

- Arcade Nirvana
- Jeff Frohwein's Technical Central - Game Boy repair
- Randy Fromm's Web Site - Everything for arcade games
- Mike's Arcade Shop
- Myarcadegames.com - Arcade game restoration
- Pinball, Video and Jukebox corner - Flippers.com
- Pinball Machine Repair (Marvelous Marvin)

- Rec.Games.Pinball Archive
- The 'Wiretap' Arcade Game Collector's Archive
- www.pinball.com.au - All pinball

Miscellaneous Repair/Info

- http://www.promelec.ru/ (Russian) - Consumer electronics schematics
- Cable U - Training and technical support on communications cabling
- Connections (Magnavox)
- Display Products Technology (UK) - LCD Repair, Notebook Sales, Laptop Display
- Electrónicos - Maintenance and repair forum (Spanish)
- Organ Service Corporation - Home Page
- RadioShack Product Support - Audio, automotive, computer, video, phone, more.
- Repairs.Com - Find a repair shop or contractor, more
- WR-ALC/TILTA Tech Data Home Office - View Tech Orders

Monitor Sites/Information

- Welcome to the comp.sys.ibm.pc.hardware.video FAQ
- ADCC Technical Systems, Inc. Home Page
- Al Salvage's Monitor/Terminal Repair Database
- AMR - Monitor repair tips
- AnaTek Corp.- Monitor schematics
- AnaTek Corp.- VCR, TV, Monitor Tech Tips, etc.
- Apple Service Manuals
- Aver TVGenie - NTSC/PAL to SVGA
- CADALYST: January 1998 22 Big Monitors Review
- CMM Inc. - Test Equipment and Monitor Sales
- CNC Monitors: Replacement monitors and parts for CNC equipment
- Consulenza Monitor (Italian)
- CRT Emission Tester and Rejuvenator
- Degaussers - Data Devices International
- Dell Monitor Information
- DisplayMate Monitor Test
- Display Technologies
- Display Technologies Monitor Repair Page
- Electrotek Electronics Page - Currently only a few monitor manuals and notes
- ESC - Monitor Mfgs, Links, Utilities
- GEKCO - Video test pattern generators
- Homr-built CRT Rejuvenator (jaypay)

Jerry's Monitor Fault Diagnosis Page - Info and links
KMR Technical Services - Monitor Repair/Technical Info
The Linux/XFree86 Monitor Database
LJ Enterprises - Semiconductors for monitor repair
MI Technologies - Monitor Schematics
Monitortest.net - Monitor Test Program
Monitor Schematics (v6llh.rsuh.ru)
Monitor Schematics Page
Monitor Adjustment Info
Monitor Adjustment Info
Monitor Specifications (hawks.ha.md.us)
Monitorworld - Monitor, cable, adapter database
MONITORY S - Monitor schematics and tech-tips
MμShield Magnetic Shielding
NEC Monitor Information
NIDL Monitor Reports - High performance monitors
Noahtec - Monitor repair tips, flybac, testing, more
Nokia - Ntest.zip monitor test program
Panellink Serial Digital RGB Interface
PassMark MonitorTest - Test monitors and LCD flat panel screens
Philips B.U. - Monitors
Philips Monitor Test Pattern Download Page
PC Monitor Specs - Computer Shopper 1994
RadioShack Product Support
Samsung Display Devices(korea tube lcd sdd brown tube picture tube samsung)
SciTech Display Doctor
SGS-THOMSON | TV, Monitor & VCR
SONERA Technologies DisplayMate Video Utilities
Sony Support: Displays - FAQ
Sony GDM1961 sync-on-green monitor on my PC
Snake Oil, Miracle Cures, and Monitors
Superput's Various Simple PC Monitor Display tests
James Sweet's Sony/Trinitron aperture grille/dropped monitor photos
Test patterns and images for TVs and monitors
Ultra Spec Cables - Cables, adapters, PCI FF monitor card.
Use your old Workstation Monitors with Linux/XFree86
VGA to workstation monitor FAQ
Video Standards Overview (Tektronix)

Microwave Oven Sites/Information

Richardson Electronics - Magnetrons specifications
AMI - Microwave repair parts
AWI - Microwave oven parts
All Appliance Parts
Jim Bryant's Microwave Ovens - Email help, links
How it works... Microwave ovens
How Things Work: Microwave Ovens
Microtech - How to Fix Microwave Ovens
Microtech - Microwave Oven Repair Safety Considerations
Microtech - Microwave Repair Database
Microtech - The Magnetron Tube: Structure and Operation
MiDES - Microwave Diagnosis Expert System

Manuals/Schematics

4door.com - Automotive Manuals, Wiring Diagrams and Service Literature
A. G. Tannenbaum - Service manuals.
AnaTek Corp. - Monitor schematics
Audio service Manuals - Marty Gasman
BOMARC Services - Reverse engineered schematics
Consolidated Surplus Manuals - Test equipment manual sales and rentals
Cooke International Second User Electronic Test and Measuring Equipment
Fixit USA - Consumer electronics service manuals
Heathkit Downloads (bama.sbc.edu)
Heathkit Manuals (Data Professionals)
The Heathkit Virtual Museum - Some schematics and info
Infotronix - Hard to find/out of print manuals, schematics, info
KDTV - Service Manuals
KODAK: Slide Projectors Family: Service Manuals
ManualMan - Vintage manuals for amateur, audio, and radio related equipment
Manual Merchant - Test equipment manuals
Manuals Plus - Test Equipment Manuals
Mauritron Technical Services (UK) - Manuals. publications, CDROM
Miscellaneous Service Manuals (acadia.net)
MI Technologies - Monitor Schematics
Raymond Sarrio Co. - Manuals
Sams Technical Publishing (Sams' Photofacts, etc.)
SBC Heathkit Manuals/Schematics Downloads
SBC Manuals/Schematics Downloads
Sencore Electronics Service Department

Service Manuals/Service Bulletins/VCR Diagrams CDROMs
Simpson Electric Operator's Manuals - Simpson test equipment
Treasure Chest Corp. - Owner's and Service Manuals. Many Brands/Types
Triplanetary Schematics/Diagrams
Michelle Troutman - Manuals for older equipment, test equipment, more
W7FG Vintage Manuals Homepage
Wizards Electronics - Over 85,000 manuals
W.J. Ford Surplus Enterprises - Test equipment manuals

Parts/Commercial Sites

Thomas Regional Directory
THE NETWORK - Electronic Buyers Directory
Online Technology Exchange Web
ReUse Industries Home Page; Resale, Used, Recycle, Salvage, Thrift, Non-profit
Parts & Supplies: Bry's Mail order list
Price Watch - Street Price Search Engine
TECNET - Largest Used Equipment Database of Surplus Assets
Toll Free 800 Numbers
Used Test Equipment and Used Semiconductor Production Equipment Dealers - Index
FedEx Rate Finder
United States Postal Service Rate Calculator
UPS - Shipping Information

Electronics Distributors

Action Electronics Homepage
Allegro MicroSystems Inc. (Sanken among others)
Allied Electronics Web Site, Servicing Your Electronic Needs...
Black Box On-Line Catalog
Bulb Direct - light bulb heaven
Calrad Inc. World Wide Web Site
Digi-Key Corporation Home Page
Farnell Electronic Components
H.V. Component Associates (HV diodes)
ICHE - Monitor schematics, flybacks, test equipment
Mouser Electronics
Newark Electronics
Radio Shack
RadioShack Corporation Home Page

Richardson Electronics, Ltd.
Tech America Home Page
Time Electronics: Capacitors Online
Wholesale Products - Homepage

Electronics Service Parts Sources

A+G Computerware Limited (UK) - Monitor replacement cables
Antique Electronic Supply Online!
Asti Magnetics - Flybacks, video heads, etc.
Audio Lab of Georgia - Jap. Semis, some TV, VCR parts
B & D Enterprises
Continental Modules - Factory direct broker of TV tuners, modules, parts.
Dalbani
DIEMEN - Replacement flyback transformers
Dreisilker Electric Motors, Inc.
Electro-Dynamics, Inc. - Service parts
Electronic Parts Center - Includes flyback and CD pickups
Fargo Enterprises, Inc. - Kodak repair parts, etc.
Flyback Transformers (Cactus Technology)
Flyback Transformers
Good Vibes Parts for Sale - Hard-to-fine, NOS inventory, A/V, etc.
Grainger Industries (motors, etc.)
Heathkit Educational Systems/Parts
I. G. Electronics (UK) - CD, LD, DVD service, parts, info.
I. G. Electronics (UK) - Original aser pickups.
LJ Enterprises - Jap semis, monitor and computer parts
MCM Electronics HomePage
NEI Nationawide Electronics, Inc. - Electronics components
Pacific Semiconductors Inc. - Homepage
Panasonic Magnetrons
Panasonic Parts and Service On-line
Parts Express Home Page
Ramsey Electronics - On-line Parts
Russell Industries - PRB Line distributor
Satcure - UK satellite TV & CB radio spares, & repairs
Sonyspares.com - Parts for Sony consumer and professoral A/V equipment
Techsonic - Semiconductors
Tritronics - Electronics Parts and Accessories
Wholesale Products Consumer Electronics Web Sites

Surplus Mail Order

- All Electronics Corp.
- Alltronics
- Angela Instruments
- B.G. Micro (Electronics, Kits, Surplus, Online Catalog)
- Bull Electrical (UK)
- C and H Sales Company - Electronic surplus
- CTR Surplus - Electrical, PSs, RF, Optics, more
- Dan's Small Parts and Kits
- DIY Electronics - Electronic Kits and Links
- Electronic Goldmine. Electronic Wholesale Surplus, Electronic Kits
- Electronic Rainbow
- Electronics Surplus - C and H Sales Company
- EIO Electronic Surplus
- Fry's Electronics - Ad Nauseam: Breakfast at Fry's
- Mark Hannah - Electronic Parts and Supplies - New and Surplus
- Halted Specialties - HSC Electronic Supply Homepage
- Herbach and Rademan
- Hosfelt (Specials include laser pointers, etc.)
- Information Unlimited - Weird Project Stuff
- Jameco Hompage
- MECI - Surplus Electronics - Mendelson's Electronics Co., Inc.
- Mega Surplus
- MPJA Electronics Mail Order Co.
- Murphy's Surplus Electronics
- Resources Un-LTD
- Scientific Surplus
- Silicon Valley Surplus Sources
- Surplus Electronics MECI
- Surplus Sales of Nebraska Home Page

Miscellaneous Parts, Kits

- A1 Parts - Electronic Kits
- All Electronics - New/surplus
- Almost All Digital Electronics - Kits and Software
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Gootee Systems - Curve tracer, surplus and used equipment, etc.
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Wid Industries - Buy, Sell, or Trade used Equipment
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Education and Tutorials

101 Science - Science Learning Center (www.101science.com)
ABCentral - Links to all sorts of educational resources
ACEE - AC Electricity & Electronics (D. L. Heiserman)
Alex's Library - Educational tutorials
Basic DC, AC, Devices, Circuits Problems/Solutions (sweethaven/203)
Basic Electronic Design, Build, and Test (gknott5413)
Basic Electronics (ualberta.ca)
Basic Electronics Circuits and Systems Explained (jadams)
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Basic Electronics (jhutton)
Basic Electronics (Graham Knott)
Basics of Electricity (engi202)
Brian's Electronics Page - ELCAD (Basic electronics CAD program)

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Dynamic Software Limited - Electrotechnology courses on-line
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Electronics Educational Links (ecai.pair.com)
Electronics: An Online Guide for Beginners - Home
Electronics tutorials links (Component Kits, LLC)
The Electronics Workshop
EPE - Basic Soldering Guide
Free-Seek Electronics - Free on-line courses
The Heathkit Virtual Museum
How Stuff Works - Introductory articles on common technology
How Things Work Home Page
The How Things Work educational program (kinsler)
Introductory Digital Electronics
Jason's Electronic Universe - Electronics Quizes
Learn Electronics (twisted-pair.com)
International Rectifier - Technical documents, basics
Internet Guide to Basic Electronics (John Adams)
NEETS - Navy Electricity and Electronics Training Series
NEETS - Navy's Electrical Engineering Training Series (mirror)
NIST WebBook
Physics Lecture Notes - PHYS 395 Electronics (ualberta.ca)
Play-Hookey! - Introductory digital electronics, computer, optics, etc.
Ray's Electtronics and Tutorial Page
Semiconductor Devices (latrobe.edu)
ThinkQuest - High school technology competition
Transmission Line Transformers - Theory
Twisted Pair: Learning center for electronics
TVI TAFE : Electronics and IT Home page
VIDCAM - Electronics formulas (vidcam.com.au)
Video University (includes VCR repair guide)

FCC Information

- The Code of Federal Regulations
- FCC ID Search Form (Old)
- FCC ID Search Form
- FCC RF Interference Handbook
- Federal Communications Commission (FCC) Home Page
- The On-line Equipment Authorization Database
- Sci.Electronics FAQ: Repair: FCC IDs

Patent Information

- USPTO Databases: Patent, Bibliographic, and AIDS
- Delphion Patent Server
- IBM Patent Server: Philips Patent 4835668 HV Power Supply
- IBM Patent Server: Melles Griot Patent 4649545 Compact gas laser
- IBM Patent server: Optical Feedback Locking of Semiconductor lasers. Patent #4907237
- IBM Patent Server: Cyonics Patent 4625317 Internal Mirror Laser
- IBM Patent Server: Wang SDP Patent 5129061
- IBM Patent Server: Sam's DDD Patent 4737921

Publishers/Publications

- The Art of Electronics - Horowitz and Hill
- The Computer Journal - Recent Issues of TCJ
- Delmar Publisher's Electronic Technology Resource Center
- EDN On-line
- Electronics Australia
- Electronic Design Online
- Electronics Repair Center Bookstore
- Elektor Electronics - the electronics and computer magazine
- The Engineering Musician Web Magazine
- Everyday Practical Electronics (EPE)/ ETI Magazine
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- Helios - Daily Science News
- How Things Work Home Page
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- The Institute of Physics
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Lindsay Publications
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Electrostatic Machines (Dr. Antonio Carlos Moreirão de Queiroz)
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- Medicine (NLM)
- Neodymiumarium - What to do with neat powerful magnets
- Press Release: The Nobel Prize in Physics 1997
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- Physics Forum
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- ResonanceResearch - Science museum electrical exhibits
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- The Sands of Time Mechanical Museum
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- Science News Online - The Weekly Newsmagazine of Science
- Science Projects (Headstrong)
- Science Websites (Santa Barbera Science)
- Scientific American - Amateur Scientist Index (SAS)
- Scientific American - Amateur Scientist Index (K2PGP)
- SciQuest - Scientific information and products search
- Scitoys.com - Simple science projects
- Search4science - Search for scientific info
- Shufflebrain - Giving salamanders frog thoughts and more
- Society for Amateur Scientists
- SAS Amateur Scientists' Forum (Archives)
- SAS Amateur Scientists' Forum (Postings Page)
- The Science Guide
- SciCentral: Gateway to the Best Science and Engineering Online Resources
- Tinker's Guild - Resources for hands-on science
- Tinker's Guild (SAS) Science Store - SciAm Amateur Scientist Archive CDROM
- TIPTOP/VLAB - Physics related simulations, animations, etc.
- Wonderquest with April Holladay
- X-ray Generation Forum (Mike Gray)

Weird Stuff

Amateur Science (Bill Beaty)
Sam Barros' POWERLABS! Science in action!
Barry's Coilgun Site
Can Crusher's Homepage
Electrum
Information Unlimited - Weird Project Stuff
Lightning On Demand Homepage
Muller Magnetic Technology Profile - Table Of Contents
Scientific & Medical Index Page (H. Kent Craig)
Tampere Anti-Gravity Report - The Journal of Ideas Issue ^
Virtual Theater: Very Cool and Unusual Information
Welcome to VoltNet.com!

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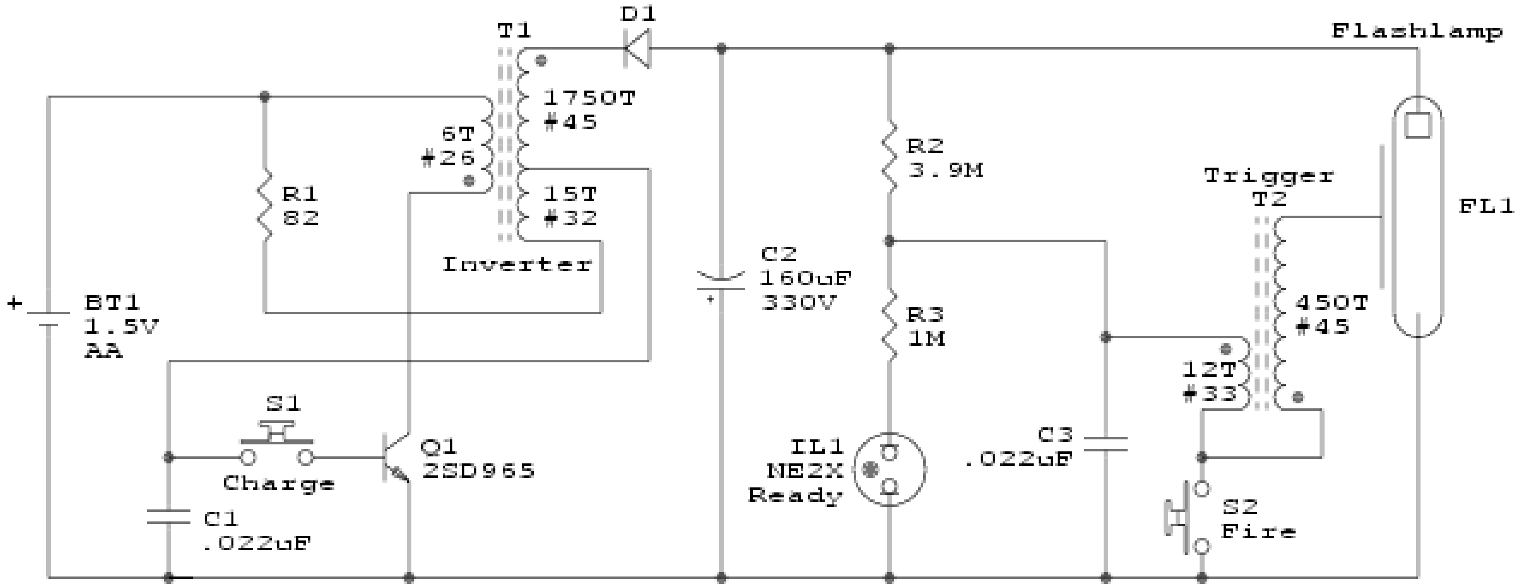
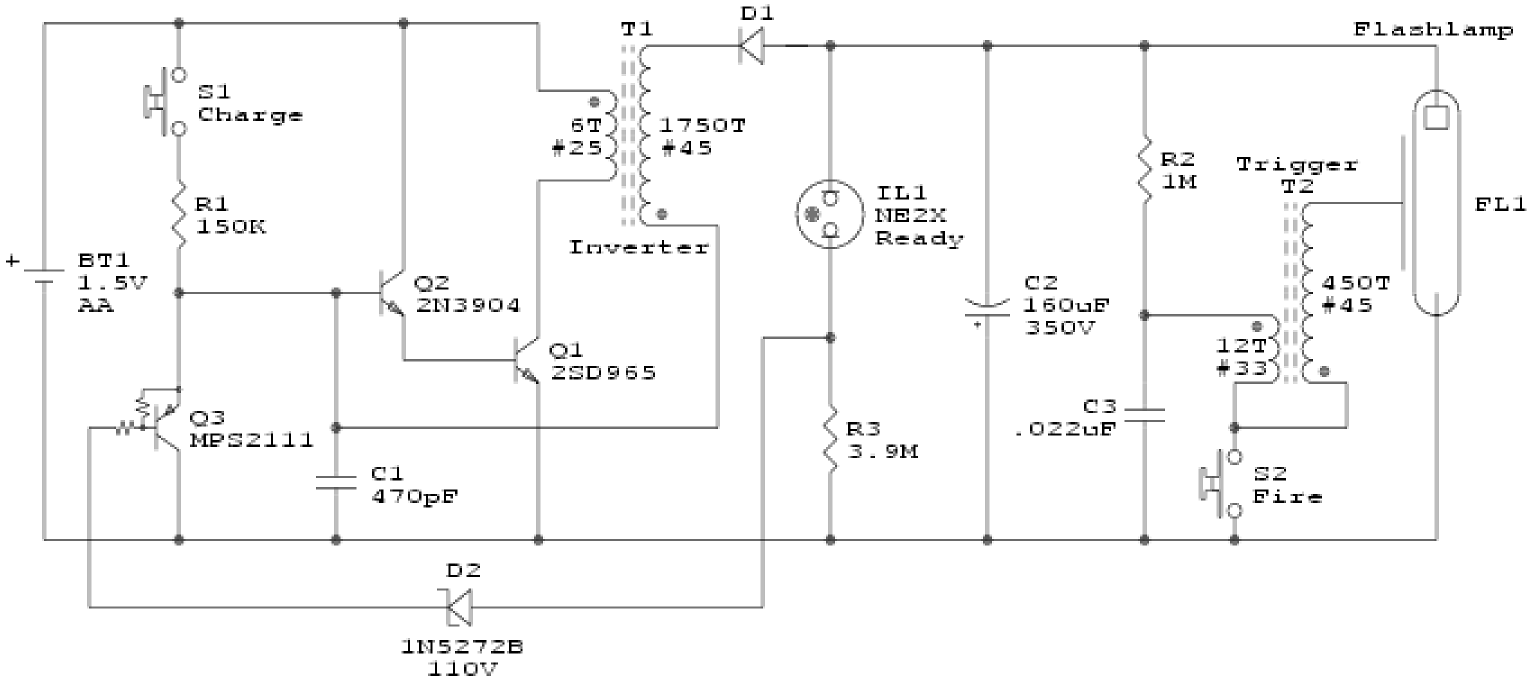
The Friden Web Site
Friden EC-130 Electronic Calculator
Datamath Calculator Museum
The Friden SRW
Collecting Calculators - www.geocities.com/SiliconValley/park/7227/
Calculating Machines - www.webcom.com
The Museum of HP Calculators
The Museum of HP Calculators - Motor Driven Mechanical Calculators
The Old Calculators Web Museum
Vintage Calculators

- Back to Sam's Neat, Nifty, and Handy Bookmarks Table of Contents.

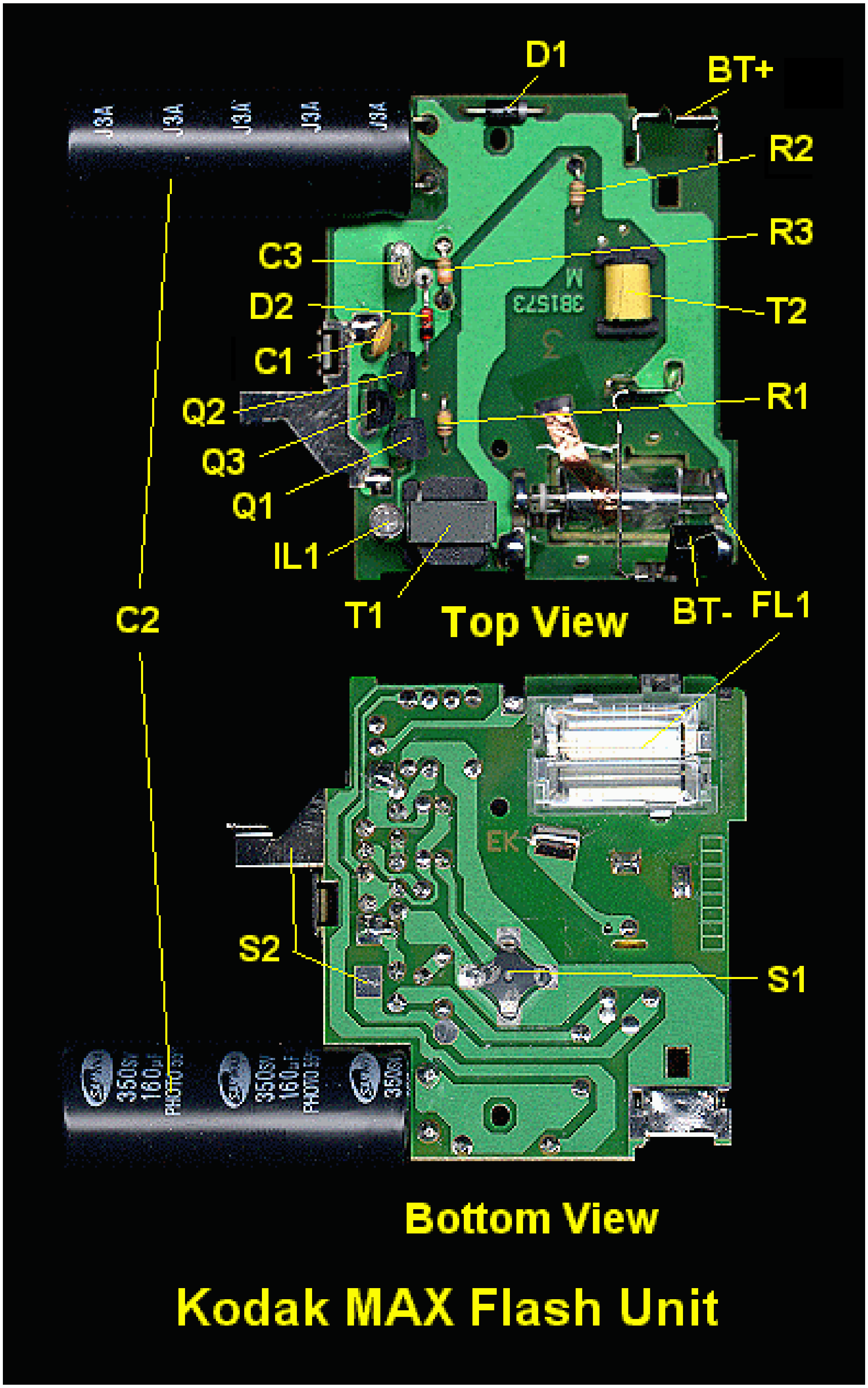
-- end V4.20e --

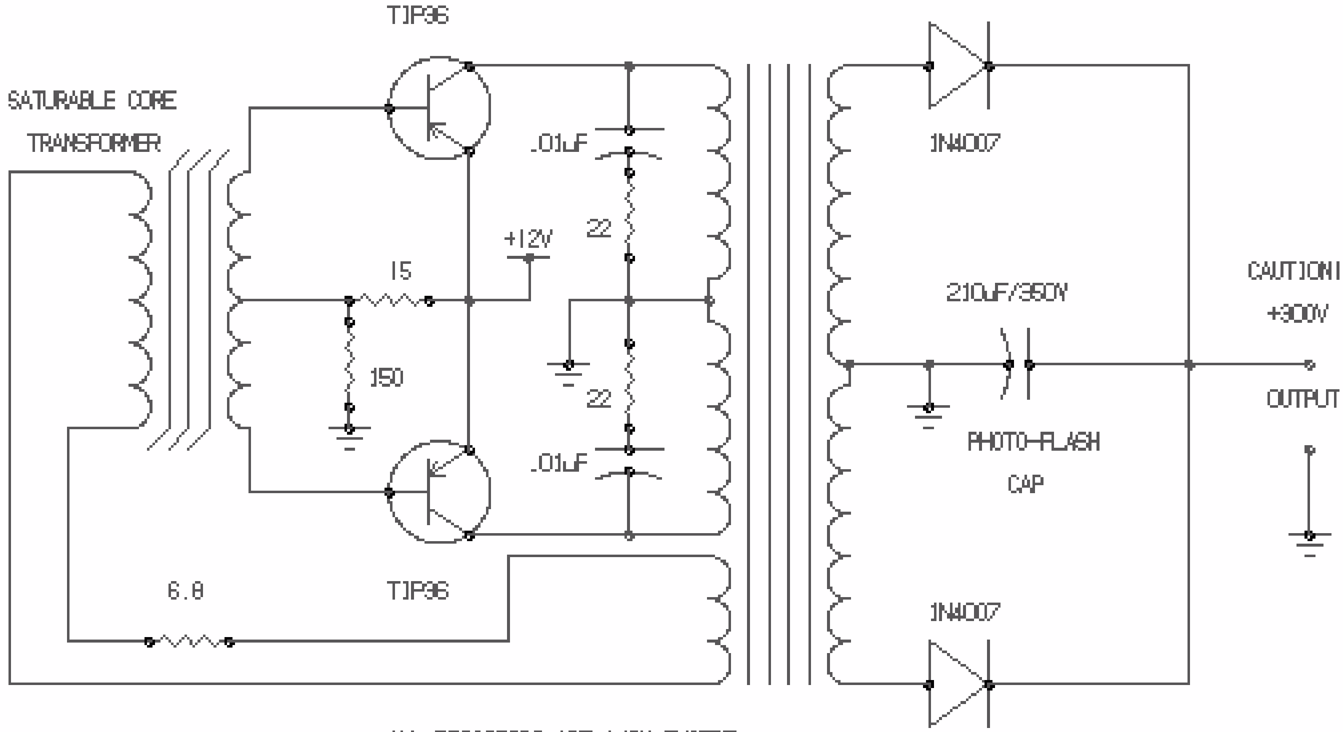


Kodak Funsaver Flash Unit



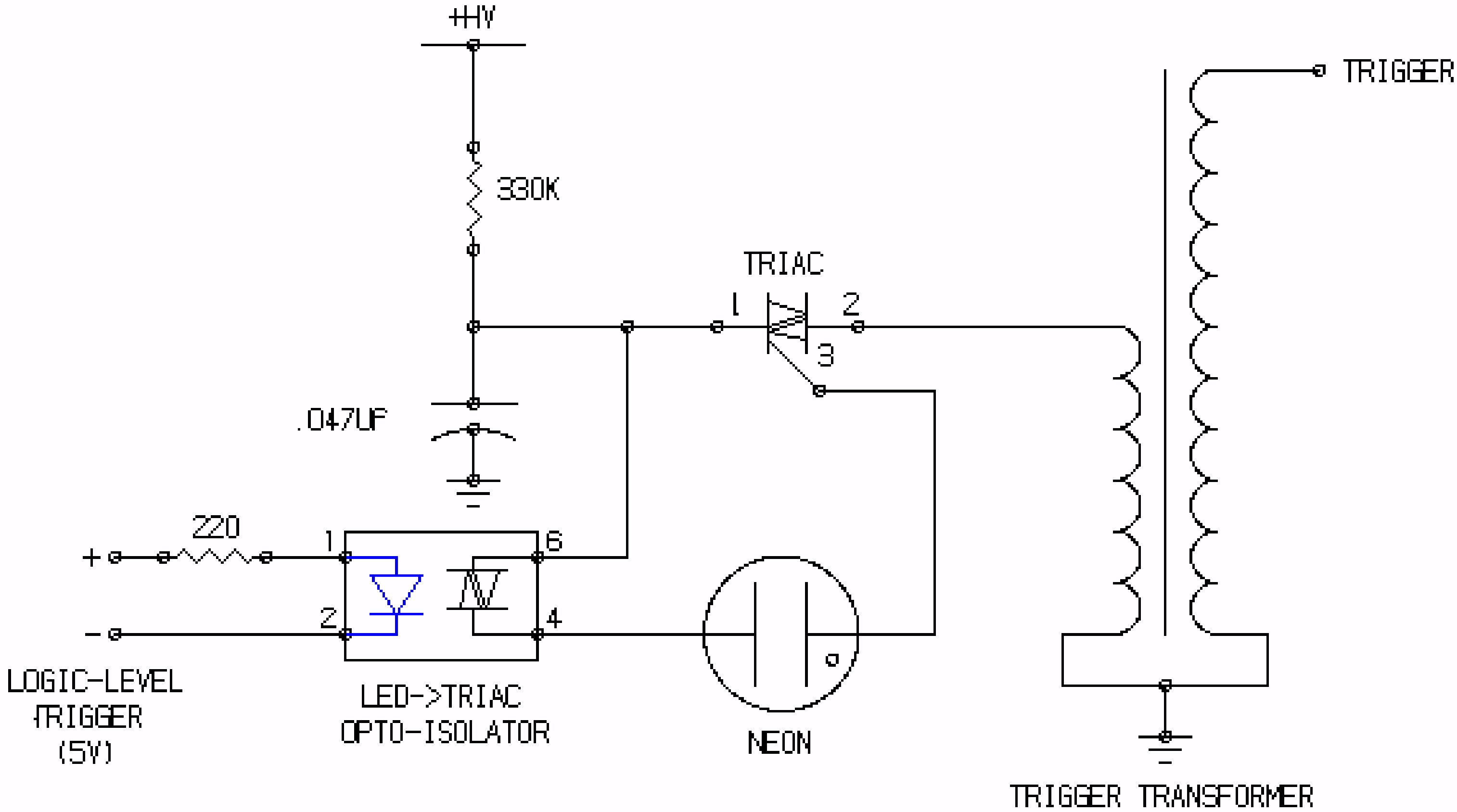
Kodak MAX Flash Unit


D1
BT+
R2
R3
T2
C3
D2
C1
Q2
Q3
Q1
IL1
T1
R1
BT-
FL1
C2
Top View
S2
S1
Bottom View
Kodak MAX Flash Unit

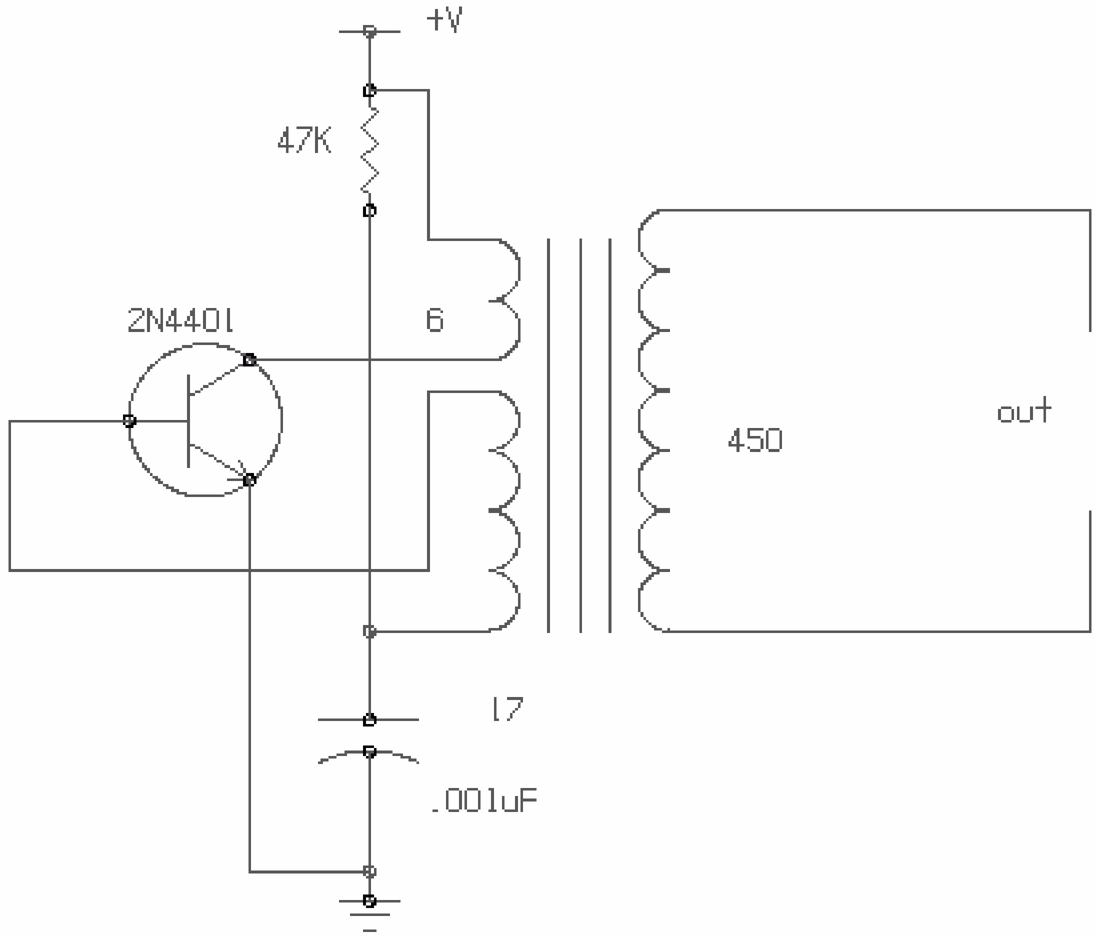


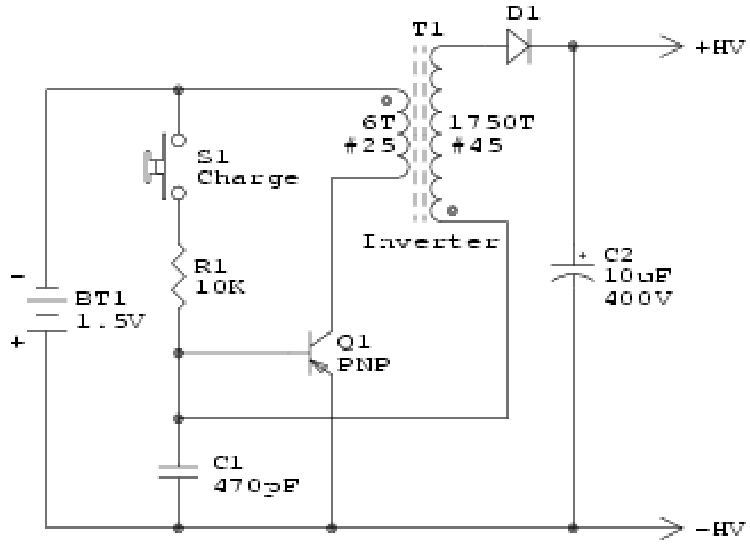
ALL RESISTORS ARE 1/2W EXCEPT:
150- 3W
15- 1W

ALL RESISTORS IN OHMS

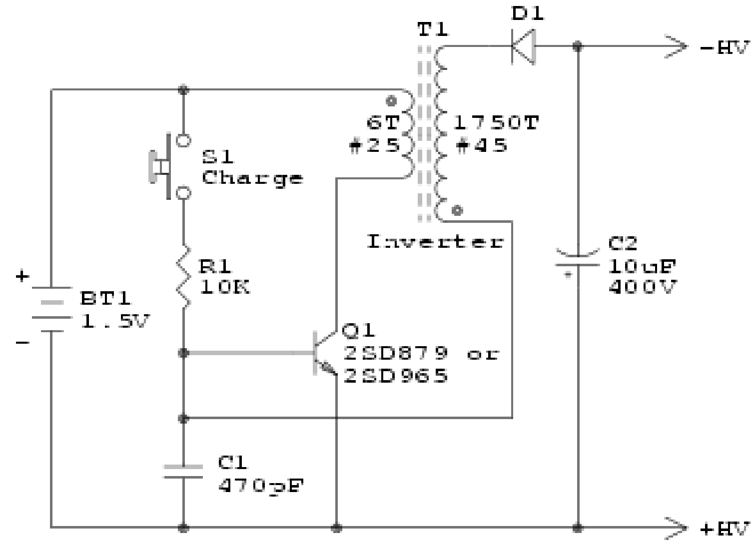


+HV
330K
TRIAC
1
2
3
.047UF
220
+
-
1
2
6
4
LOGIC-LEVEL
TRIGGER
(5V)
LED->TRIAC
OPTO-ISOLATOR
NEON
TRIGGER
TRIGGER TRANSFORMER

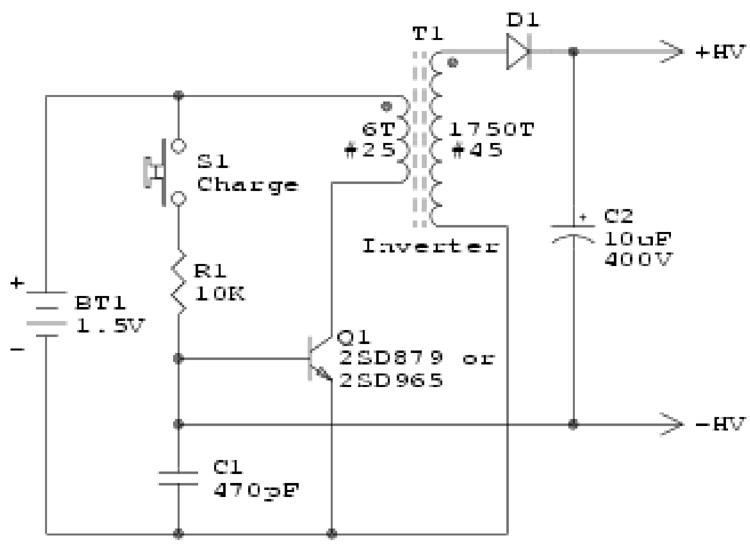

+V
47K
2N4401
6
450
out
17
.001uF



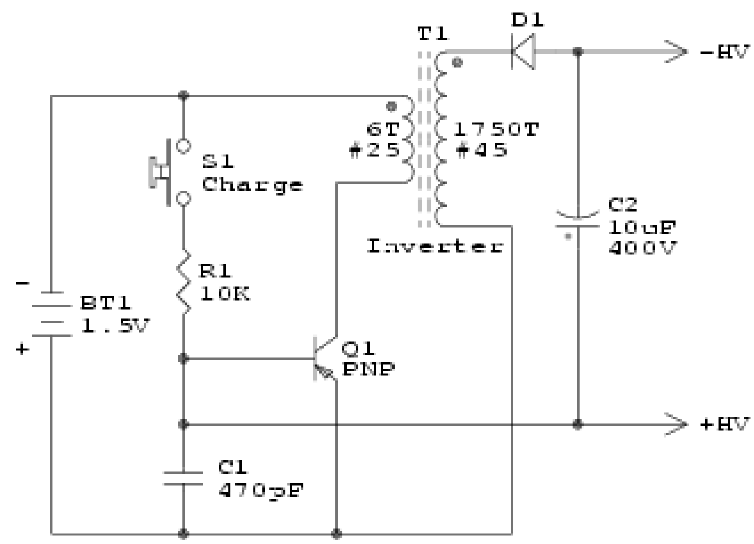
Positive Output Type 1



Negative Output Type 1

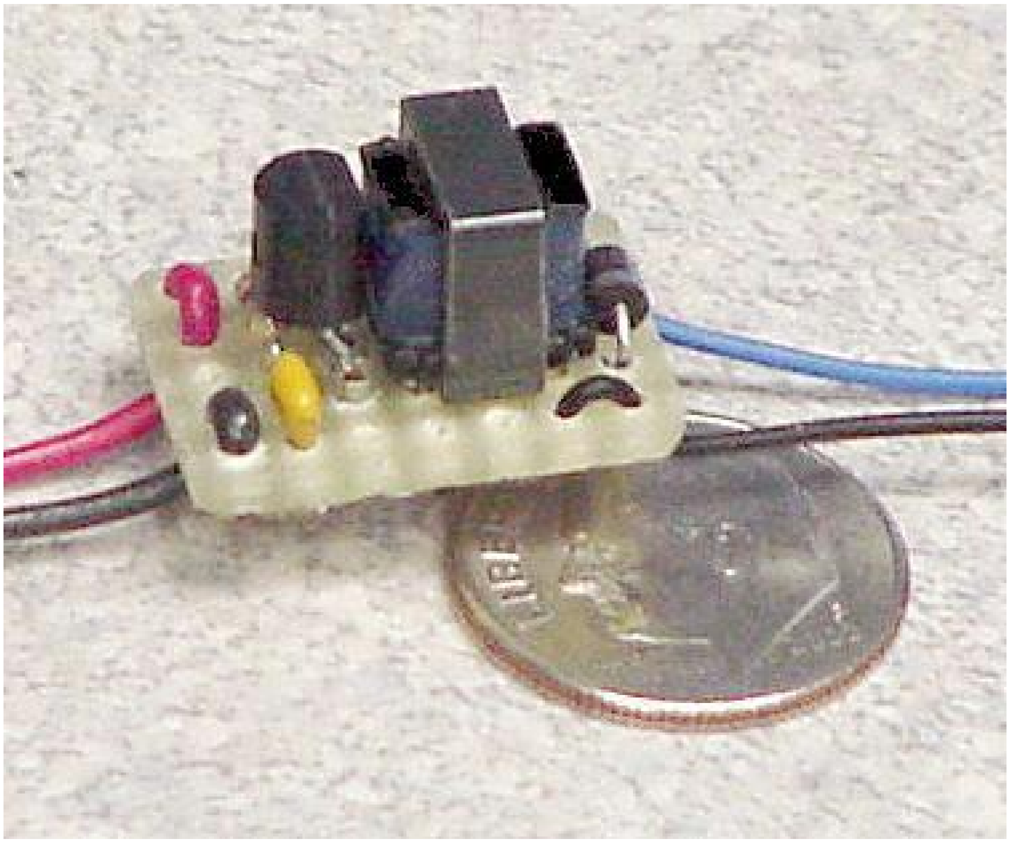


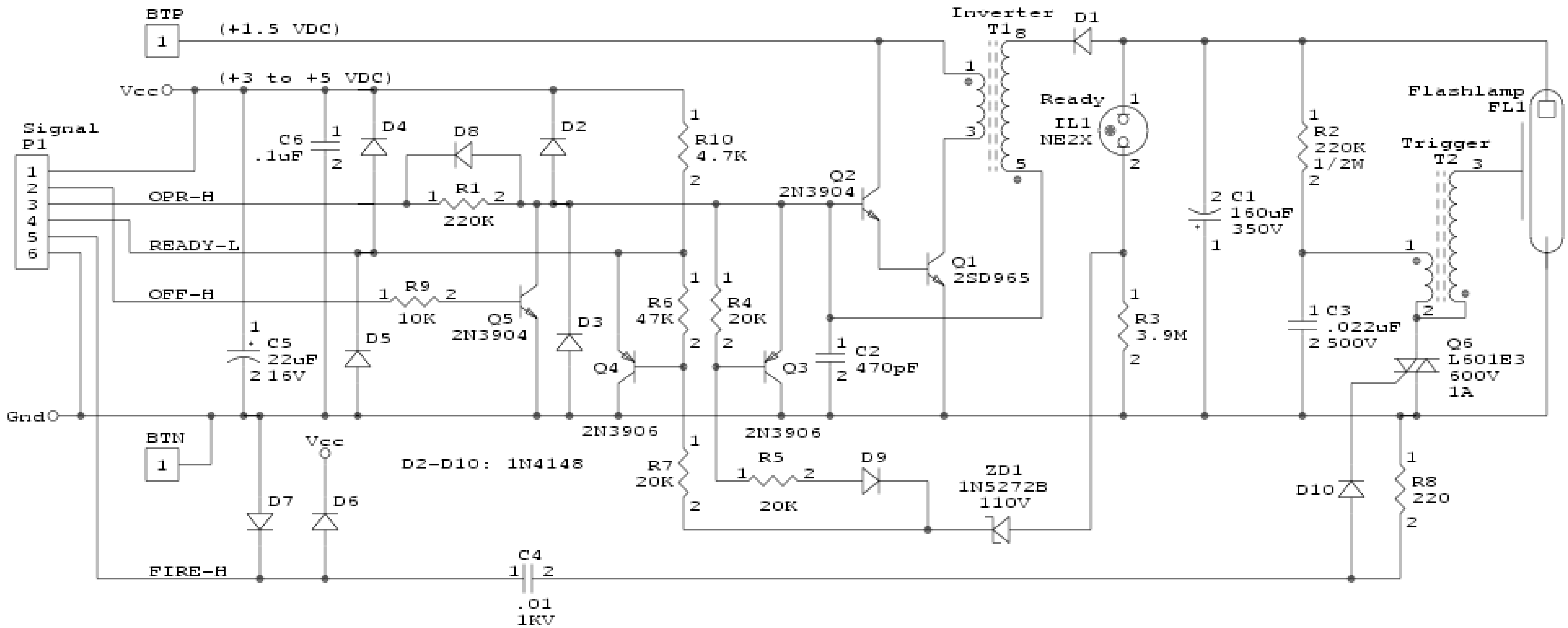
Positive Output Type 2



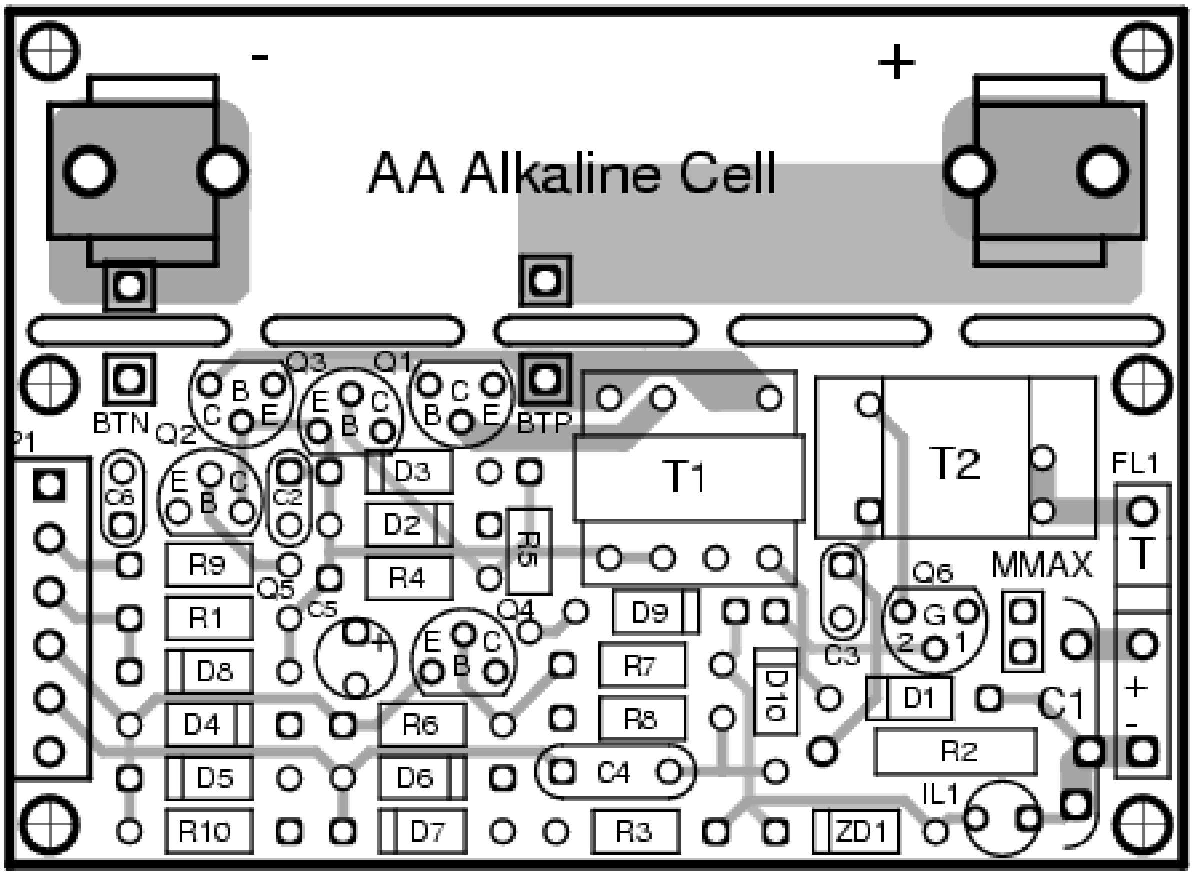
Negative Output Type 2

Ultra-Compact 350 V Capacitor Charger

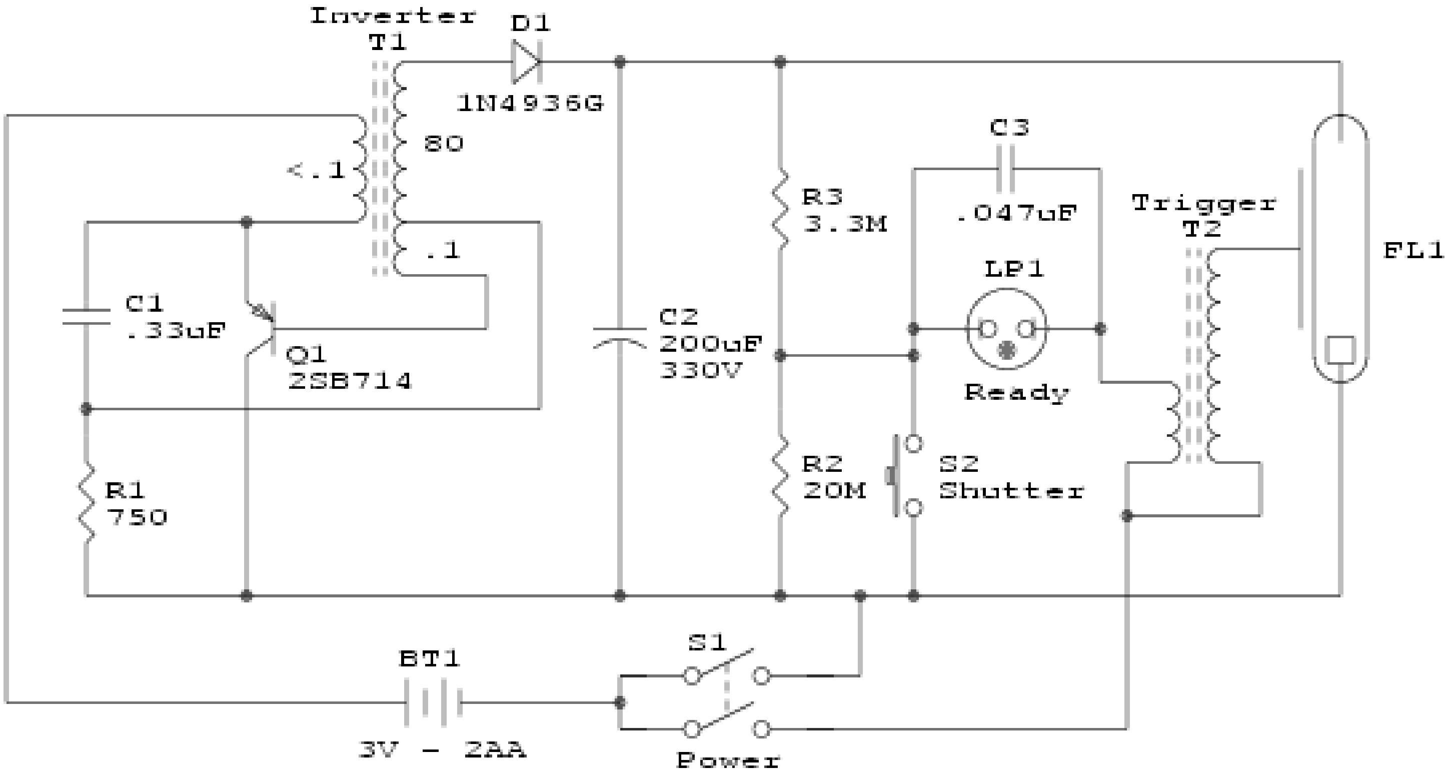




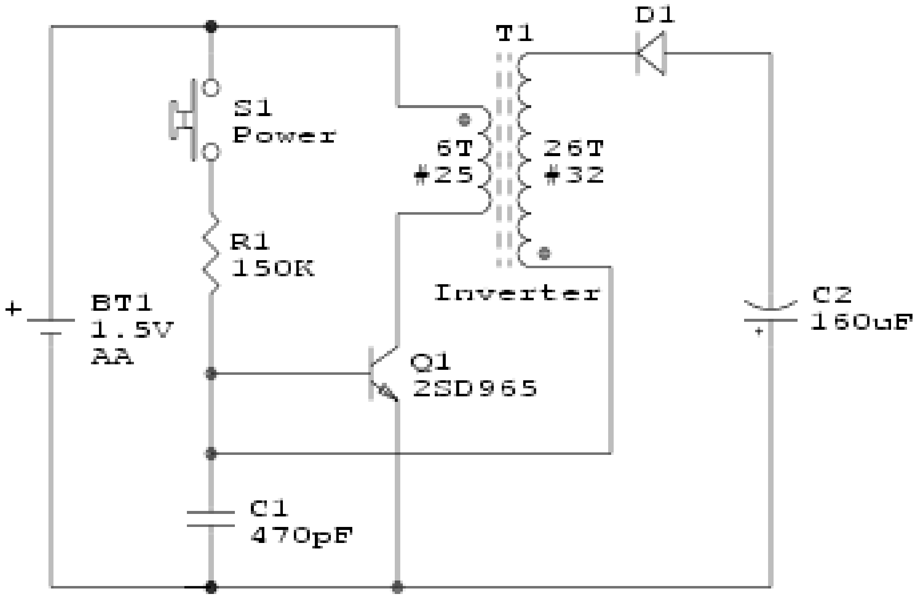
Modified Kodak MAX Flash Unit



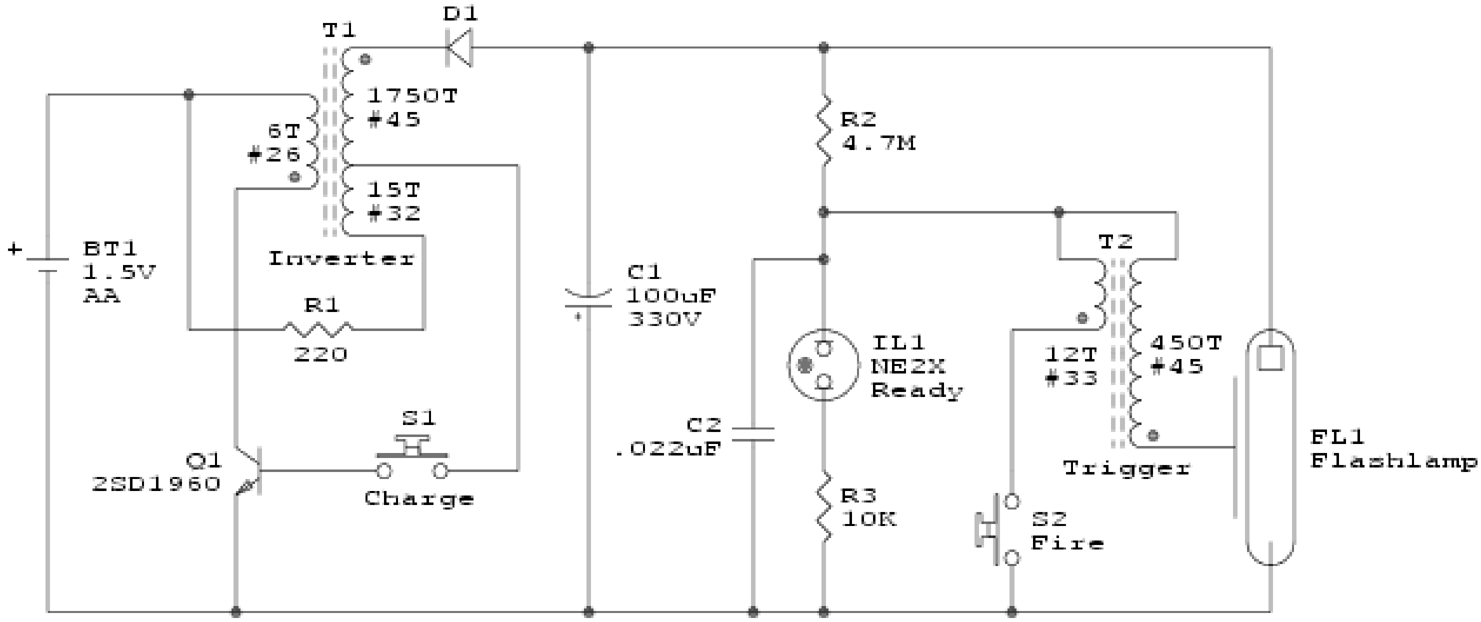
Modified MAX Flash PCB Layout



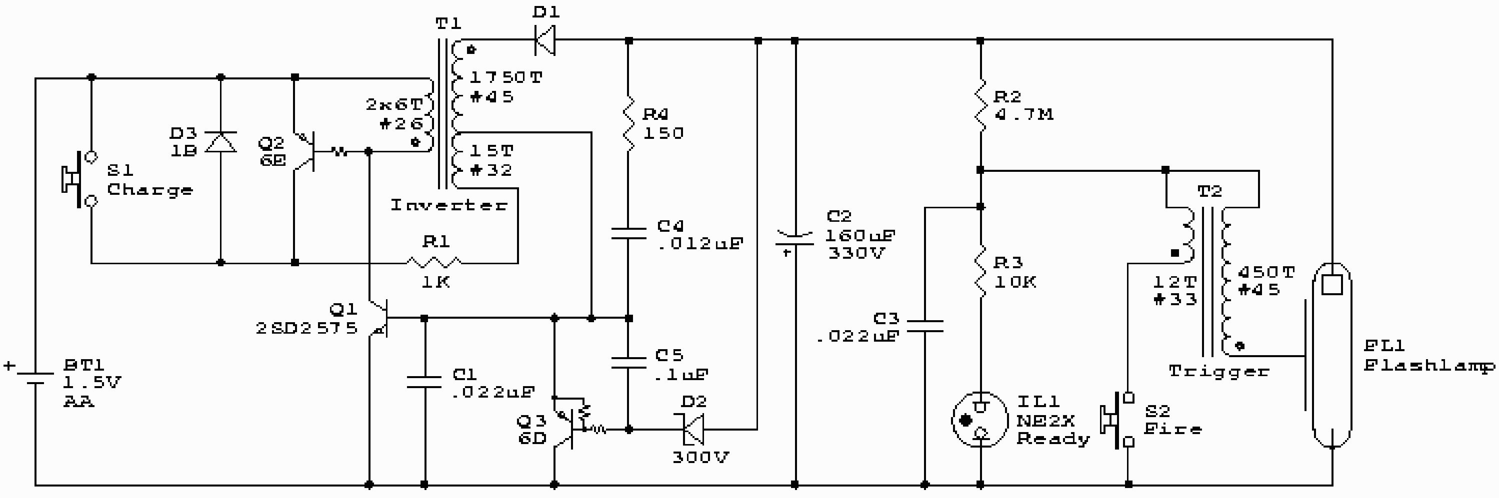
Kodak Ektralite 10 Flash Unit



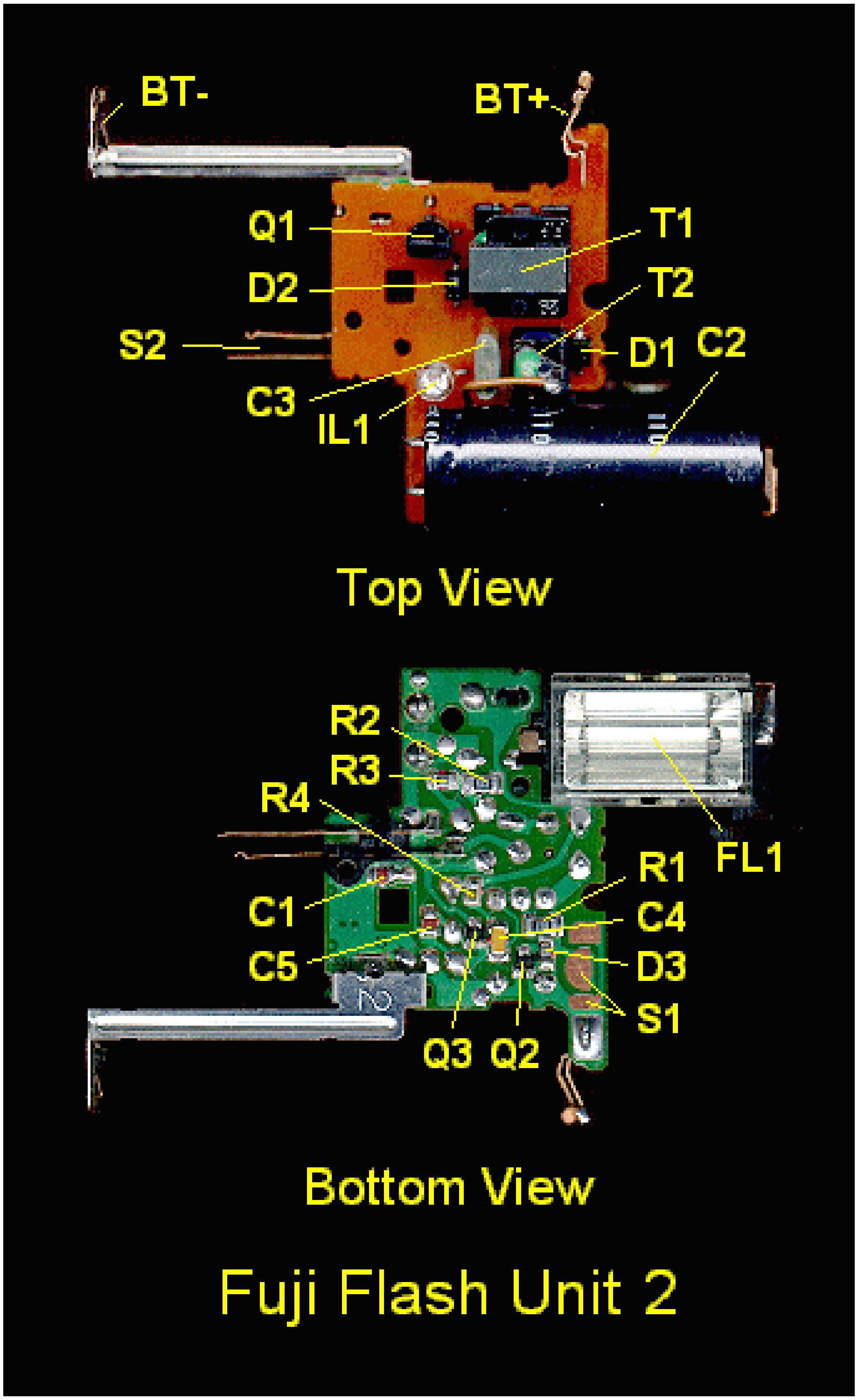
Mini Power Supply



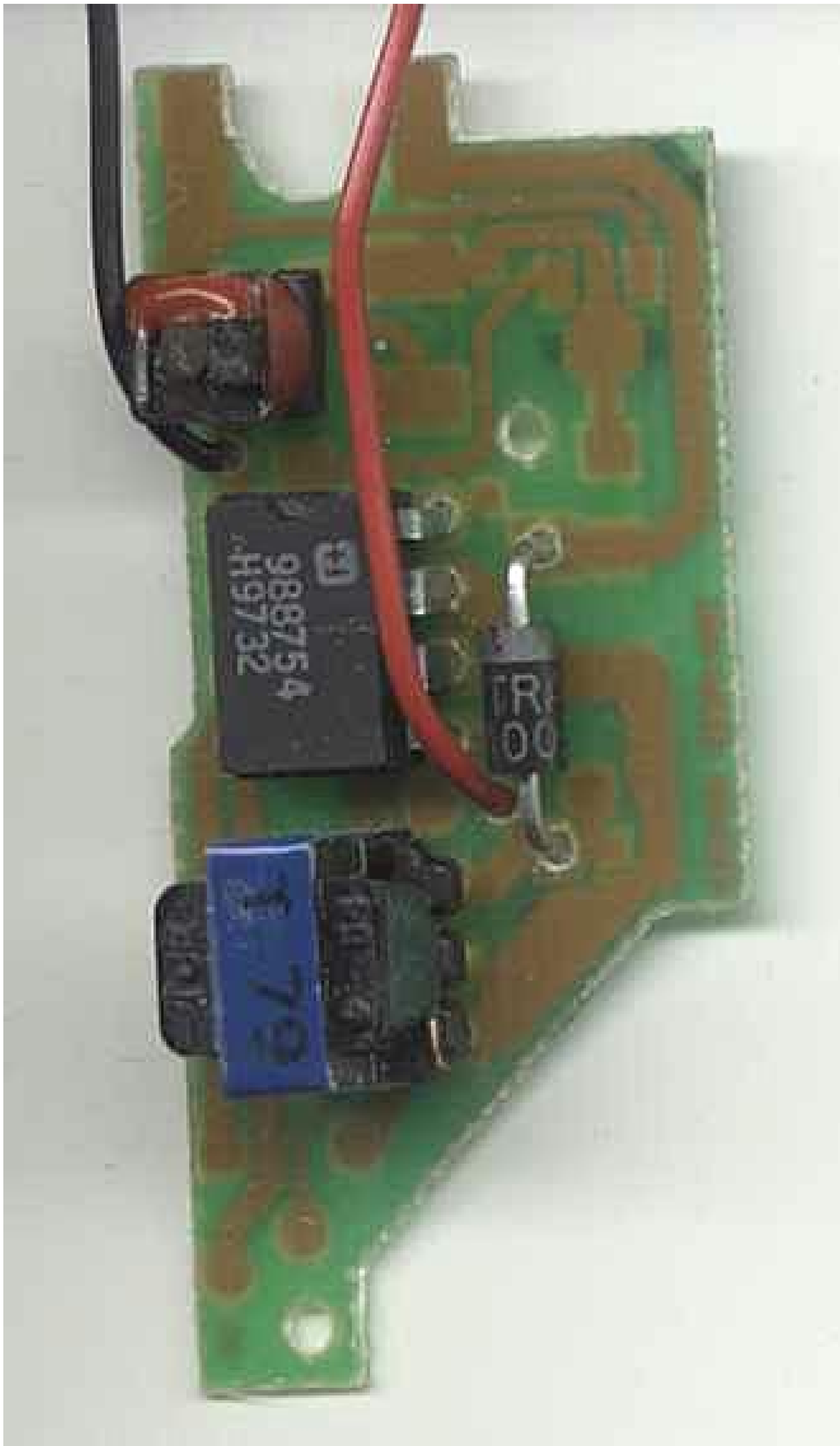
Fuji Flash Unit 1

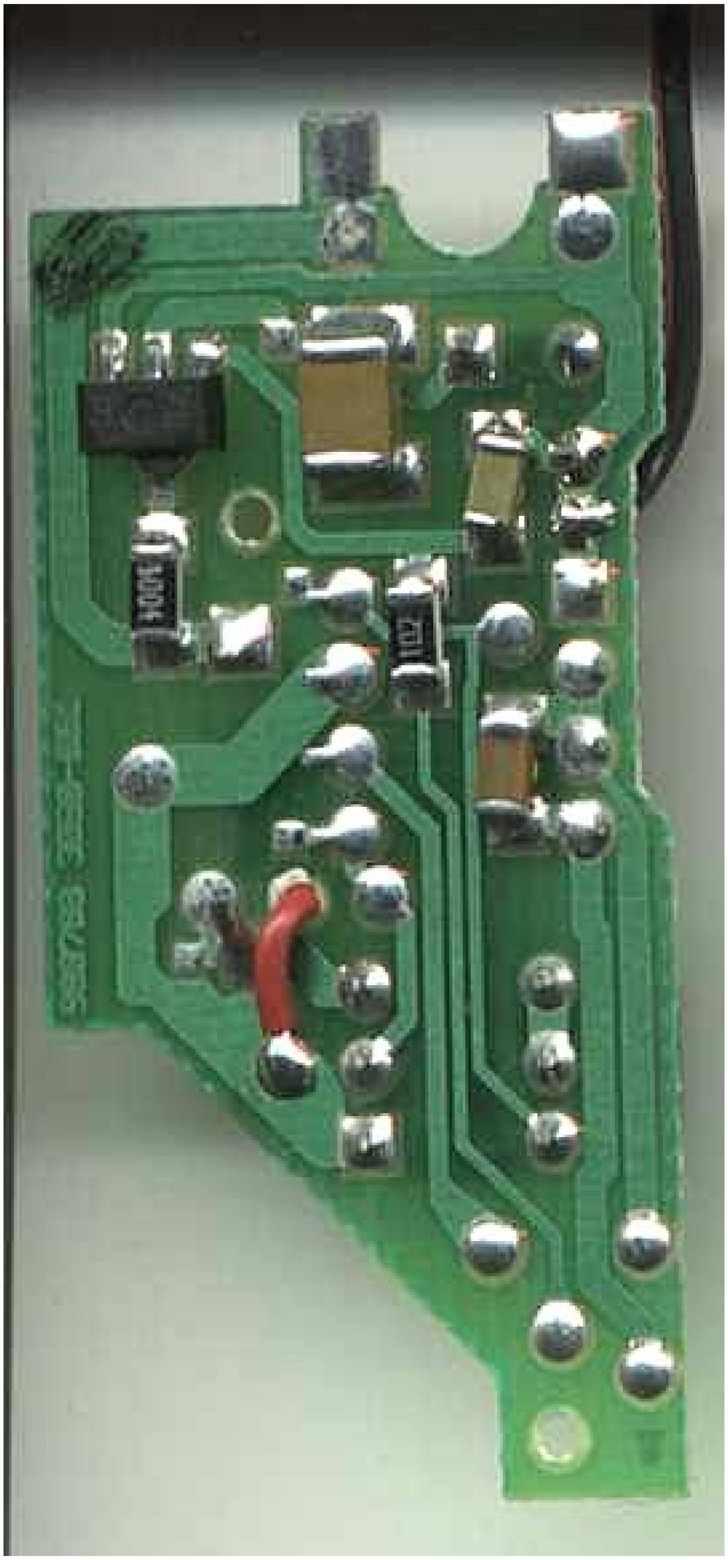


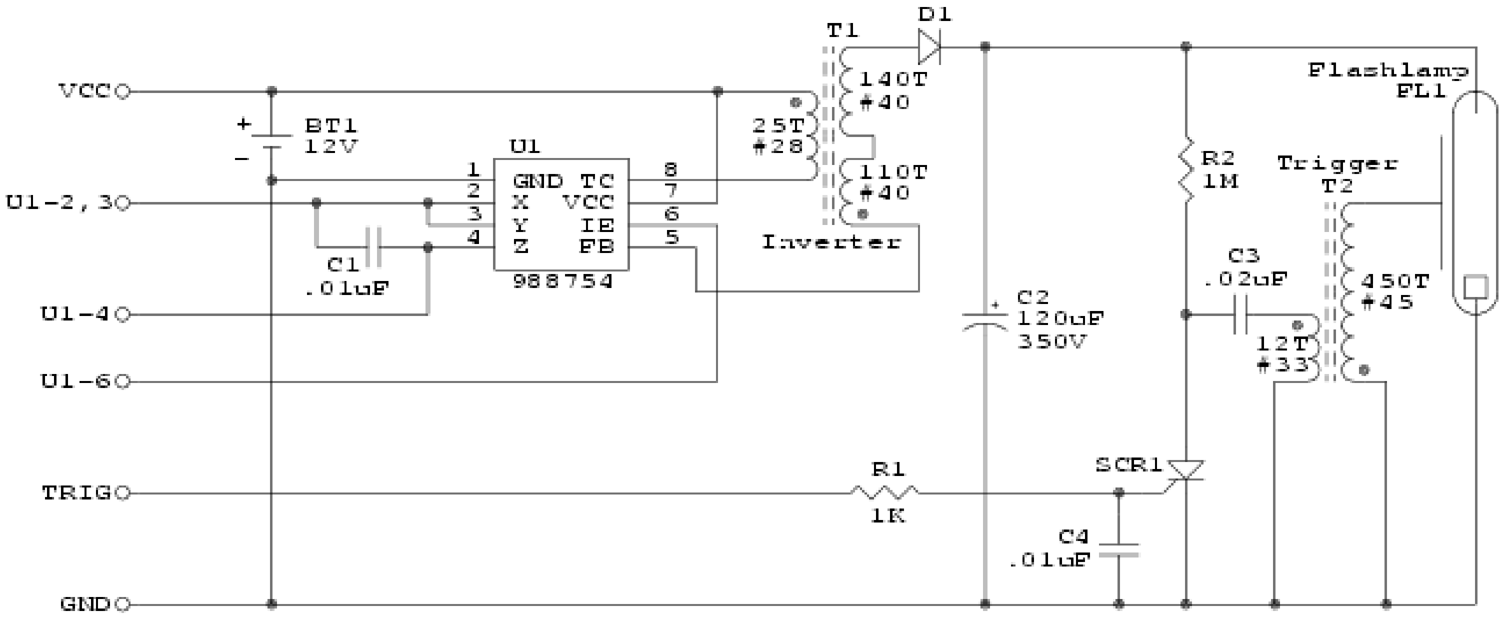
Fuji Flash Unit 2



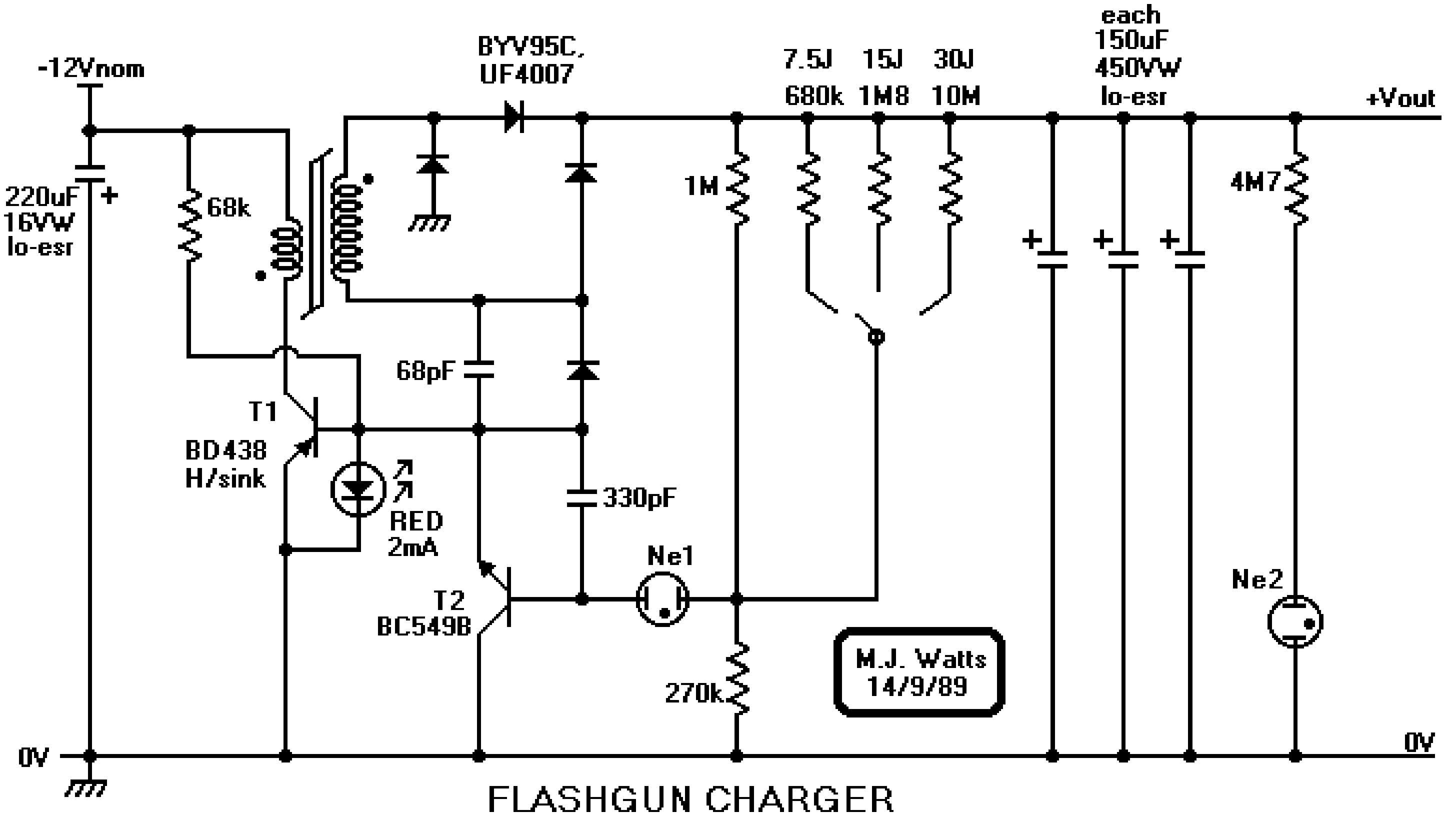
Fuji Flash Unit 2


988754
H9732





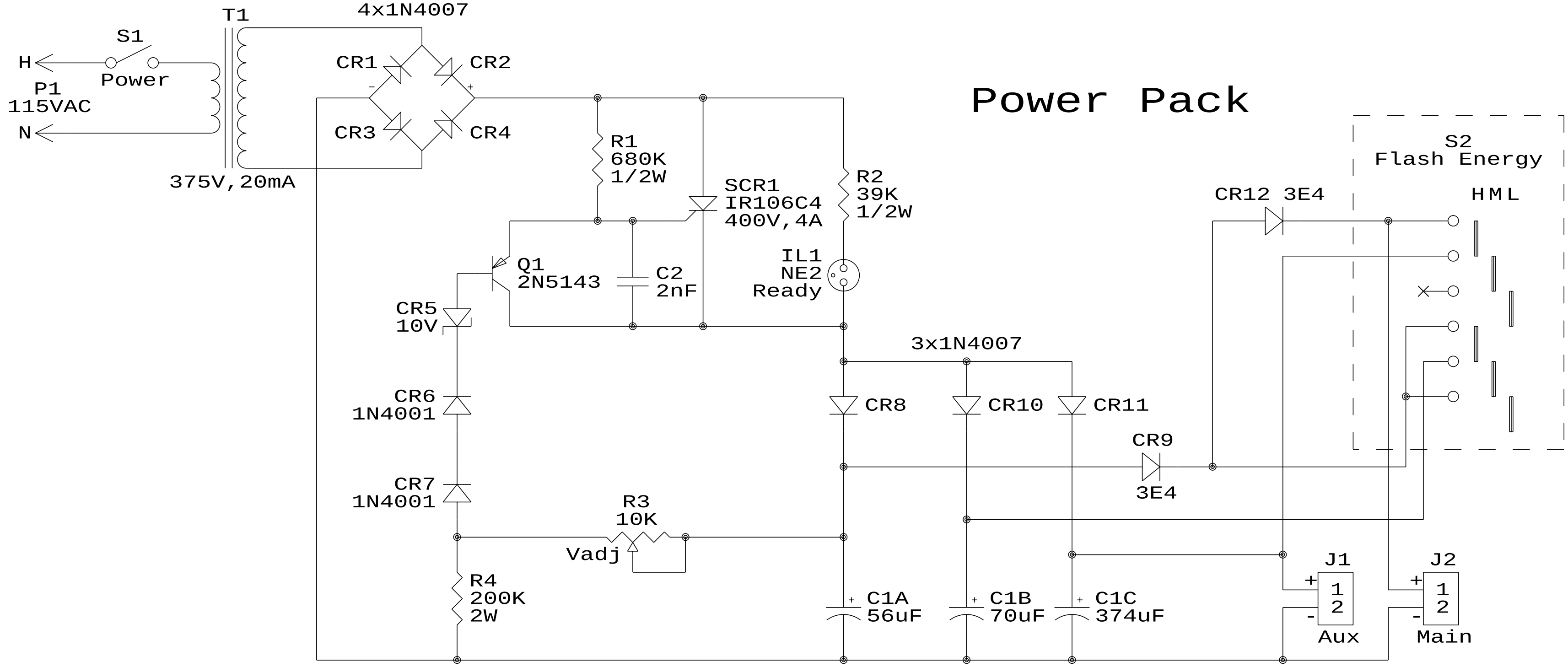
Flash Circuit Using IC 1

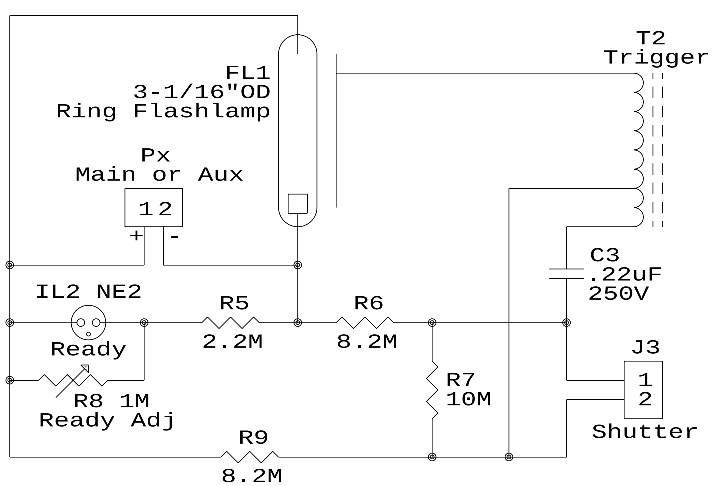


FLASHGUN CHARGER

NOTES :
- minor heatsinking of T1 sufficient for intermittent duty only
- switchable output capacitor energy approximate only and depends on resistor, capacitor and neon tolerances
- transformer in my unit was made from an ungapped RM6-R core of 3C85 material with Np = 20t and Ns = 1000t (wire size and insulation chosen to fill winding window).
- higher frequency operation is possible with fewer primary turns
- the core must be ungapped for correct operation
- T2 in combination with Ne1 and the associated resistor string sets output voltage and stored capacitor energy
- details of flashtube and trigger circuit not shown

Power Pack





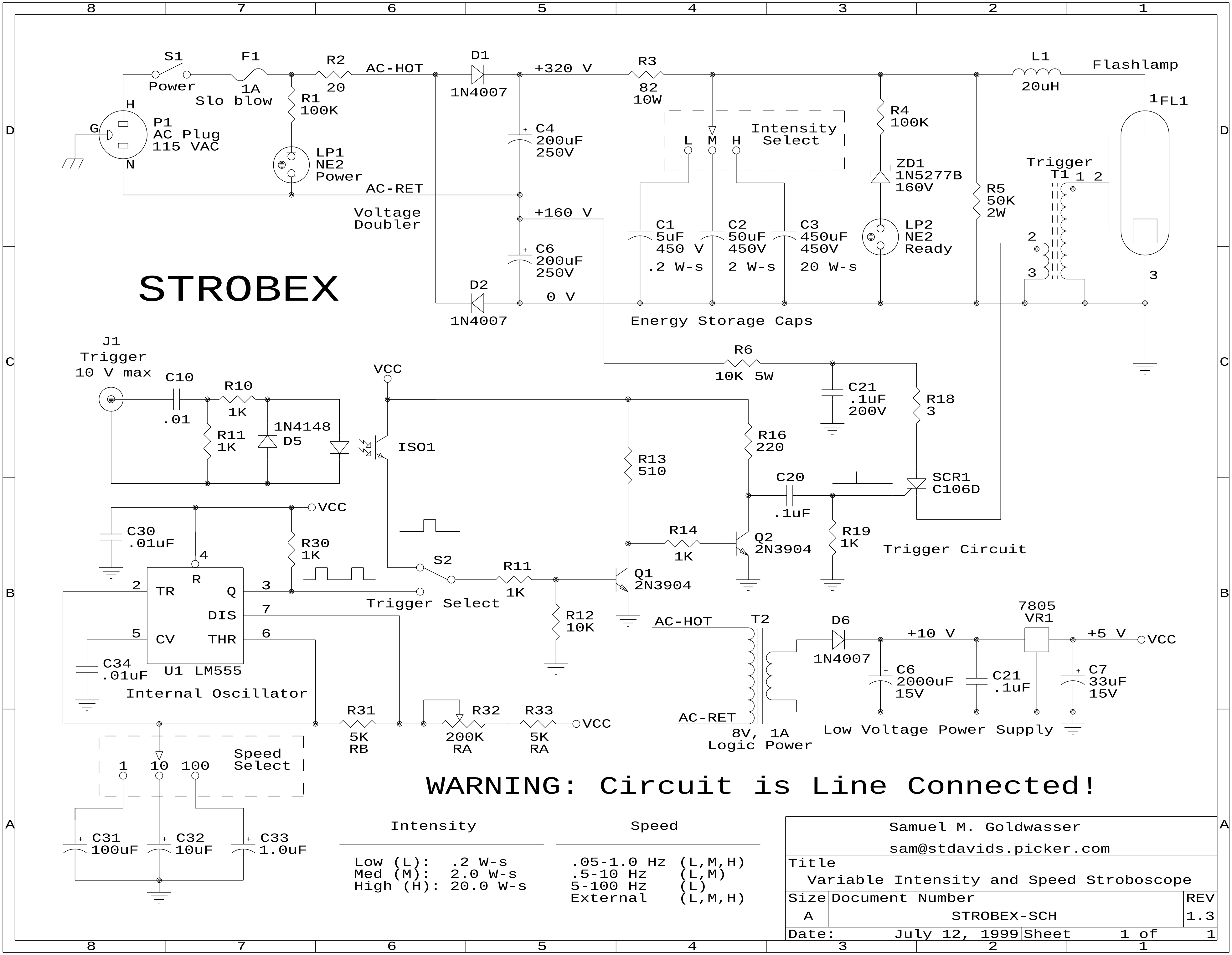
Flash Head

Honeywell Prox-O-Lite Flash Unit

Notes:

1. Main: L=4.5 w-s, M=10 w-s, H=40 w-s.
   Aux: L=30 w-s, M=30 w-s, H=40 w-s.
2. Vadj set for 400 VDC on C1A/B/C.
3. Part numbers may not be same as on PCB.
4. All resistors 1/4 watt unless noted.

Redrawn by: Samuel M. Goldwasser		
sam@repairfaq.org		
Title: Honeywell Prox-O-Lite Flash Unit		
Size: A	Document Number: HWPL1-SCH	REV: 1.0
Date: February 7, 2003	Sheet 1 of 1	



WARNING: Circuit is Line Connected!

Intensity	
Low (L):	.2 W-s
Med (M):	2.0 W-s
High (H):	20.0 W-s

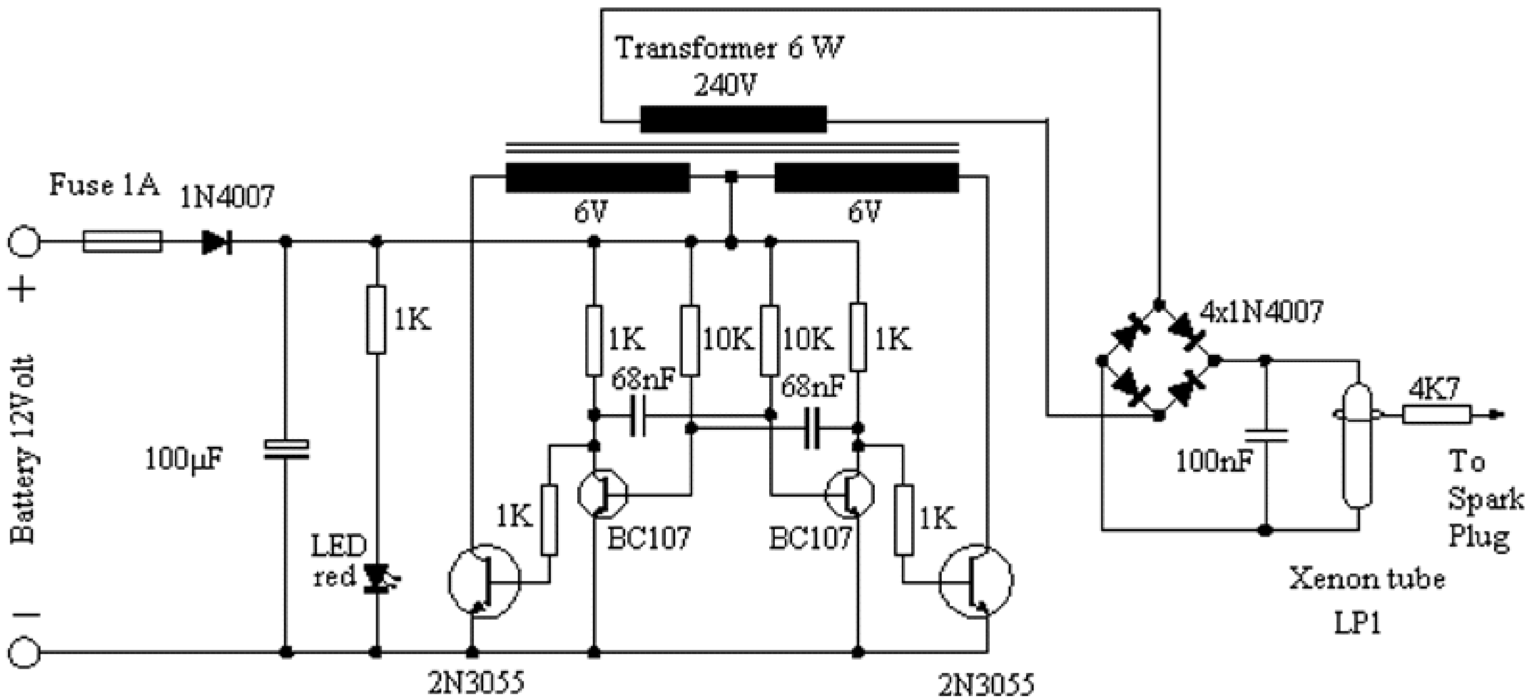
Speed	
.05-1.0 Hz	(L,M,H)
.5-10 Hz	(L,M)
5-100 Hz	(L)
External	(L,M,H)

Samuel M. Goldwasser
sam@stdavids.picker.com

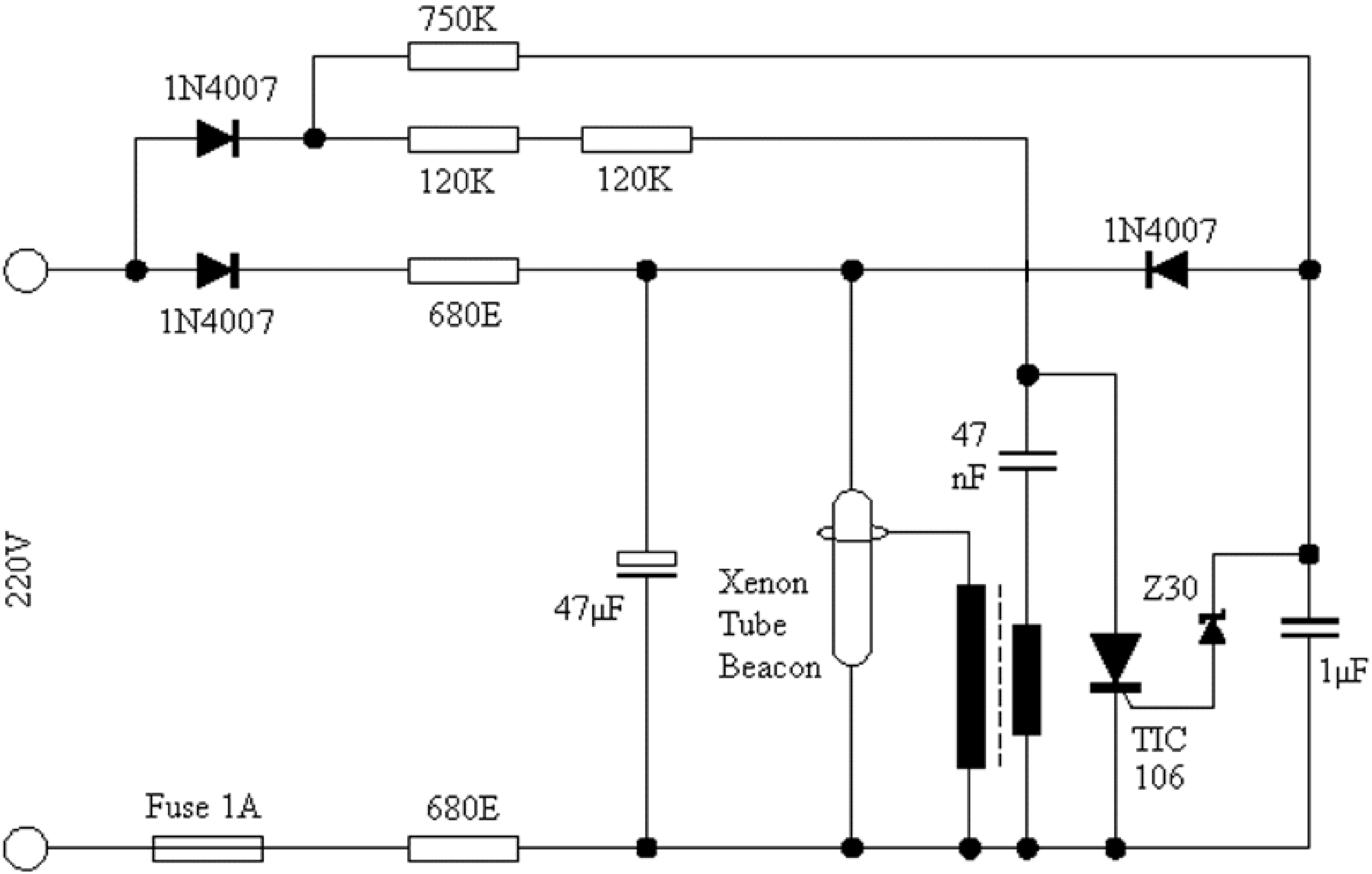
Title: Variable Intensity and Speed Stroboscope

Size	Document Number	REV
A	STROBEX-SCH	1.3

Date: July 12, 1999 Sheet 1 of 1



Car Ignition Timing Strobe



Alarm Beacon

LASER FAQ

SAM'S
Techology
Resource

Simple High Voltage Generator:
Low Voltage DC In, up to 30 kV Out

Version 1.25a

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

- Go (Back) to Various Schematics and Diagrams.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

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Introduction

Simple High Voltage Generator

The basic circuit described in this document is capable of generating up to 30 kilovolts or more from a low voltage DC source using the flyback (LOPT) transformer salvaged from a B/W or color TV or computer monitor. Typical output with a 12 VDC 2 A power supply or battery will be 12,000 V. Maximum output current at full voltage is typically around 1 to 2 mA. Higher currents are available but the output voltage will drop. At 2 kV, more than 10 mA may be possible depending on your particular flyback transformer input voltage and current.

Safety Considerations

Before thinking about experimenting with anything using or producing high voltages, see the document: Safety Guidelines for High Voltage and/or Line Powered Equipment. While the circuit described below isn't likely to be lethal using the suggested input voltage and components, who knows how you might 'enhance' it! :-)

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High Voltage Inverter

HV Inverter Circuit Diagram

As you can see from the schematic below, it doesn't get much simpler than this!

```
+Vcc     Q1   +----------------+
  o           |                 )::
  |       B |/ C                )::
  |  +------|    2N3055         )::
  |  |      |\ E          5 T  ):: +------|>|----------o  +HV
  |  |        |                 )::(   HV Diode, usually
  |  |       -_-                )::(    built in.
  |  |                          )::(
  +--|-------------------------+ ::(
  |  |   Q2  _-_                )::(
  |  |        |                 )::( Secondary (HV) winding,
  |  |    B |/ E          5 T  )::(  intact.
  |  |  ----|    2N3055         )::(
  |  |  |   |\ C                )::(
  |  |  |     |                 )::(
  |  |  |     +----------------+ ::(
  |  |  |                        ::(
  |  |  -----------------------+ :: +------------------o  -HV
  |  |                     2 T  )::
  |  |                +---------+ ::
  |  |                |     2 T  ):: T1 - Flyback transformer from B/W or
  |  +-------------------------+         color TV or computer monitor.
  |                    |
  |           R1       |    R2
```

```
     +----------/\/\/\--+--/\/\/\--+
                110        27   _|_
                5 W        5 W   -
```

Pinout for TO3 metal can transistor:

```
                _
              / O \          View from bottom (pin side).
            / o   o \
           (  B   E  )       B = Base, E = Emitter, C = Collector.
            \       /
              \ O / C        The metal case is the Collector.
```

Pinout for the TO220 or TOP3 plastic case transistor:

```
                    TO3Pn
        TO220       _____
        _____      /     \
       |  o  |    |   O   |      View from front (label side).
       |-----|    |-------|
       |Label|    |       |      B = Base, E = Emitter, C = Collector.
       |_____|    | Label |
        | | |     |_______|      If there is an exposed metal tab, that is
        | | |       | | |         the Collector as well.
        B C E       | | |
                    B C E
```

A slightly modified version of this basic circuit which I use as an RF source to excite a glow discharge in helium-neon laser and other gas discharge tubes is shown in: Flyback Based RF Source. This one uses a flyback transformer without a high voltage rectifier (or with the rectifier removed). The inductor, L1, is an addition that should reduce the stress on the transistors and power supply by limiting current at the time each of the transistors go into saturation just before the base drive switches to the opposite side. I have not specifically tested this circuit with the inductor but have used it with similar inverters.

These designs are similar to circuits found in: "Build your own working Fiberoptic, Infrared, and Laser Space-Age Projects", Robert E. Iannini, TAB books, 1987, ISBN 0-8306-2724-3 and many other places.

For larger (e.g., color TV or monitor) flybacks, or use with more than 12 VDC in, transistors with higher power ratings may be needed for sustained operation in addition to a good heat sink. An alternative is to parallel more than one power transistor along with small (e.g., .05 ohm, 2 W) current balancing resistors in series with their emitters.

HV Inverter Assembly

Read the following in its entirety! This assumes the basic circuit using a small flyback and input voltage of 12 VDC or less. Some modifications may be needed when using larger flybacks and higher input voltages.

1. Obtain flyback transformer with known good HV secondary winding. primary may be left intact if it is known to be in good condition - non shorted. A flyback removed due to failure may be used if it was the primary that failed and the primary turns can be removed without damaging the HV secondary or losing the secondary return connection! Flybacks fail in both ways (primary and secondary).

2. Locate the return for the high voltage winding. This may be a different color wire than the low voltage winding or may exit from the potted part of the flyback in a different place. It is not possible to use an ohmmeter to locate the return for the high voltage winding if your flyback has a built-in HV rectifier or multiplier as the forward voltage drop of the rectifier diodes is much greater than the battery voltage used in your multimeter. However, a winding connection that has infinite resistance to every other terminal is likely to be the HV return. On flybacks with no HV rectifier or multiplier, the return is easily located by measuring resistance between the HV output and all other terminals. The HV winding will have a resistance of 100s-1000s of ohms compared to single digit readings or less for all the other windings.

3. Wind 10 turn center tapped drive winding and 4 turn centertapped feedback winding using #16 to 20 gauge insulated wire. Make sure both halves of each coil are wound in same direction. Connect centertap in each case at the winding - do not bring out a loop. Insulate well with electrical tape.

4. Vcc should typically be in the range 12 to 24 volts at a couple of amps. Circuit should start oscillating at around a Vcc of 5 V or so. If you do not get any HV out, interchange the connections to the transistor bases. Heat sinks are advised for the transistors. Be aware of the capability of your flyback (B/W monitors up to 15 kV, color up to 30 kV). You risk destroying the secondary windings and/or HV rectifier if you get carried away. Running this on 24 volts will probably cause an internal arc-over in a small flyback, at which point you start over with more caution and a new flyback.

5. Actual output will depend on turns ratio of the flyback you have.

   - For a typical small B/W TV, monochrome computer monitor, or video display terminal, you should be able to get around 12,000 volts with 12 VDC input.

     I built one from a dead Mac-Plus flyback from which I removed the (dead) primary windings.

   - With a large color TV or color monitor flyback, 30,000 V or more will be possible using a 24 VDC power supply.

6. The frequency of operation will be in the kHz to 10s of kHz range depending on Vcc, load, and specific flyback characteristics.

7. You can experiment with the number of turns, resistor values, etc. to optimize operation and power output for you needs.

8. CAUTION: contact with output will be painful, though probably not particularly dangerous due to low (a few mA) current availability.

   HOWEVER, if you add a high voltage capacitor to store the charge, don't even think about going near the

HV!

HV Inverter Parts List

None of the component values are critical. It is quite likely that everything needed is already patiently waiting in your junkbox. If not, except for the flyback, most if not all of the parts should be available from Radio Shack. See the section: "Low voltage power supply" for a simple design to use with this inverter.

Some experimenting with different value resistors and even the number of turns on each winding may improve performance for your particular flyback.

- Q1, Q2 - 2N3055 or similar NPN power transistors (reverse polarity of Vcc if using PNP transistors.) Maximum stress on transistors are about 2 to 3 times VCC. Heat sinks will be needed for continuous operation.

- R1 - 110 ohms, 2 W resistor (5 W for Vcc of 24 V). This provides base current to get circuit started.

- R2 - 27 ohms, 5W resistor. This provides return path for base feedback during operation.

- T1 - Flyback transformer from/for B/W TV, video display terminal, color TV, computer monitor, etc., modified according to text above.

  Most modern flybacks include built-in HV rectifier diode(s) and/or voltage multiplier (tripler) so output without additional components will be high voltage positive or somewhat smoothed HV DC.

  Note: this kind of flyback transformer drives the CRT directly and uses its glass envelope as the main high voltage filter capacitor. (A foot square piece of 1/8 inch Plexiglas with Aluminum foil plates makes an filter capacitor.)

- Wire - a couple of feet of #16-#20 hookup wire, magnet wire, or any other insulated wire for home made primaries. Use electrical tape to fix windings to core. Wind feedback winding on top of drive winding.

Suggested Enhancements

Here are some minor changes that should improve the efficiency of this circuit.

(From: Robert (rrtcj@hotmail.com).)

- Use a more modern transistor like the 2N3773 instead of the 2N3055. It has higher current (30 A) and higher voltage (140 V) ratings as well as higher Hfe thus requiring less base current.

- Use a single feedback winding (2 turns) with each end connected to the base of one transistor and over a 150 ohm resistor connected to Vcc. (I'm not quite sure exactly what this means but my guess is to connect a 150 ohm resistor from one of the bases to Vcc to provide the startup base drive. --- Sam.)

- Add an inductor (about 0.4 mH, can be more but not less) in series to the flyback circuit. Since both transistor are switched on for a little moment (when there is no voltage in the feedback), so there will be high currents (causing losses resulting in excessive power disspation in the transistors) The coil prevents the current spike without wasting power like a resistor.

Measurements: With an input voltage of 16 VDC, the output voltage is about 12 kV. Without the filter choke, the input current with no load is 5 A; with the filter choke it is only 3.2 A. With the output shorted (arcing), the current is about 9 A in both cases.

In fact I don't need big heatsinks. With the 2N3773, I can drive this circuit continuously with one medium-size heatsink and the transistors get only warm!!!

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Low Voltage Power Supply

LV Power Supply Description

The power supply (12 to 24 V) doesn't need to be anything fancy. Regulation is not needed so a simple power transformer-bridge rectifier-filter capacitor design will be fine. The circuit described below will provide about 15 VDC at up to 3 A. Unless you are going for maximum output, this should be adequate.

During initial testing at least, a Variac on the input (or variable voltage power supply) is highly desirable to avoid blowing anything should your wiring or parts not be quite right and to gain a feel for the capabilities of your circuit before it is too late! In neither of these is available, use a 10 ohm 25 W power resistor or 100 W light bulb in series with the load (inverter) to limit current to a safe value - one that won't fry too many things too quickly.

A typical circuit is shown below:

```
                  _         T1
  H o-----o/ o---- _------+                5 A diodes
       S1 Power  F1 Fuse   )||             or bridge
                  1 A      )|| +---------+----|>|-------+-------+-----o +Vcc
                           )||(         ~|        D1    |+      |
                           )||(          +----|<|----+  |     +_|_ C1
 115 VAC                   )||( 12 VAC            D2 |  |      ___ 20,000 uF
                           )||(          +----|>|----|--+     - |  25 V
                           )||(          |        D3 |          |
                           )|| +---------+----|<|----+----------+--+--o Gnd
                           )||          ~         D4     -        _|_
  N o---------------------+                                        -
```

LV Power Supply Parts List

All of these parts should be readily available:

- T1 - 12 V, 3 A power transformer.
- S1 - SPST toggle switch.
- F1 - Fuse, 1 A.
- D1-4 - Silicon rectifier diodes, 5 A minimum. Or, 5 A bridge rectifier.
- C1 - Electrolytic filter capacitor, 20,000 uF or more, 25 V minimum.

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Typical Flyback Schematic

This diagram shows a typical flyback that might be found in a direct view color television or computer monitor. Resistances are included for illustrative purposes only and may be quite different on your flyback!

The high voltage section on the right may actually be constructed as a voltage multiplier rather than a single winding with multiple HV diodes. The rectifiers or multiplier, and/or focus/screen divider may be external to the flyback transformer in some models.

Flyback transformers used in black-and-white TVs and monochrome computer monitors do not have a focus and screen divider network.

The ferrite core of a flyback transformer is constructed with a precision gap usually formed by some plastic spacers or pieces of tape. Don't lose them if you need to disassemble the core. The ferrite core is also relatively fragile, so take care.

The focus and screen divider network uses potentiometers and resistors (not shown) with values in the 10s to 100s of M ohms so they may not register at all on your multimeter. The high voltage rectifiers (CR1 to CR3 on this diagram) are composed of many silicon diodes in series and will read open on a typical VOM or DMM.

Note that there is no standardization to the color code. However, the fat wire to the CRT is most often red but could also be black. Of course, you cannot miss it with the suction cup-like insulator at the CRT anode end.

```
                                        +--|>|-----------o  HV to CRT
              _                   1  ::(   CR1             (25 to 30 kV,
             |   B+  o-------------+ ::(                    suction cup on
    Drive    |                      )::(                    fat red wire)
    winding <                       ):: +-------+
             |             1.32     )::         |
             |                    2 ):: +--|>|--+
             |_  HOT o-------------+ ::(   CR2
              _                   3  ::(
             |   50  o-------------+ ::(
             |                      ):: +-------+
```

```
             |              .11   4 )::          |
             |   35  o------------+ :: +--|>|--+
  Various    |                      )::(   CR3  |
  auxiliary <               .28     )::(        /
  windings   |                    5 )::(        \<-------o  Focus
             |   16  o------------+ ::(         /          (3 to 10 kV,
             |                      )::(        \           orange wire)
             |              .12   6 )::(        |
             |_   0  o----------+--+ ::(  9     |
              _                 | 7  :: +--+    /
             |   H1  o----------)--+ ::    |    \<-------o  Screen
 CRT Heater <               .08 | 8 )::    |    /          (200 to 800 V,
             |_  H2  o----------+--+       |    \           brown wire)
                                |          |    |
                                |          +----|--------o  To CRT DAG
                                |               |            ground
                                +---------------+
```

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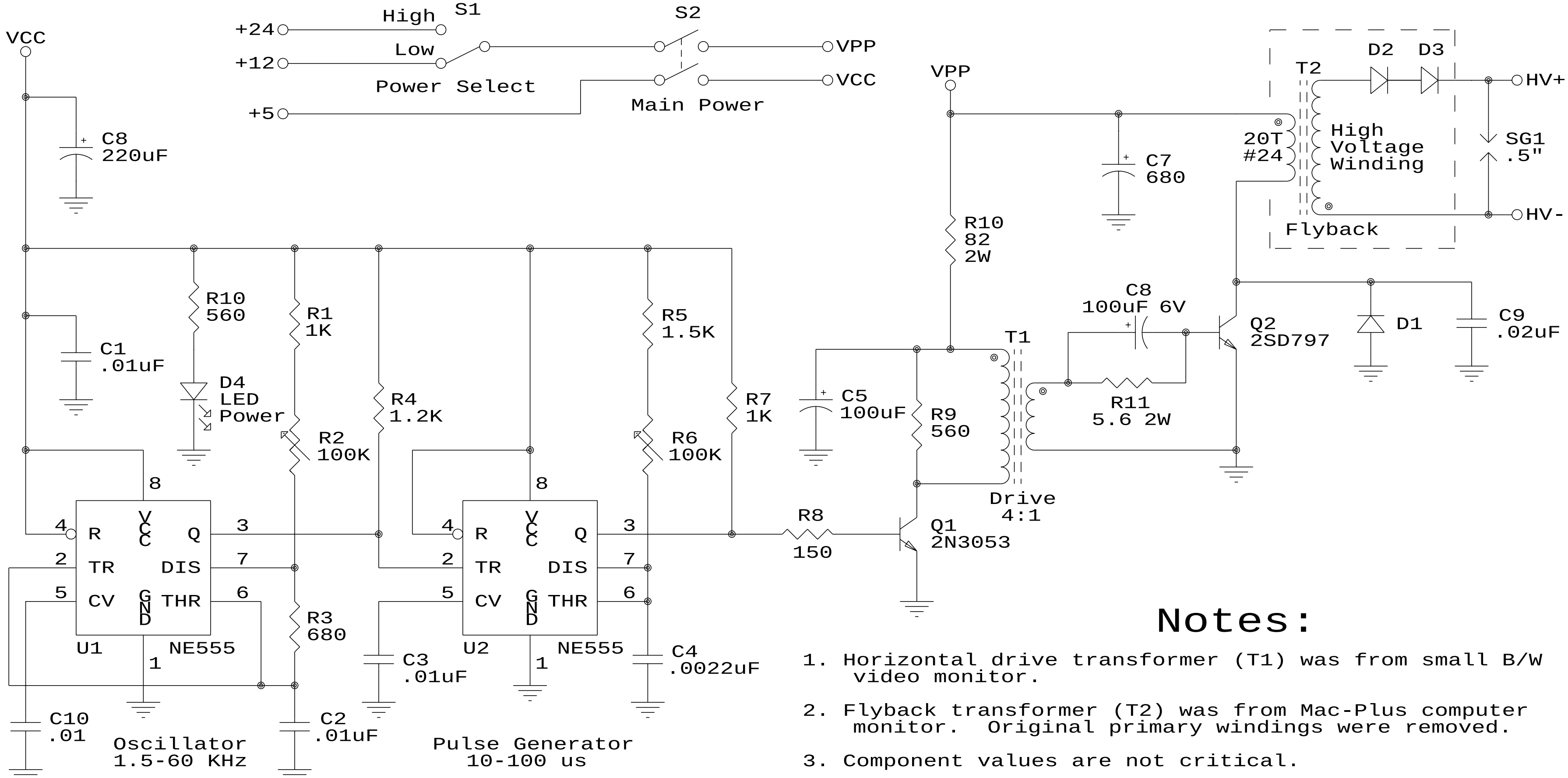
-- end V1.25a --



Notes:

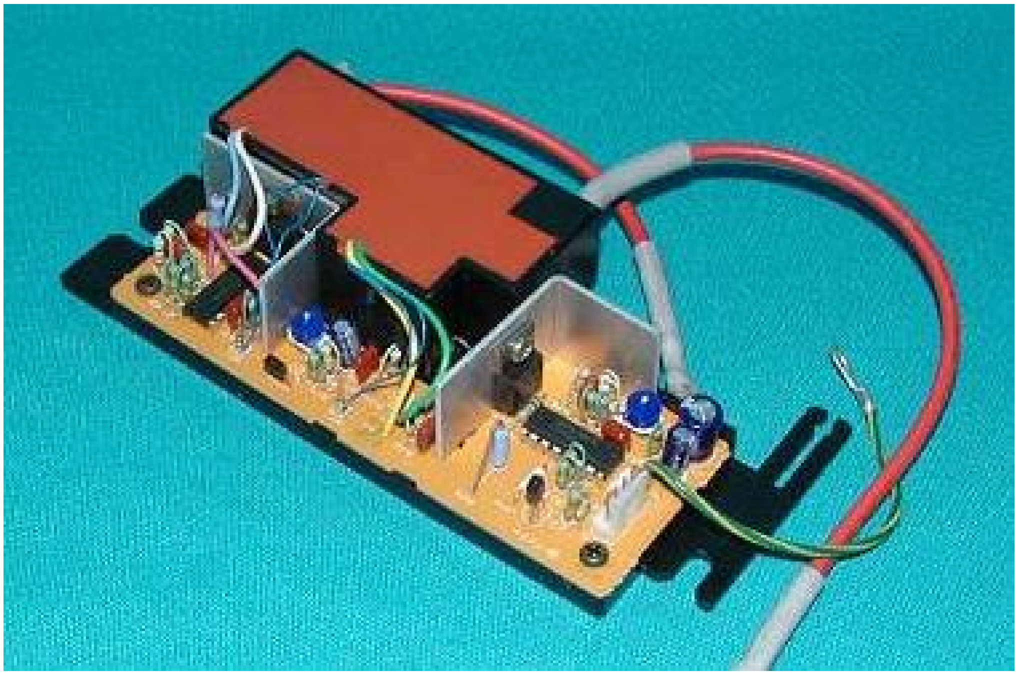
1. Horizontal drive transformer (T1) was from small B/W video monitor.
2. Flyback transformer (T2) was from Mac-Plus computer monitor. Original primary windings were removed.
3. Component values are not critical.
4. Output may exceed 25,000 V at certain combinations of frequency and pulse width with 24 V power - could destroy The sparkgap provides some protection.
5. Input power was current limited to about 5 A.
6. Good heatsink important on Q2 for continuous operation.

HVGEN32

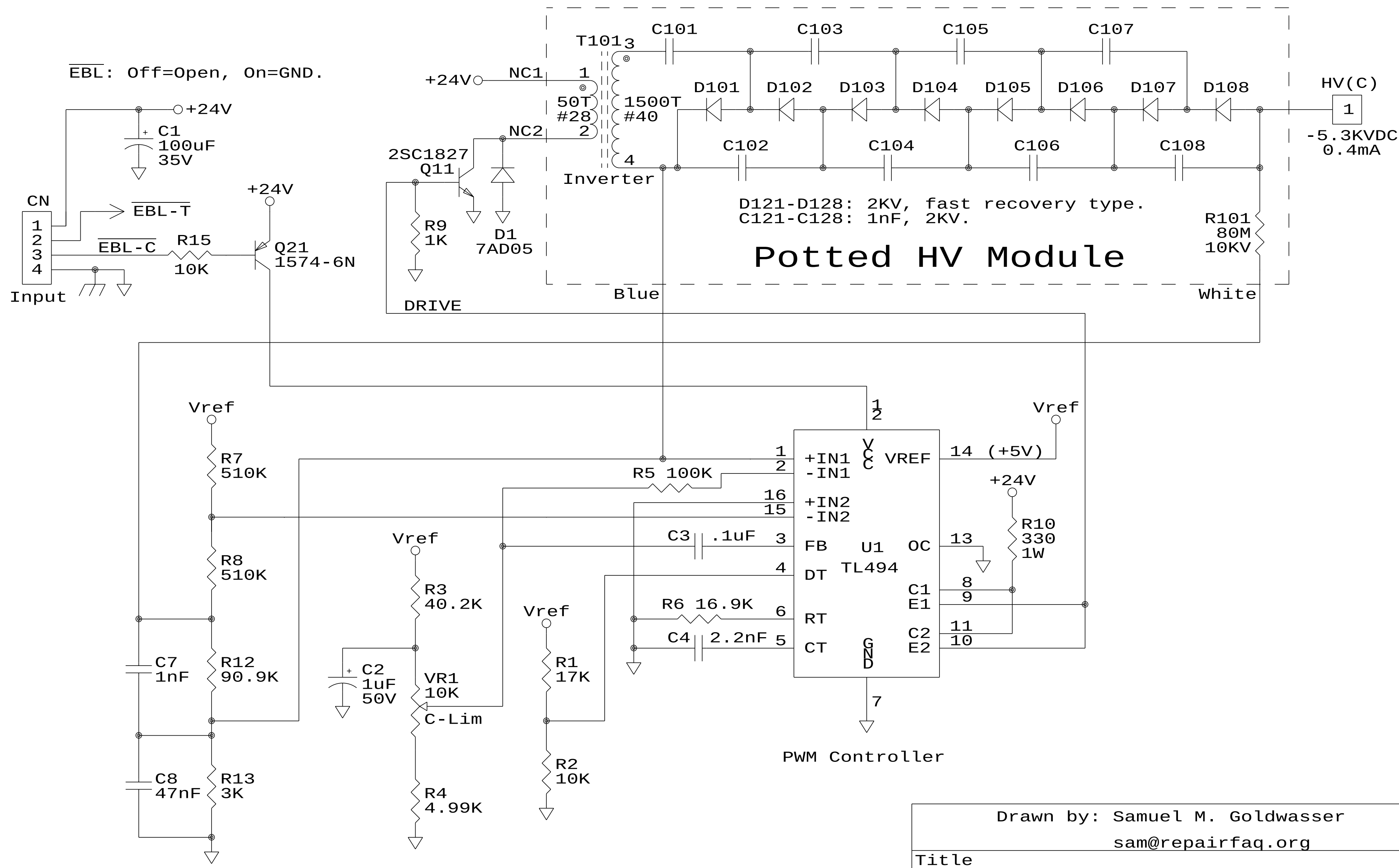
Adjustable High Voltage Power Supply

Samuel M. Goldwasser
sam@stdavids.picker.com

Title	Adjustable High Voltage Power Supply	
Size	Document Number	REV
A	HVGEN32-SCH	1.1
Date: September 23, 2002	Sheet 1 of 1	

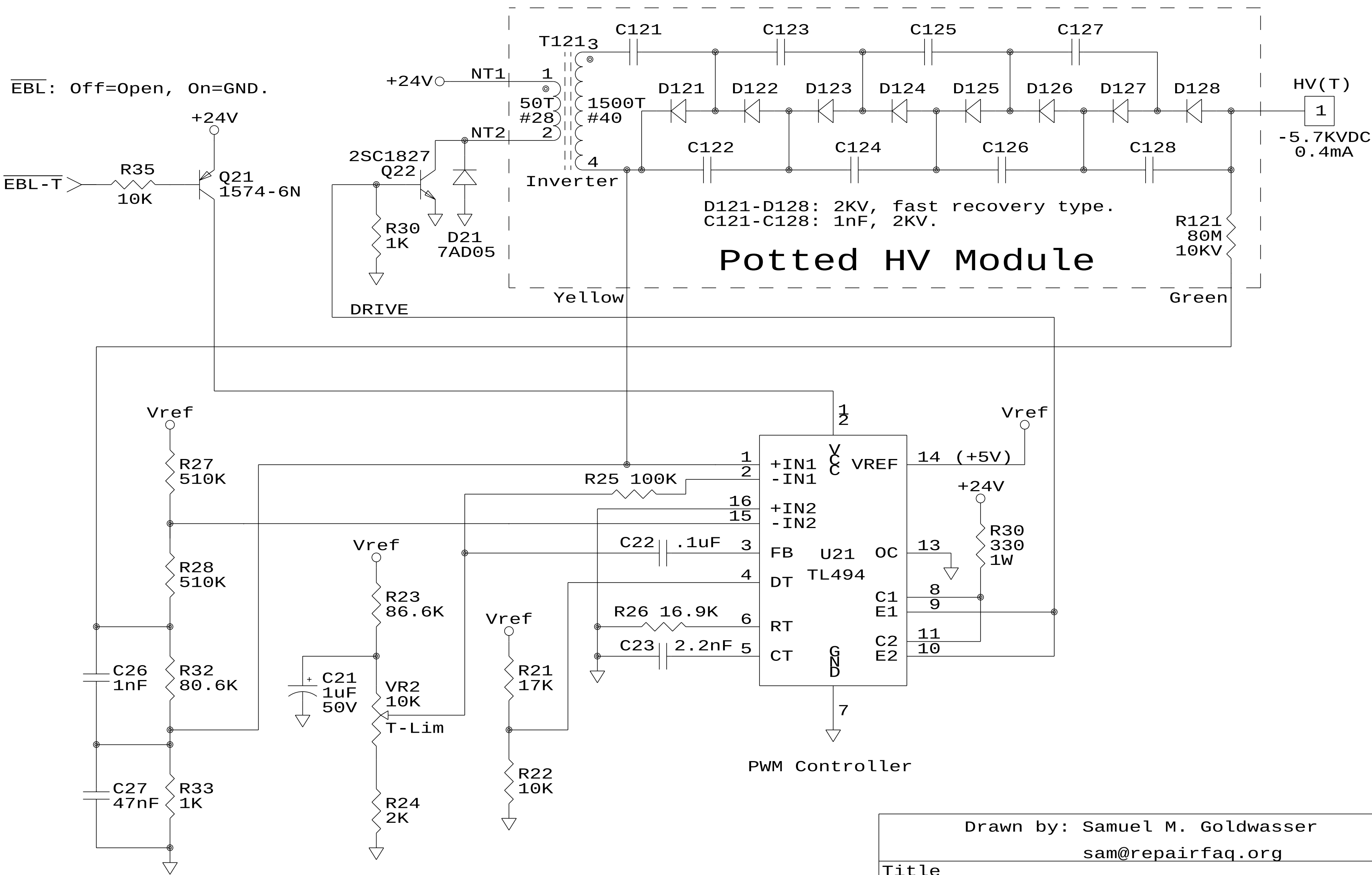


Ricoh 3E06-1 HVPS - Part 1 (RI-3E6)



Drawn by: Samuel M. Goldwasser sam@repairfaq.org		
Title Ricoh 3E06-1 HVPS - Part 1 (RI-3E6)		
Size: A	Document Number: RI-3E6-1-SCH	REV: 1.0
Date: April 8, 2003	Sheet 1 of 2	

Ricoh 3E06-1 HVPS - Part 2 (RI-3E6)



Drawn by: Samuel M. Goldwasser sam@repairfaq.org		
Title Ricoh 3E06-1 HVPS - Part 2 (RI-3E6)		
Size A	Document Number RI-3E6-2-SCH	REV 1.0
Date: April 8, 2003	Sheet 2 of 2	

Jacob's Ladder (Climbing Arc) Construction

Version 1.34

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

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DISCLAIMER

Jacob's Ladders - especially large ones using line powered transformers - can be both deadly, destructive, or both.

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

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Introduction

What is a Jacob's Ladder?

A Jacob's Ladder is the type of high voltage "climbing arc" display seen in many old (and usually bad) Sci-Fi movies. Jacob's Ladder come in all shapes, styles, and sizes. Here is info on a common type that is easy to construct with readily available parts. However, read the section: Jacob's Ladder SAFETY before attempting to power any high voltage project of this type.

How Does a Jacob's Ladder Work?

The simple explanation is that an arc starts at the bottom and due to the fact that hot air rises, tends to move up the diverging rods until they are too far apart for the voltage provided by the power source. A more complete explanation is given below:

(From: Kenny Greenberg (kenny@neonshop.com).)

While it is true that warm air pushes the arc up the ladder, there is also the typical 'high leakage' or reactance curve of the transformer contributing to the effect. The transformer will happily arc across the bottom as long as Paschen's Law will allow. Once this arc is struck the current in the arc will actually increase to the transformer's preset limit. The heat is also creating higher resistance.

Normally the transformer would try choke the voltage down as current increased. But just above the arc exists a path that the transformer can easily maintain and which in fact will lower its current. Voila.

At the top of course we are not only at the upper limit of the transformer but it is also where the current is very low and so all the fun breaks apart only to reignite down below.

A very interesting variant existed in the 1930's which used separate horizontal electrodes at various points along one side instead of a continuous vertical line. Each electrode is attached to a separate neon unit. They are tied together and return to the HV transformer. The convection current was optimized by placing this in a housing with vents at the bottom and top. The result is an animator with no moving parts.

The downside is the nitric acid that gets produced so keep it away from things that may be corrode.

Jacob's Ladder SAFETY

WARNING: See Safety Guidelines for High Voltage and/or Line Powered Equipment before firing up any Jacob's Ladder or other high voltage or line powered project!

Make sure that no one can come in contact with this - particularly curious onlookers. Separating the potential victims from any possible contact with the high voltage is really the only foolproof way of protecting against fools or the unaware - and you from a lawsuit. People not familiar with high voltage phenomena (or aware only through grade-C sci-fi movies) can be incredibly naive.

A GFCI (Ground Fault Circuit Interrupter) is of no use in protecting against HV contact since the secondary of a neon sign transformer is isolated from the line but its centertap is usually connected to the case - which should be grounded. However, a GFCI would be a good idea in any case when you are working with line connected equipment.

12,000 volts will jump approximately anywhere from 3/8 to 3/4 inch in dry air, with sharp points and edges generally but maybe not quite always favoring longer distances. This distance occaisionally varies unpredictably with humidity. Don't forget that 12,000 VAC is approximately 17,000 V peak. Neon sign transformers have current limited outputs - 30 mA is typical - but that is still highly dangerous - lethal under the wrong conditions.

You can build a small Jacob's Ladder using a high voltage transformer of lower capacity or a DC-AC inverter using a TV flyback transformer. While these would be less dangerous, there is little room for carelessness when working with any type of high voltage device. Even if there is no resistive path, the stray capacitance can permit enough AC current to flow to give you a painful experience!

Electrical discharges in air are also a producer of ozone which may be a health hazard. See the section: About Ozone Production. They also can produce significant Radio Frequency Interference (RFI) so the FCC may come calling if you run the thing for an extended period of time.

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Building a Jacob's Ladder

Basic Components

There are only two major parts to a basic Jacob's Ladder: a high voltage power source and a pair of rods arranged in a narrow V configuration on an insulated and fireproof support.

You will need 12 to 15 kVAC at 20 to 30 mA. However, the exact values are not at all critical. A neon sign (luminous tube) transformer is the usual source for this power though an oil burner ignition transformer will work in a pinch (some say better and cheaper) or you could build an inverter type power supply.

- Luminous tube transformers can be obtained used from sign shops or demolition companies. The cost will be anywhere from free to $50 or more depending on size and condition and whether the seller has a use or other buyers for this sort of equipment.

  Typical ratings: 12,000 to 15,000 VRMS current limited to 20 to 30 mA. Larger ones are available - up to 60 mA or even 120 mA - but this is not required. More information on neon sign transformers can be found in the chapter: The Home-Built Laser Assembly and Power Supply of Sam's Laser FAQ.

- Oil burner ignition transformers can be removed from discarded oil burners. These will probably be free for the asking at your local HVAC company. However, you will likely have to disassemble the disgustingly icky burner assembly and properly dispose of the unwanted parts as part of the deal.

  Typical ratings: 8,000 to 10,000 VRMS current limited to 10 to 25 mA.

- Both neon signs and oil burner ignitions may be powered by solid state inverters in some cases. These are likely suitable as well - and higher tech!.

  Inverter voltage and current ratings will be similar to their transformer counterparts, above. However, since the frequency of operation is in the 10s of kHz range instead of 50/60 Hz, behavior for the Jacob's Ladder will differ somewhat. For example, if they run on filtered DC (internally), there will be none of that 50/60 Hz buzz associated with those classic sci-fi movies! Perhaps, more of a starship engine sound. :)

- A small Jacob's Ladder can be powered from the types of high voltage inverters described in Various Schematics and Diagrams. However, since these only produce a couple of mA, the result will not be quite as spectacular.

- I DO NOT recommend the following: microwave oven transformers, utility pole transformers, and 100 kVA substation transformers :-). See the section: Why NOT to use Microwave Oven Transformers for additional comments if you are not yet convinced.

  - Microwave oven transformers produce only about 1,500 to 2,500 VAC which is too low. Several in series would be required but this is an extremely dangerous and unwieldy arrangement. They can supply AMPS of current which is an instantly lethal situation, are not current limited to anything that would conceivably let a human survive (0.5 AMPs or more), and do not have the required insulation for such operation.

  - Utility pole and substation transformers. Aside from requiring a fork lift or 10 ton crane to move, I don't think the power company would be happy if one of these were to disappear one night :-). It goes without saying that these would even be overkill (no pun...) for the State electric chair.

Having said that, see the section: Notes on Really BIG Jacob's Ladders for some more information.

Construction

Take a pair of thin metal rods - the steel wire from old metal coat hangers works quite well. Straighten them out and mount them on an insulated non-flammable support with a gap of about 1/4 inch at the bottom and 1 to 3 inches at the top forming a narrow tall 'V'. Mounting locations should not be in the path of the rising arc. Connect the high tension output of the transformer to the two rods using high voltage insulated wire unless the routing is such that there is no chance of arcing where you don't want it. DO NOT use automotive ignition cable for this unless it is the non-resistive type. Some adjustment of the spacing at the bottom (to get the arc started) and at the top (to determine when the arc is extinguished and how fast it rises) may be required (but do so only with the power off!). Depending on the voltage and power rating of your high voltage source, these dimensions may vary considerably. Spirals and other more creative configurations are also possible.

```
                             ___   1-3 inch gap or more at top.
                              ^  \     /
                     2-3 feet |   \   /
                      or more |    \ / 1/4 inch gap at bottom.
                             _v_   / \
                           +----X-'   '-X----+  X is mount attachment.
                           |   Insulated,    |
                       HV  |  non-flammable  |
                      +----+  mounting base  |
                   ||(                       |
        Hot o---+  ||(                       |
                  )||(       Luminous tube   | HV insulated wire
                  )||(  CT    transformer    |
    AC Line       )|| +---+   (12 kV, 30 mA, |
                  )||(    |   typical)       |
                  )||(    |                  |
     Neutral o---+ ||(    |                  |
                   ||( HV |                  |
              Case |  +----------------------+
                   |      |
Safety Ground o---+------+
```

IMPORTANT SAFETY NOTE: Essential line fuse, power switch, and power indicator lamp not shown. Centertap (case) MUST be connected to Safety (earth) Ground!!

A Jacob's Ladder works on the principle that the ionized air in the arc is a lower resistance than the air around it and heated air rises. The arc strikes at the point of lowest breakdown voltage - the small gap at the bottom. The heated plasma rises and even when it is an inch or more in width is an easier path for the current to follow. Eventually, the gap becomes too wide, the arc extinguishes and is reestablished at the bottom. For best results, shield the whole thing from drafts but don't use anything that can catch fire!

Clive's Gabriel Electrode to Help the Arc to Strike

(From: Clive Mitchell (clive@emanator.demon.co.uk).)

You know how critical the gap between the electrodes at the bottom of a Jacob's ladder can be. Too wide and the arc won't strike, and too narrow and it won't make it all the way to the top.

Because I live in the UK I'm more or less saddled with a 10 kV limit on the maximum neon transformer available. Since the lower voltage makes the gap even more critical, I designed a slight enhancement that works really well.

It's simply a third electrode placed between the strike gap at the bottom of the vee. It is connected to either one of the main electrodes via two 1M ohm high voltage resistors.

When an arc should occur, the following happens...

1. The voltage on the middle electrode floats to the potential of the electrode it's connected to via the resistors.

2. It's easy for an arc to jump the short distance from the other electrode to the middle one.

3. When an arc has struck and current is flowing, the voltage on the middle electrode flies up due to the high resistance value.

4. The combination of high voltage at the middle electrode and the ionized path makes the arc strike all the way across.

It's simple, but works perfectly.

I've never seen anyone use this on a Jacob's ladder before so what do I call it? How about the Gabriel electrode (in keeping with the biblical theme).

Why NOT to use Microwave Oven Transformers

Using multiple high voltage transformers from microwave ovens to construct a Jacob's Ladder is a very bad idea for several reasons:

- Microwave oven transformers are absolutely positively lethal if you or anyone else gets too close, AMPS available - especially if you are going to put them in series as would be needed to obtain adequate voltage. You might as well tap directly off of your utility's substation power bus.
- Unlike luminous tube (neon sign) or oil burner ignition transformers, they are NOT current limited to anything that will allow running on a 15 or 20 amp branch circuit so some other means of preventing your breakers (or your utility's substation breakers) from popping like cherry bombs will be needed.
- The most you will get out of a microwave oven transformer is about 2 to 2.5 kVAC. This is way to little for a decent Jacob's Ladder and putting them in parallel will not help. Therefore, 4 or 5 in series would be needed to obtain adequate voltage.
- Their insulation is not rated for series operation so one or more of the windings will see excessive voltage. There will likely be fireworks - and not where you want them.

I bet you are also going to try to run them on 220 VAC to double the output voltage as well, huh??

Similar comments apply to the use of utility pole or substation transformers.

A word to the wise: at some point, bigger is just stupid. Sorry.

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Additional Information

Notes on Really BIG Jacob's Ladders

(From: Steve Roberts (osteven@en.com).)

Microwave oven transformers make excellent Jacob's Ladders and Tesla Coil drivers with a properly chosen series cap in the primary for power factor correction. One of the major problems with the hollow "E" core current limited neon sign and furnace ignition transformers is that they do not source enough current to maintain a plasma on larger Jacob's Ladders, and the current limiting makes them lousy as pulsed laser drivers as well.

However, the high current from a microwave oven transformer will source a 10" inch arc in nitrogen/oxygen mixtures once it has been started at about 1/2". There are several European web sites that show back to back microwave oven transformer powered ladders. A key problem is that you have to mount the transformers on Lucite or Lexan because the center tap is grounded on the secondary side. For a advanced safety conscious experimenter it is not a problem to use these, provided you use either 1" diameter rods of copper or carbon rods for the ladder rails. While I would not approve of just anybody playing with these either, it can be done and produces spectacular results, if you don't mind the electric meter spinning at Mach 1!

They also make nice stable cores for high current low voltage transformers when rewound, I use them to power 25 amp 3.2 volt laser tube filaments all the time with out blowing breakers.

Snock's High Voltage Page has a number of articles and links relating to large Jacob's Ladders and other high voltage projects.

And Now for the Audio Feed

(From: Norman E. Litsche (nlitsche@worldnet.att.net).)

One of those old(bad) movies had a huge Jacob's Ladder inside a large transparent (glass, I assume - Plexiglass wasn't around then) hollow column resonant at 60 Hz. Unbelievable sound! Always wanted to build one like this but never had the time, the big resonant column or the really huge neon sign transformer that would have been needed.

(Assuming 1,100 feet per second for the speed of sound in air, a column closed at one end would be a 1/4 wavelength resonator resulting in an actual height of about 4.6 feet for a 60 Hz fundamental. --- sam)

About Ozone Production

If the Jacob's Ladder is large, significant ozone is an inherent byproduct unless you run it in an inert gas which might be an interesting experiment though I don't know how performance will be affected.

(From: Pamela Hughes (phughes@omnilinx.net).)

The arc is a plasma of hot ionized gas. Molecules like O_2 are broken down to the atomic level and ionized. when these ions collide with the surrounding air, they cause chemical reactions... the O can combine with nitrogen and form small amounts of nitrogen oxides, and with O_2 to form ozone (O_3). However, the high temps in an arc also tend to destroy these molecules too so you'd probably only produce trace amounts if it weren't for the UV given off by the arc. Ultraviolet seems to be the main mechanism for producing O_3 as it can ionize in the air far enough from the arc that it will be cool enough for ozone to exist (a spark gives off UV and ionizes the air around it) A glow discharge is better at generating ozone than an arc though, since it maximizes the UV and the pressures and temps are much lower (i.e., put a conductive coating on the outside of a glass tube and a wire down the center of it, then apply enough voltage to produce a glow discharge inside the tube as you pump oxygen at low pressure through the tube. Shortwave UV lamps will produce it too (they use these as sterilizers in dairy barns).

Jacob's Ladders and the FCC

Operating Jacob's Ladders (as well as Tesla coils) are broad-band RF sources and can interfere with radio, TV, maybe cell phone, cordless phone, and other communications equipment. There have been reports of the FCC tracking down and fining people for this interference - I don't know if these stories are true but it is definitely something to think about before running your creation for an extended period of time, at least. The FCC would probably confiscate your setup as well - which would likely be more traumatic than the fine (as hefty as it might be!) Perhaps, consider a Faraday cage in addition to the Plexiglass ozone shield :-).

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-- end V1.34 --

Basic Testing of Semiconductor Devices and other information including Introduction to Curve Tracers

Version 2.41a

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

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DISCLAIMER

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

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Introduction

Scope of This Document

The first part of this note describes procedures for testing of diodes (signal, rectifier, and zener); bipolar (NPN or PNP, small signal and power) transistors; SCRs, and MOSFETs for catastrophic failures like shorts and opens.

In most cases, this will identify bad silicon transistors. Gain, frequency response, etc. are not addressed here. While the tests can be applied to germanium devices, these are more likely to change characteristics, it would seem, without totally failing.

It is also possible to determine the lead arrangements of identified diodes and bipolar transistors as well as breakdown voltage ratings.

Curve tracers are pieces of electronic test equipment similar to an oscilloscope. They can not only test transistors and other devices but evaluate the functional specifications as well. The chapter: "Curve Tracer Design" includes information on their basic principles of operation and provides details on some very additions to conventional scopes to add some basic curve tracer capability.

This document evolved from a posting on the USENET newsgroup: sci.electronics (no longer active - closest replacement in the sci.electronics hierarchy is probably sci.electronics.components) from Randy Fromm (Randy@randyfromm.com) who maintains a Technical Department with an extensive collection of repair related information.

Safety Considerations

None of the tests described in this document require probing live circuits. However, should you need to do so, see the document: Safety Guidelines for High Voltage and/or Line Powered Equipment first.

Before touching, probing, or unsoldering any component, make sure the equipment is unplugged and any large capacitors have been safely discharged. See the document: Capacitor Testing, Safe Discharging, and Other Related Information or the specific document dealing with your equipment for details. Not only can coming in contact with a live circuit or charged capacitor ruin your entire day, your test equipment could be damaged or destroyed as well.

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Testing Semiconductor Devices with a VOM or DMM

VOMs and DMMs

Analog and Digital meters behave quite differently when testing nonlinear devices like diodes and transistors. It is recommended that you read through this document in its entirety.

Caution: An analog VOM on the lowest resistance range may put out too much current for smaller devices possibly damaging them. Ironically, this is more likely with better meters like the Simpson 260 which can test to lower ohms (X1 scale). Use the next higher resistance range in this case or a DMM as these never drive the device under test with significant current. However, this can result in false readings as the current may be too low to adequately bias the junctions of some power devices or devices with built in resistors.

Testing Diode Junctions with a Multimeter

On an (analog) VOM, use the low ohms scale. A regular signal diode or rectifier should read a low resistance (typically 2/3 scale or a couple hundred ohms) in the forward direction and infinite (nearly) resistance in the reverse direction. It should not read near 0 ohms (shorted) or open in both directions. A germanium diode will result in a higher scale reading (lower resistance) due to its lower voltage drop.

For the VOM, you are measuring the resistance at a particular (low current) operating point - this is not the actual resistance that you will see in a power rectifier circuit, for example.

On a (digital) DMM, there will usually be a diode test mode. Using this, a silicon diode should read between .5 to .8 V in the forward direction and open in reverse. For a germanium diode, it will be lower, perhaps .2 to .4 V or so in the forward direction. Using the normal resistance ranges - any of them - will usually show open for any semiconductor junction since the meter does not apply enough voltage to reach the value of the forward drop. Note, however, that a defective diode may indeed indicate a resistance lower than infinity especially on the highest ohms range. So, any reading of this sort would be an indication of a bad device but the opposite is not guaranteed.

Note: For a VOM, the polarity of the probes is often reversed from what you would expect from the color coding - the red lead is negative with respect to the black one. DMMs usually have the polarity as you would expect it. Confirm this using a known diode as a reference. Also, 'calibrate' your meter with both silicon and germanium semiconductors so you will know what to expect with an unknown device.

Transistor Testing Methodology

As with diode junctions, most digital meters show infinite resistance for all 6 combinations of junction measurements since their effective resistance test voltage is less than a junction diode drop (if you accidentally get your skin involved it will show something between 200K and 2M Ohms). The best way to test transistors with a DMM is to make use of the "diode test" function which will be described after the analog test. For both methods, if you read a short circuit (0 Ohms or voltage drop of 0) or the transistor fails any of the readings, it is bad and must be replaced. This discussion is for OUT OF CIRCUIT transistors *ONLY*.

One exception to this occurs with some power transistors which have built in diodes (damper diodes reversed connected across C-E) and resistors (B-E, around 50 ohms) which will confuse these readings. If you are testing a transistor of this type - horizontal output transistors are the most common example - you will need to compare with a known good transistor or check the specifications to be sure. There are some other cases as well. So, if you get readings that do not make sense, try to confirm with a known good transistors of the same type or with a spec sheet.

Before testing an unknown device, it is best to confirm and label lead polarity (of voltage provided in resistance or diode test mode) of your meter whether it be an analog VOM or digital DMM using a known good diode (e.g., 1N4007 rectifier or 1N4148 signal diode) as discussed below. This will also show you what to expect for a reading of a forward biased junction. If you expect any Germanium devices, you should do this with a Ge diode as well (e.g., 1N34).

The assumption made here is that a transistor can be tested for shorts, opens, or leakage, as though it is just a pair of connected diodes.

```
          C                                     C
          o                                     o
          |           +--|>|---o C              |           +--|<|---o C
        |/            |                       |/            |
   B o---|     =  B o---+                  B o---|     =  B o---+
        |>            |                       |<            |
          |           +--|>|---o E              |           +--|<|---o E
          o                                     o
          E                                     E

        NPN Transistor                        PNP Transistor
```

Obviously, simple diodes can be tested as well using the this technique. However, LEDs (forward drop too high more most meters) and Zeners (reverse breakdown - zener voltage - too large for most meters) cannot be fully tested in this manner (see the specific sections on these devices).

Testing with a (Analog) VOM

For NPN transistors, lead "A" is black and lead "B" is red; for PNP transistors, lead "A" is red and lead "B" is black (NOTE: this is the standard polarity for resistance but many multi-meters have the colors reversed since this makes the internal circuitry easier to design; if the readings don't jive this way, switch the leads and try it again). Start with lead "A" of your multi-meter on the base and lead "B" on the emitter. You should get a reasonable low resistance reading. Depending on scale, this could be anywhere from 100 ohms to several K. The actual value is not critical as long as it is similar to the reading you got with your 'known good diode test', above. All Silicon devices will produce somewhat similar readings and all Germanium devices will result in similar but lower resistance readings.

Now move lead "B" to the collector. You should get nearly the same reading. Now try the other 4 combinations and you should get a reading of infinite Ohms (open circuit). If any of these resistances is wrong, replace the transistor. Only 2 of the 6 possible combinations should show a low resistance; none of the resistances should be near 0 Ohms (shorted).

As noted above, some types of devices include built in diodes or resistors which can confuse these measurements.

Testing with a (Digital) DMM

Set your meter to the diode test. Connect the red meter lead to the base of the transistor. Connect the black meter lead to the emitter. A good NPN transistor will read a JUNCTION DROP voltage of between .45v and .9v. A good PNP transistor will read OPEN. Leave the red meter lead on the base and move the black lead to the collector. The reading should be the same as the previous test. Reverse the meter leads in your hands and repeat the test. This time, connect the black meter lead to the base of the transistor. Connect the red meter lead to the emitter. A good PNP transistor will read a JUNCTION DROP voltage of between .45v and .9v. A good NPN transistor will read OPEN. Leave the black meter lead on the base and move the red lead to the collector. The reading should be the same as the previous test. Place one meter lead on the collector, the other on the emitter. The meter should read OPEN. Reverse your meter leads. The meter should read OPEN. This is the same for both NPN and PNP transistors.

As noted, some transistors will have built in diodes or resistors which can confuse these readings.

Testing Power Transistors

Power transistors without internal damper diodes test just about like small signal transistors using the dual diode model, high in one direction B-E or B-C. If there is a built in damper diode, it is across C-E back biased under normal operating conditions. Therefore, a reading between C-E will also test low in one direction and B-C will show a double diode drop in the reverse direction. Also, there is often a low value resistor - about 50 ohms - between B-E when there is a built in damper. This will show up as a nearly zero volt junction drop on the diode test scale of a DMM but such a reading does not indicate a bad part. Use the resistance scale to confirm.

Testing Darlington Transistors

A Darlington is a special type of configuration usually consisting of 2 transistors fabricated on the same chip or at least mounted in the same package. Discrete implementations as well as Darlingtons with more than 2 transistors are also possible.

In many ways, a Darlington configuration behaves like a single transistor where:

- the current gains (Hfe) of the individual transistors it is composed of are multiplied together and,
- the B-E voltage drops of the individual transistors it is composed of are added together.

Darlingtons are used where drive is limited and the high gain - typically over 1,000 - is needed. Frequency response is not usually that great, however.

```
                                   C
```

```
                    o
                    |
            +-------+
            |       |
        B1 |/ C1    |
    B o-----|       |
           |\ E1    |
            |  B2 |/ C2
            +-----|
                  |\ E2
                    |
                    o
                    E
```

Testing with a VOM or DMM is basically similar to that of normal bipolar transistors except that in the forward direction, B-E will measure higher than a normal transistor on a VOM (but not open and 1.2 to 1.4 V on a DMM's diode test range due to the pair of junctions in series. Note, 1.2 V may be too high for some DMMs and thus a good Darlington may test open - confirm that the open circuit reading on your DMM is higher than 1.4 V or check with a known good Darlington.

Testing Digital or Bias Resistor Transistors

Occasionally you may find a transistor that includes an internal bias resistor network attached to the base and emitter so that it can be driven directly from a digital (e.g., TTL) source. These may be used in consumer electronic equipment where space is critical or for no good reason other than to make it difficult to locate a suitable replacement device!

```
                     C
                     o
                     |
          R1        |/
    B o---/\/\---+----|      Typical R1, R1: 47K.
                 |    |\
                 /     |
              R2 \     |
                 /     |
                 |     |
                 +------+
                       |
                       o
                       E
```

The addition of R1 makes testing with a multimeter other than for shorts more difficult. With a VOM, you should see a difference in the B-E and B-C junctions in the forward and reverse directions. However, a DMM will probably read open across all pairs of terminals.

Testing Unijunction and Programmable Unijunction Transistors

Unijunction Transistors (UJTs) and Programmable Unijunction Transistors (PUTs) are used in similar sorts of circuits though the UJT is all but extinct. They both exhibit a negative resistance characteristic and can be used easily in low to medium frequency free running relaxation oscillators and other trigger type circuits.

- The UJT goes into heavy conduction from E to B1 when E becomes more positive than a critical trigger voltage, Vt = n * Vbb + .6. (n, the 'intrinsic standoff voltage' is typically about .6). It continues to conduct until the emitter current drops below some minimum 'valley current' value. Sounds sort of like a thyristor, right? :)

- The PUT is even more like a thyristor: The PUT in that the triggering takes place when the G becomes more positive than the A (probably plus a diode drop, .6 V) so that the threshold voltage can now be set with a voltage divider feeding the anode. Then, current flows from the G to the K terminal. Note that its leads are even labeled like an SCR but it behaves sort of backwards!

For an initial test, check between B1 and B2 (UJT) or A and K (PUT) with an ohmmeter. The resistance should be the same in both directions and typically a few K ohms or more. A short or wildly different readings would indicate a bad device.

This doesn't prove that the device is good - only that it isn't blown up. A more complete test requires a simple circuit and some means of detecting an audio output signal.

For the UJT:

```
 +5 VDC o--------+---------+
                 |         |
                 /         |
              R1 \         |
            100K /         |
                 \         |
                 |         |B2
                 +-----. |-+
                 |      \|   Q1 UJT
                 |      E|-+--------o
                 |         |B1
             C1 _|_        /      To scope or
          .01uF ---     R3 \      audio amp
                 |      1K /      ~1K Hz
                 |         \
                 |         |
   Gnd o---------+---------+--------o
```

For the PUT (Programmable Unijunction Transistor), an additional voltage divider (R3 and R4) is needed to set the threshold:

```
+10 VDC o--------+---------+
                 |         |
                 /         /
              R1 \      R3 \
            100K /      1K /
```

```
              \         \
              |         |
              |         +-------+
              |         |       |
              +-----.   |A      |
              |     G\__|__ Q1  |
              |       _\_/_ PUT |
              |         |K      |
              |         +-------|------o
              |         |       |
          C1 _|_        /       /   To scope or
       .01uF ---     R2 \    R4 \   audio amp
              |      1K /    1K /   ~1K Hz
              |         \       \
              |         |       |
Gnd o---------+---------+-------+------o
```

(From: Spehro Pefhany (speff@interlog.com).)

A PUT is essentially an SCR with a large reverse gate breakdown voltage (G can be more positive than A by maybe 40 V) and a sensitive gate. When the voltage at A exceeds the voltage at G by a diode drop, and assuming enough voltage from A to K, the SCR turns on (conducts from A to K) and stays that way until the current drops below the holding current (typically around 100 uA, but it drops with increasing resistance in series with the gate).

Symbol and example:

```
                       _
                     /   \
  A   G              -----
  | /               |     |
-----               |     |
 \ /    PUT          -----  2N6028
-----                | | |
  | K                A G K
```

If you connect your meter from A to K, it should measure open both ways. If you connect the positive lead (which may be red or black, depending on the meter design) to A and the negative lead to K, and then momentarily short G to K it should change to a relatively low resistance reading (meter dependent). It will most likely stay latched when the G lead is returned to being open, because the meter measuring current will exceed the "holding current" of the PUT (called "valley current" in PUT specs).

If your meter has a "diode" range (in the ohms group), using that would assure there is enough open-circuit voltage to make this work, but it works this way in the half-dozen or so meters I have checked, using reasonable ohms ranges.

Measurements between A and G, with K open, should be similar to a silicon diode (fairly low in one direction, open in the other). Between G and K, with A open, should be open in both directions.

PUTs are pretty sensitive (less than 1 uA trigger current) so be sure to keep fingers away from the G lead.

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Thyristors - SCRs and Triacs

What are Thyristors

Thyristors are used to control power in numerous applications including light dimmers and motor speed controls, solid state relays, some microwave ovens, photocopiers, traction motors for electric locomotives and electric cars, power inverters for transmission of electric power over long distances, frequency converters, other DC-DC or DC-AC or AC-AC inverters, AC-DC regulated power supplies, and many other applications where efficient power control is required.

A Silicon Controlled Rectifier is one type of thyristor used where the power to be controlled is unidirectional. The Triac is a thyristor used where AC power is to be controlled. (There are exceptions in both cases but for this simple discussion these can be ignored).

Both types are normally off but may be triggered on by a low current pulse to an input called the Gate. Once triggered on, they remain on until the current flowing through the main terminals of the device drops below a hold value which is very close to zero. It is usually not possible (at least not easy) to turn thyristors off while current is flowing. However, there are special types called Gate Turnoff Thyristors which enable this type of control as well.

Both SCRs and Triacs are 4 layer PNPN structures.

How Does a Thyristor Work?

The usual way an SCR is described is with an analogy to a pair of cross connected transistors - one is NPN and the other is PNP. The base of the NPN is connected to the collector of the PNP and the base of the PNP is connected to the collector of the NPN.

If we connect the positive terminal of a supply to say, a light bulb, and then to the emitter of the PNP transistor and its return to the emitter of the NPN transistor, no current will flow as long as the breakdown voltage ratings of the transistor are not exceeded because there is no base current to either transistor. However, if we provide some current to the base of the NPN (IG(+).)ransistor, it will turn on and provide current to the base of the PNP transistor which will turn on providing more current to the NPN transistor. The entire structure is now in the solid on state and will stay that way even when the input to the NPN's base is removed - until the power supply goes to zero and the load current goes below the hold value.

The same scenario is true if we reverse the power supply and use the IG(-) input for the trigger.

```
               +------+
+ >------------+ LOAD +----------------+
               +------+                |
                                       |
                                     E \|
                                 PNP    |---+-------< IG(-)
```

```
                                      C /|   |
                                       |     |
                                       |   |/ C
                     Gate IG(+)  >-----+---|    NPN
                                           |\ E
                                             |
                                             |
- >------------------------------------------+
```

A Triac works in a basically similar manner except that the polarity of the Gate can be either + or - during either half cycle of an AC cycle.

For a light dimmer or motor speed control, for example, the exact time when the thyristor is triggered relative to the zero crossings of the AC power is used to determine the power level. Trigger the thyristor early in the cycle and the load is driver an high power. Trigger the thyristor late in the cycle and there is only a small amount of power delivered to the load. The thermal or mechanical inertia is generally counted to smooth out the power and results in smooth continuous operation (i.e., a light bulb controlled by a dimmer does not flicker.)

The advantage of thyristors over simple variable resistors is that they (ideally) dissipate very little power as they are either fully on or fully off.

There are a wide variety of other types of thyristor and thyristor-like devices. In particular, are diacs and sidacs which have no gate input but simply turn on when a specified threshold voltage is exceeded across their main terminals. See the section: Testing Diacs and Sidacs. These are often used to trigger other thyristors in phase control applications.

For more information on thyristors, see Horowitz and Hill or any thyristor databook.

Testing SCRs and Triacs

- For SCRs, the gate to cathode should test like a diode (which it is) on a multimeter. The anode to cathode and gate to anode junctions should read open in both directions.

- For triacs, the gate to main terminal 1 (MT1) should test like a diode junction in both directions. MT1 to MT2 and gate to MT2 junctions should read open in both directions. (CAUTION: I'm not sure the MT1 and MT2 designations are universal - check the datasheet to be sure!)

- For diacs and sidacs, there is no gate terminal - resistance should be infinite in both directions. For more complete testing, see the section: Testing Diacs and Sidacs.

Note: Some thyristors will have a low G-K/MT1 resistance but it should not read as a short.

The real test is quite simple but will require a low voltage DC power supply and two resistors. For triacs, a negative output from the supply is desireable as well to test the triggering when the gate is negative).

R1 will be used to limit current through the device and R2 will be used to limit current to the gate. A 12 VDC supply of at least 200 mA capacity with a 100 ohm 2 W resistor for R1 and 1 K 1/4 W resistor for R2 should work for most small to medium power SCRs. Check the 'minimum gate current' and 'holding current' specs to be sure. For larger devices, R1 and/or R2 may need to be smaller.

```
                 R1
  + o----+-----/\/\---------+-----o Test+
         |   100, 2W      __|__
         |                _\/\_ Device Under Test - DUT
12 VDC   |    R2          / |   (SCR or triac).
         +---/\/\---o <--'  |
             1K     o       |
                    |       |
  - o---------------+------+-----o Test-
```

1. Connect the supply as shown.

2. Trigger the gate from the positive of the supply through the current limiting resistor (R2) and see that the DUT turns on stays on when the gate is disconnected.

3. Open the circuit to the anode (with the gate connected to the cathode) and again reconnect the anode resistor. The DUT should now be off again.

- For triacs, repeat steps (2) and (3) with R2 supplied from a negative voltage.
- For diacs, testing must be at full rated voltage. See the section: Testing Diacs and Sidacs.

If the device passes these tests, it is behaving properly and is probably functional. However, without applying full voltage or current, there is no way of knowing if it will meet all specifications.

You can replace the DC supply with a low voltage power transformer (say, 12 VAC). Use a scope to monitor the voltage across the DUT or R1. Then, when the gate is connected to R2, you should see the voltage across the DUT drop to nearly zero when it switches on part way through the positive cycle. This phase will be determined by the voltage and value of R2. It should remain off for the entire negative cycle (SCRs only) with the gate connected and remain off all the time with the gate connected to the cathode.

(From: T. O. Prellwitz (timilen@halcyon.com).)

If you have a semiconductor curve tracer you can configure a small audio transformer circuit to drive the gate. I did this with my B&K and it works well. The secondary should provide enough voltage to drive the gate of the SCR and the negative swing of the AC will cycle the scr off while the positive phase turns it on. I drive the transformer with an audio generator. Hope this offers some ideas.

Testing Diacs and Sidacs

Diacs and Sidacs are thyristors without any gate terminal. They depend on the leakage current to switch them on once the voltage across the device exceeds their specified ratings. With an ohmmeter, they can be tested only for shorts. Resistance should be infinite in both directions.

However, you can test a diac or sidac with a resistor, variable power supply (you will need at least the rating of the device), and a DMM. Hook them in series and monitor across the device. With care, your variable supply can be a Variac, 1N4007, and 1 uF, 200 V capacitor. Use a 47 K resistor to limit the current:

```
            D1            R1
   ~ o----|>|----+-----/\/\---------+------o Test+
        1N4007   |      47K         |
                _|_ C1            __|__
Variable AC     --- 1 uF          _\/\_ Device Under Test - DUT
0 to 140 VRMS    |                  |
                 |                  |
   ~ o-----------+------------------+------o Test-
```

CAUTION: this is not isolated from the power line. Use an isolation transformer for safety. If the DUT is rated more than about 180 V, you will need to use a doubler and higher voltage capacitor but testing is otherwise similar.

As you increase the input, the voltage on the DUT will track it until the rated voltage at which point it will drop abruptly to zero and stay there until the voltage is reduced below its holding current. Repeat with the opposite polarity.

With a scope it is even easier as you can use an AC supply directly (remove D1 and C1) and observe that the DUT will turn on at the proper voltage on both polarities of the AC waveform and stay on until the voltage crosses 0.

Use an isolation transformer for safey.

Thyristors Driving Inductive Loads

> "I am trying to turn on a triac which is driving an inductive load (solenoid) using a digital signal without using an opto triac. I get limited success."

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

It is soooo easy: just use a DC current to drive the gate of the triac. Even the polarity of the current doesn't matter, although most triacs are more sensitive for a negative input current (flowing out of the gate to a negative supply). A large triac may require some 50 mA.

There will be some applications where there is no 50 mA supply available. That's where you would want to drive with short pulses. But these pulses would have to occur around the expected instant of the zero-crossing of the load current, which is a bit tricky with an inductive load.

As an alternative you could look for a more sensitive triac, for not too large load currents there are types down to 5 mA or so. If you have 50 mA of DC to spare, go for it, it will work.

By the way, never switch an inductive load like a power transformer ON at the zero crossing of the mains voltage. That's guaranteed to drive the transformer into saturation and create the worst possible current transient. Try and switch on at maximum mains voltage, at +/- 90 degrees delay. Do not use a voltage differentiator to generate +90 degrees phase shift, as it will be too sensitive to mains disturbances. Instead, use a double integrator to give 2 * -45 degrees and a low-pass filter. Using only 1 integrator to approach -90 degrees gives too much attenuation of the voltage, hence 2 are recommended.

Burning Up of Thyristors

(From: Neill Means (means@expert.cc.purdue.edu).)

Any thyristor will have a maximum change in current vs change in time dI/dt. If this is exceeded, then current flowing through the thyristor will find the path of least resistance through the silicon. Unfortunately, for us, this can be thought of as a molecular sized lightning bolt streaking through the doped layers of silicon - finding the path of least resistance from individual molecule to individual molecule. This soon results in an 'avalanche' of electrons streaming through a very small path and this process feeds on itself until the thyristor dies. This whole process probably takes only microseconds to happen.

I don't know if fast blow fuses will help this situation if the current changes too rapidly. A fuse is a very analog device with mass and it seems like it would be a slow, lumbering giant compared to almost instantaneous current change.

The solution for this problem? I am guessing putting an appropriately sized inductor in series with the light bulb, but just be sure to add the correct over voltage snubbing network. The inductor will keep the current from changing too rapidly.

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Additional Semiconductor Tests

Identifying Unknown Bipolar Transistors

The type (NPN or PNP) and lead arrangement of unmarked transistors can be determined using a multimeter based on similar considerations. This, again, assumes the back-to-back diode model. The collector and emitter can then be identified based on the fact that the doping for the B-E junction is always much higher than for the B-C junction. Therefore, the forward voltage drop will be very slightly higher - this will show up as a couple of mV (sometimes more) difference on a DMM's diode-test scale or a slightly higher resistance on an analog VOM.

To determine the lead arrangement, label the pins on the unknown device 1, 2, and 3. Put the positive probe (as determined above) of you multimeter on pin 1. Now, measure the resistance (VOM) or diode drop (DMM) to the other two pins. If the positive probe is on the base of a good NPN transistor, you should get low resistance readings or a low diode drop to the other two leads. The B-C resistance or diode drop will be just slightly lower than the B-E reading.

If one or both measurements to the other two pins is high, put the positive probe on pin 2 and try again. If still no cigar, try pin 3.

If this still doesn't work, you may have a PNP transistor - repeat with the negative probe as the common pin.

If none of the six combinations yields a pair of low readings - or if more than one combination results in a pair of low readings, your transistor is likely bad - or it is not a bipolar transistor!

As noted, some power transistors have built in base resistors or damper diodes and will confuse these measurements. However, the lead arrangement of these types of transistors is usually self evident (standard TO3, TOP3, or TO220 cases). There are also some transistors with series base resistors which may prove confusing. There are relatively rare, however.

Voltage ratings are more difficult and require a low current variable DC power supply with a maximum voltage output greater than the expected (or desired) breakdown rating of the transistors being tested. A fixed DC supply with a suitable potentiometer is also satisfactory. For tests up to 100 V, a 100K ohm pot would be satisfactory. Put a current limiting resistor of about 100 K ohms in series with the output. For higher voltage transistors, use an appropriate power supply and increase the value of the potentiometer (if used) and current limiting resistor. It should be possible to determine approximate values for Breakdown Voltages such as:

BVcbo - collector to base, emitter open. BVceo - collector to emitter, base open. BVces - collector to emitter, base shorted to emitter. BVebo - emitter to base, collector open.

Apply your variable voltage across the appropriate leads and monitor at the transistor with your VOM or DMM. The breakover point should be easily detectable. The current limiting resistor should prevent damage to the part from power dissipated in the reverse biased junction.

This approach also works for signal, rectifier, zener diodes, and other similar devices.

Luke's Comments on Junction Voltage Drops and Doping

(From: Luke Enriquez VK3DLE (ecsclfe@lux.latrobe.edu.au).)

The B-C junction voltage drop is always very slightly lower than the E-B junction drop. The drop is given by the equation:

$$Vdrop = Vt * \ln (Na*Nd/ni^2)$$

where:

```
Vt = kT/q = 26 mV at 300 degrees K

ni = intrinsic carrier concentration in a pure sample of silicon
     (ni = 1.5 * 10^10 cm-3 at 300 deg K for silicon)

Nd = doping density atoms/cm^3 in the n-type material

Na = doping density atoms/cm^3 in the p-type material
```

This equation means that if the doping density at the Base-Emitter junction is higher than the Base-Collector junction, the Vdrop of the Base-Emitter junction will be higher than that of the Base-Collector junction.

This has been confirmed below on a selection of common transistors using an El-cheapo DMM:

Transistor	B-C Voltage	B-E Voltage
TIP3055	0.640	0.642
TIP2955	0.668	0.668
BD140	0.697	0.699
2N2369A	0.682	0.710
PN3563	0.752	0.753
BC108	0.715	0.716

CAUTION: Do not hold the transistor under test in your hand. For every degree the transistor increases in tempreture, the Base-Emitter Diode Drop (commonly called Vbe) decreases by 2 mV. This is a significant amount when determining the B-E and B-C junctions.

Lance's Method for Determining C and E on an Unmarked Bipolar Transistor

(Slightly edited for readability --- sam)

(From: Lance (cast@iafrica.com).)

Using an analog (VOM - a DMM will not work), on its highest resistance range I test across the collector and the emitter one way and then change the leads around. The reading that is lower reading is the one to note (the one with the most leakage on a uA meter). Sometimes the needle only just barely moves. For a PNP the positive lead is on the emitter and for a NPN the positive lead is on the collector. Now you know the base collector and emitter, this has helped me work out how a circuit works by finding the legs of the working transistors and then repairing it. I found this in a very old mag more than fifteen years ago. If I can't remember which way is what I use a known transistor. I then find out the hard way. (Note: for a VOM, the polarities of the leads are often opposite of the color code as noted above --- sam).

Testing MOSFETs

(From: Paul Mathews (optoeng@whidbey.com).)

1. Verify gate has infinite resistance to both drain and source. Exception: FETs with protection circuitry may act like there is a zener shunting GS, i.e., diode drop for gate reverse bias, ~20V breakdown in fwd bias.

2. Connect gate to source. Drain to source should act like a diode.

3. Forward bias GS with ~5 V. DS in forward bias should measure very low ohms. In reverse bias, it will still act like a diode.

The usual failure mode: GS short AND DS short. In other words, everything connected together.

(From: Richard Torrens (4qd@argonet.co.uk).)

A lot of common multimeters have a diode range: you can use this to measure a MOSFET out of circuit and get a good idea of whether it is OK. Meter negative on the source, you should get no reading (open circuit) on the drain. Not on the gate but if you measure the drain AFTER measuring the gate you will find it conducts. A finger between source and gate will bleed away the charge and the MOSFET stops conducting.

You really need a 'scope to check the drive circuit. What it does will depend on the circuit configuration, whether there is current limiting etc.

(From: E. Wolsner (interser@algonet.se).)

My way of testing a power MOSFET is indeed simple and normally sufficient:

One ohmmeter is connected to the drain and the source, measuring the resistance between drain and source, which should be very high. Another ohmmeter is connected between gate and source. This ohm-meter should have a high resistance capability (maybe 20 M ohms) and thus have a relatively high test voltage (more than 5 volts). Now this voltage, when connected with the proper polarity, will turn the mosfet on, which will be indicated by the first ohm-meter. It will show zero resistance. To turn the transistor off, you reverse the gate-source voltage, and the drain-source ohm-meter will again indicate high resistance.

(Portions from: Egon Wolsner (interser@algonet.se).)

The multimeter must be able to provide at least 5 volts output on the resistance measuring range (this usually means that a DMM will not work). If it does, here is the procedure:

First you measure the resistance between the drain and source terminals, it should be infinity. Then connect the plus to the gate and the minus to the source pin. That should turn the MOSFET on. Then you measure the resistance between the drain and source pins, which should verify that the resistance is indeed near zero. (The gate capacitance will hold the device in the on-state long enough for this test.) Turn the mosfet off by shorting the gate and source pins (for a n-channel MOSFET)

(From: Bruce (reglarnavy@aol.com).)

You can get a pretty good idea about the condition of a MOSFET with some quick & simple bench tests. The first thing you can do with a meter is measure the parasitic substrate diode that connects the drain to the source. In an NMOS part, this diode's cathode will be at the drain, and the anode at the source. It will meter out similar to any conventional diode in both fwd / reverse directions. You can see this diode in the schematic representation of the FET in some databooks and a few schematics. The FET should show infinite resistance, gate - source and gate - drain. If it does not, then the gate oxide may be blown.

A second simple test can be done with a meter and a 9 V battery. First, short the gate to the source to discharge any stored charge there. Then put your meter on ohms and connect it across the drain - source. It should measure as an open. Briefly connect the 9 V across the gate (+) to source (-) , again, NMOS polarities, and the meter resistance should fall to a very low resistance, on the order of an ohm or less. Removing the battery will not change the reading, because in a good FET, Ciss will remain charged for a long time and keep the FET on. Most FETs come on at Vgs=2 volts or so.

If these two tests work, then the FET is off to a good start. Substituting a power supply and a proper load resistor for the meter, and a variable voltage (a pot across the 9v will work) for the Vgs supply, in the aforementioned test, will obviously be a more realistic test, and will also let you measure Vds, Id, etc.

BEWARE ESD WITH FETS! Wear a wrist strap, keep the parts away from insulators like plastics, and make sure your soldering iron tips are grounded. If you do not have any of the black ESD foam to keep your parts in, then look around for an anti-static bag that once may have contained a computer board, SIMMs, etc.

Testing IGBT

Basic testing IGBTs (Insulated Gate Bipolar Transistors) should be similar to an enhancement mode N-channel MOSFET except that the threshold voltage may be larger than a typical MOSFET (e.g., 8 V instead of 4 V).

1. Check for shorts with an ohmmeter.
2. Put a current limited supply across C-E with an ammeter in series.

3. Apply at least 10 V G-E. The transistor should turn on.
4. Ground the gate. The transistor should turn off.

A curve tracer should be able to be configured for IGBT testing to determine more complete behavior.

Testing LEDs

Electrically, LEDs (and IR emitting diodes, strictly speaking called IREDs) behave like ordinary diodes except that their forward voltage drop is higher.

Typical values are:

IR: 1.2 V, Red: 1.85 V, Yellow: 2 V, Green: 2.15 V. The new blue LEDs will be somewhat higher (perhaps 3 V). These voltages are at reasonable forward current. Depending on the actual technology (i.e., compounds like GaAsP, GaP, GaAsP/GaP, GaAlAs, etc.), actual voltages can vary quite a bit. For example, the forward voltage drop of red LEDs may range at least from 1.50 V to 2.10 V. Therefore, LED voltage drop is not a reliable test of color though multiple samples of similar LEDs should be very close. Obviously, if the device is good, it will also be emitting light when driven in this way if the current is high enough.

So, test for short and open with a multimeter (but it must be able to supply more than the forward voltage drop to show a non-open condition).

An LED can be weak and still pass the electrical tests so checking for output is still necessary.

Therefore, if these tests don't find a problem, drive the LED from a DC supply and appropriate current limiting resistor. For the IR types, you will need a suitable IR detector. See the document: "Notes on the Troubleshooting and Repair of Hand Held Remote Controls" for a variety of options.

Testing Opto-Isolators and Photo-Interrupters

Both these classes of components are basically similar: a light source (usually an IR LED) and photodetector together in a single package.

- The opto-isolator will be totally sealed with adequate separation between the two parts to provide the specified isolation voltage rating.

- The photo-interrupter (and similar devices) will provide a beam path that can be blocked or otherwise modified by external means.

For both types, the photodetector can be a photodiode, phototransistor, photothyristor, or other more complex device or circuit.

Refer to an optoelectronics databook or the catalog of a large electronics distributor for specific pinouts and specifications.

Assuming a photodiode or phototransistor type (most common), these can be tested for basic functionality pretty easily:

Wire up a test circuit as follows:

```
 +5 o-----+------------------+
          |                  |
          /                  /
          \ 500              \ 5K
          /                  /
          \                  \
          |  _|_ S1          |
          +--- ----+         +-------------o Out
               - - | - - - - | -
              :  __|__      _|_ :
          LED :  _\_/_ ---> /_\ : Phododiode
              :    |         |  :
               - - | - - - - | -
Gnd o--------------+---------+-------------o Gnd
```

Depressing S1 should result in the Output dropping from +5 V to close to 0 V. For monitoring on a scope, drive the LED with a pulse generator and current limiting resistor instead of S1. With a photo-interrupter type, blocking or adding a reflector to the optical path (as appropriate) should result in similar behavior.

Testing Thermistors

There are two types of thermistors:

- Positive Temperature Coefficient (PTC) types have a resistance that increases with increasing temperature.
- Negative Temperature Coefficient (NTC) types have a resistance that decreases with increasing temperature.

For a small thermistor, put an ohmmeter on it and the heat it up with a blow dryer, heat gun, or the tip of a soldering iron - the resistance should change smoothly (up or down depending on whether it is PTC or NTC type). If the resistance changes erratically, or goes to infinity or zero, the device is bad. However, you will need specifications, temperature measuring sensors, etc. to really determine if it is operating correctly.

Testing Thermo-Electric (Peltier) Devices

While these are often called Thermo-Electric Coolers (TECs), they are equally good (or poor) at heating. The typical TEC uses a series connected string of thermocouple-like junctions sandwiched between a pair of ceramic plates. They are generally specified in terms of maximum temperature difference (typically between 60 to 70 °C); maximum current, voltage, and power dissipation; and physical dimensions.

Most problems will be obvious - like the entire thing was smashed by your pet elephant or melted down due to applying too much power. :) However, a hairline crack in one of the interior junctions could be undetectable without testing.

The best way to test a TEC is to apply a controlled current and monitor the voltage across the device as a function of current and measure the temperature difference between the hot and cold surfaces. Then, compare the readings with the device's specifications. If these aren't known, it may be possible to match up your device with one of similar dimensions. One major supplier is Melcore.

Testing for continuity can be done with an ohmmeter but really only if the temperature of the two sides is exactly equal - otherwise there will be a voltage offset (the junctions also generates voltage when a temperature difference is present - and this can also serve as a test of sorts).

The I-V characteristics should be fairly linear over a relatively wide range of current within the device's specified operating range. However, the voltage for a given current does vary slightly with the temperature difference between the hot and cold surfaces.

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Miscellaneous Information

Differences Between Ordinary, Fast Recovery, and Schottky Diodes

When the polarity reverses on a diode, it takes finite time for the charge carriers to be cleared from the area of the junction. During this time, reverse current flows. For high frequency applications - i.e., switching power supplies, horizontal deflection circuits, etc. - a normal diode would act more like a short circuit and result in poor performance or even burn out.

There are a variety of alternatives: fast, super-fast, ultra-fast (and so forth) recovery diodes, schottky diodes, and others that must be used in high frequency signal, switching, and power supply circuits:

Thus, if you find a bad diode in a piece of electronic equipment, don't assume it is just an ordinary diode because the case looks the same. Replacing a fast recovery diode with a 1N4007 will very likely just result in more confusion. A proper device must be used even for testing. In most cases, a faster part can be substituted without problems. However, there are occasional situations where the specific characteristics of a slow part (a reverse pulse due to its long recovery time or high capacitance) are depended upon for the circuit to operation properly!

(From: John Popelish (jpopelish@rica.net).)

Fast recovery diodes have a little gold added to the silicon (and perhaps other process changes) that make the minority carriers (holes in n type and electrons in p type sides of the junction) have shorter lifetimes, so that in addition to sweeping them out by applied voltage, the carriers spontaneously disappear. This makes the diodes turn off faster. Other tricks help the diodes to turn off with less of a snap, to reduce high frequency noise generation. These changes usually compromise other properties of the diode, like reverse leakage, forward drop or breakdown voltage, so there are lots of different combinations of trade-offs.

Schottky diodes are really just half diodes. A metal intimately bonded to a p type semiconductor. Holes have a zero lifetime in metal, so the minority lifetime is just about zero for schottky diodes. They also have about half a diode drop in the forward direction, and so are twice as efficient even for low frequency rectification. The trade off here is that they can only be made to handle low reverse voltages and even there, they have more reverse leakage than junction diodes.

Motorola published a diode handbook that goes into a lot more detail on these things and I recommend it.

Horizontal Output Transistor Pinouts

You will nearly always find one of two types of horizontal output transistors in TVs and monitors:

- Metal can - TO3 package:

```
                  _
                / O \          View from bottom (pin side).
              / o   o \
             (  B   E  )       B = Base, E = Emitter, C = Collector.
              \       /
                \ O / C        The metal case is the Collector.
```

- Plastic tab - Mostly these will be the TO3Pn (n = several suffixes) package but some B/W TVs and mono monitors or video display terminals may use HOTs in the smaller TO220 package:

```
                     TO3Pn
       TO220         _____
       _____        /     \
      |  o  |      |   O   |      View from front (label side).
      |-----|      |-------|
      |Label|      |       |      B = Base, E = Emitter, C = Collector.
      |_____|      | Label |
       | | |       |_______|      If there is an exposed metal tab, that is
       | | |         | | |         the Collector as well.
       B C E         | | |
                     B C E
```

Some other transistor types use the same pinout (TO66 for metal can, TO218 and TO220 for plastic tab) but not all. However, for horizontal output transistors, these pinouts should be valid.

Note that those with a built in damper diode may read around 50 ohms between B and E (near 0 on the diode test range) - this is normal as long as the resistance is not really low like under 10 ohms.

Difference Between Normal and 'R' Marked Parts

> "Does anyone know the difference between transistor BDY58R and BDY58 (if any at all)?"

(From: Paul Grohe (grohe@galaxy.nsc.com).)

Yep! We "hit our head" on this one while diagnosing a sick scope.

Electrically, the parts are exactly the same. The "R" stands for 'reverse'. The 'R' pinout is a mirror image of the normal one.

```
                 C                                   C
            ____|_|____                         ____|_|____
```

```
      |           |                      |           |
      |___________|                      |___________|
       | |     | |                        | |     | |
        B       E                          E       B

Top view of 'normal' SOT              Top view of 'R' SOT
```

This makes layout of high-frequency pairs easier because traces do not have to cross over one another, and the layout is 'cleaner' but bites you if you are unaware!

Testing Zener Diodes

The following applies to both testing of zeners for failure and determining the ratings of an unknown device. Zeners most often fail short or open with short probably more likely. However, it is also possible, though a lot less common, for the zener voltage to change (almost always to a lower voltage) and/or for the shape of the I-V curve to change dramatically (e.g., become less sharp cornered).

With a VOM, a good zener diode should read like a normal diode in the forward direction and open in the reverse direction unless the VOM applies more than the zener voltage for the device. A DMM on its diode test range may read the actual zener voltage if it is very low (e.g., a couple V) but will read open otherwise. The most common failure would be for the device to short - read 0.0 ohms in both directions. Then, it is definitely dead. :)

Some zeners are marked with a JEDEC (1N) part number, others with a couple of colored bands (e.g., for 18 V, brown/gray), or a house number or house color code.

You can easily test a zener and identify its voltage rating with a DC power supply, resistor, and multimeter. You will need a power supply (a DC wall adapter or AC wall adapter with a rectifier and filter capacitor is fine) greater than the highest zener voltage you want to test. Select a resistor that will limit current to a few mA. For example, for zeners up to about 20 V, you can use:

```
                 R=2K
24VDC o----------/\/\----------+----------o
                              _|_.        +
                             '/_\ ZD   VOM/DMM
                               |          -
  Gnd o------------------------+----------o
```

This same approach applies to other devices that exhibit a similar behavior such as the B-E junction of a bipolar transistor.

Testing MOVs

MOVs are used mostly for surge suppression in power strips and the front-ends of the power supplies of TVs, VCRs, and other consumer electronic equipment. They are those brightly colored things that look like Epoxy dipped capacitors. At least, that's what they look like when new. A common failure mode is for the MOV to be totally obliterated by a surge or from old age. Then testing is not needed! :)

They are supposed to be located beyond the line fuse (though possibly not always). In this case, where the line fuse blows but there is no visible damage to the MOV(s), the simplest test may be to just temporarily remove the MOV(s) and see if your problem goes away.

A multimeter can be used to test for leakage (there should be none) but the best option is to remove the device. Since the proper functioning of the equipment doesn't depend on any MOVs (in 99.9999 percent of the cases - the exception being where the MOV is used as a high voltage triggering device or something like that rather than a surge suppressor), remove the MOV(s), test the equipment, and just replace the MOV(s) if in doubt.

(From: Brad Thompson (Brad_Thompson@pop.valley.net).)

Usually, the manufacturers specify a maximum leakage current (usually one milliampere) at a AC specified voltage. You'd need a Variac adjustable AC source, an isolation transformer (for safety), an AC voltmeter and an AC milliammeter to make the measurement.

An MOV works as follows: It's essentially a batch of metallic-oxide grains separated by insulating layers. Repeated voltage surges break down the insulating layers, lowering the overall resistance and eventually causing the device to draw too much current and trip whatever overcurrent protection is inherent in the system.

I've seen MOVs exuding tiny metallic "teardrops" through their epoxy coatings, which remained bright and shiny. These devices needed replacement!

(From: Kevin Carney (carneyke@us.ibm.com).)

This is not a valid test for breakdown voltage but these devices read a few megohms when damaged. The new replacements read open on my meter that has a 20 Megohm range of a DMM.

More Gory Details on Zeners and Similar Diodes

(From: Gord Neish (gord.neish@sk.sympatico.ca).)

To those how enjoy the theory!!

When is a Zener not a Zener??

If is voltage is over 6 volts, technically it's an avalanche diode. Here's an engineering text quote that explains rather well:

> "The zener effect refers to removing bound electrons from outer shells by means of an electric field. In other words, as a reverse voltage is applied to a diode, an electric field appears at the junction. When this field is intense enough, outer-shell electrons are dislodged, resulting in a significant increase in reverse current.
>
> The avalanche effect is different. In this case, when the diode is reverse biased, minority carriers are flowing. For higher reverse voltages these minority carriers can attain sufficient velocity to knock bound electrons out of there outer shells. These released electrons then attain sufficient velocity to dislodge more bound electrons, etc. The process is well named, since it is suggestive of an avalanche."

As noted, the voltage where the zener effect leaves off and the avalanche effect takes over is approximately 6 volts.

More accurately, the zener effect dominates below 4 volts and the avalanche effect dominates above 6 volts and a combination of the two between 4 and 6 volts.

Now, which one is in effect significantly affects the temperature characteristics of the device.

- A zener diode (4 volts or less) has a negative temp. coefficient (as temp increases voltage drops).
- An avalanche diode (6 volts or more) has a positive temp. coefficient (as temp increases voltage increases).
- A zener/avalanche diode (4-6 volts) the effects tend to cancel each other resulting a very temp stable diode.

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Introduction to Curve Tracers

Curve Tracer Design

A curve tracer is a piece of test equipment or an add-on to an oscilloscope which provides a graphical display of the V-I (or other parameters) of an electronic component. The design of a curve tracer is simple in principle (description here for bipolar transistors):

For the horizontal (collector supply) you need a variable ramp generator. If your scope has a sweep output, then you can derive it from this - if you are not interested in frequency response, an audio amplifier may be adequate with a volume control to adjust the amplitude.

For the base drive you need a programmable current source capable of putting out a series of constant currents for the base drive. Here, a counter driving a D/A set up for a current output mode. Use the trigger output or sweep output of the scope to increment the counter so that it sequences through a set of say, 10 current settings.

Then, you need some way of sensing collector current to drive the vertical channel - a small series resistor in the emitter circuit, for example.

For simple diode tests, you can just use a variable AC voltage source like a variable isolation transformer (with a current limiting resistor) across the diode. The X (horizontal) input of the scope goes across the device under test. The Y (vertical) input of the scope goes across the current limiting resistor or a separate series current sense resistor. See the section: Quick and Dirty Curve Tracer.

Then, you can jazz it up with microprocessor controlled on-screen display.

Curve tracers can be big expensive things (e.g., multi-$K) or little add-ons to regular scopes. Here one company selling a curve tracer kit or assembled. I have no idea how good it is but check out Gootee Systems for more info.

Popular Electronics, May 1999, has complete plans for a "Semiconductor Tester" which can handle NPN and PNP bipolar transistors, JFETs and MOSFETs, all sorts of diodes including zeners, and a variety of other devices. This is basically a curve tracer adapter for an oscilloscope. With a little ingenuity, it can be enhanced to test virtually all the semiconductors discussed in this document.

Therefore, if you want a sophisticated piece of test equipment, one of these would be suitable. Or, get yourself a used Tektronix 575 curve tracer. This will do just about everything you could possibly want (including the testing of vacuum tubes with the addition of a bit of external circuitry.)

However, to just test 2 terminal devices - or to just get a feel for device characteristics, there are much simpler, cheaper, alternatives.

Quick and Dirty Curve Tracer

I threw the following circuit together in about 10 minutes. With minor modifications, it is capable of displaying V-I curves for diodes, zeners, transistors, thyristors, resistors, capacitors, inductors, etc.

I used a 12 VAC transformer just because it was handy. You can use anything you like as long as you understand the safety implications of higher voltages and make sure the components you use can withstand the power that might be dissipated in them if the Device Under Test (DUT) is a dead short. In addition, it is bad form to blow out the DUT while testing it! A signal generator driving a small audio transformer could also be used if it is desired to test components at frequencies other than 60 (or 50) Hz.

```
          o-------+     X       R1
                  )|| +------/\/\/\------+----o Horizontal Scope Input
                  )||(                   |         (Voltage Display)
                  )||(                   o
    Adjustable AC )||(                   +
     from Variac  )||(                  DUT
                  )||(                   -
                  )||(                   o
                  )||( Y       R2        |
                  )|| +--+---/\/\/\------+----o Scope Ground
          o-------+      |
                   T1    +--------------------o Vertical Scope Input Inverted)
                                                  (Current Display)
```

CAUTION: turn down the intensity of the scope so the spot is just barely visible so that when there is no input, you don't end up drilling a hole in the face of the CRT!

- R1: Current limiting and phase shift control. I used 500 ohms which works well for small signal semiconductors and capacitors around 1 uF.
- R2: Current sense. I used 10 ohms and put the scope on the one of the .1, .2, or .5 V/cm ranges.
- T1: Small power transformer. I used the 12 VAC wall wart from an obsolete modem. This will supply a voltage of up to about 17 V peak to your DUT.

  For higher power or higher voltage devices, substitute a suitable larger transformer.

Modify these (selector switches might be nice) for your needs. A Variac provides a convenient method of adjusting the voltage applied to the DUT.

- Zener diodes - the result will be exactly like the picture in your textbook. Try this with a 5 or 6 V zener to confirm that your rig is working.
- Resistors - the display should be a straight diagonal line. You should be able to compute their value from the ratio of V to I.
- Capacitors - you should see the phase shift between voltage and current resulting in an ellipse (though you will probably have to adjust the scale factors to obtain a usable display with typical capacitor values).
- Bipolar transistors - a source of (DC) base current is needed. You can be fancy or simple. For a simple source, I used a variable 0 to 15 V power supply and a current limiting resistor. Since we know that the voltage drop across the B-E junction is fairly constant at around .7 V (for silicon), the output of the supply can be calibrated in terms of base current.
- SCRs - connect a suitable resistor in series with a diode or two (or a diac) between the gate and DUT+ (so that gate current in included in the V-I curve). When the threshold current is exceeded, the device should turn on and remain on until the zero crossing. With the reverse polarity, the device should remain off. For triacs, use diodes in parallel in both directions or a diac. A triac should trigger on both polarities of the AC waveform.

In-Circuit Tester

The following is along the same lines as the "Quick and Dirty Curve Tracer" but is suitable for in-circuit testing as the current and voltage are limited to safe values for most devices (less than 1 VAC and than 1 mAAC respectively).

The very complicated circuit is shown in: curve.gif and below in ASCII.

CAUTION: Use at your own risk. I cannot absolutely guarantee that there won't be certain devices in use today that didn't exist in 1975 that might be unhappy with this approach.

(From: Wern Thiel (wern@zoo.toronto.edu).)

```
          220
     o-----/\/\-------+---------+-------------o  Vertical Scope Input
                      |         |
                      |         \
       To the 3 V     |         / 1 K
       winding of a   |         \
       6 V center     /         /
       tapped power   \ 100     |
       transformer    /         o-------------o  Ground
                      \         |
                      |         o
                      |  Red component test lead
                      |
                      |  Black component test lead
                      |         o
                      |         |
     o----------------+---------+-------------o Horizontal Scope Input
```

In the August 1975 issue of Popular Electronics author Lou Garner wrote in a story called "A simple On-Board Tester" about this fairly simple piece of test equipment.

The device can be used with any type of oscilloscope and consists of a 6 volt filament transformer, three 1/4 watt resistors and two test probes. Half of the filament voltage is applied to a voltage divider consisting of 220 ohm and 100 ohm resistors, yielding 1 volt ac on top of the 1 K ohm resistor. This voltage can be applied to any component or combination of components across which the test leads are placed. The current is limited to one milliampere by the 1 K ohm resistor.

The voltage across the probes is connected to the horizontal input of a scope while the voltage across the 1 K ohm resistor as a result of the current through it is connected to the vertical input.

What we see on the scope is a voltage across a component under test versus the current through the component:

```
Resistors:      Open   Horizontal line.
                10 K   10 degree.
                 1 K   45 degree.
                   0   Vertical line.


Capacitor:       .1 uF  Shallow ellipse.
                2.6 uF  Circle.
               50.  uF  Narrow vertical.


Transformer:            Ellipse depending on impedance.


Diodes (Germanium):     Right angle display.


Diodes (Silicon):       Right angle one side longer
                        (any leakage showing less sharp angle).


Transistors:            Test as two diodes (B to E and B to C).


Integrated Circuits:    Input for gates and counters show a certain signature
                          display.


                        Outputs display a different signature.


                        A short will show a vertical line.


                        An open will show a horizontal line
```

In circuit testing is done with *no* power applied to the equipment under test.

With some experience one is able to test components in and out of circuit and troubleshoot without danger of a damage to components.

Testing Vacuum Tubes (or FETs) on a Bipolar Curve Tracer

A transistor curve tracer can be easily adapted to test vacuum tubes (OK, valves for those of you on the other side of the lake) if it has an adequate voltage range for the collector (now plate) drive and independent control of base and collector polarity. All that is needed is to add a separate transformer to power the tube's filament(s) and a resistor to convert base current to voltage.

For FETs, just leave off the transformer.

(From: Michael Covington (mcovingt@ai.uga.edu).)

Get an old Tektronix 575 (mine cost $25 at a hamfest). That is a transistor curve tracer that goes back to the 1950s and goes up to 200 volts.

It doesn't have FET settings, but you can control the 'base' and 'collector' polarity independently. So what you do is put a 1 K resistor from 'base' to ground, so that you can read milliamps as volts. Then put a positive-going voltage on the 'collector' and a negative-going current into the 'base'.

For tubes, emitter, collector, and base are cathode, plate, and grid, respectively. Naturally you also need a filament supply; I use a lab-type DC supply because it's handy and can't introduce hum.

I also test FETs that way (without the filament supply, of course). Then, emitter, collector, and base become source, drain, and gate respectively.

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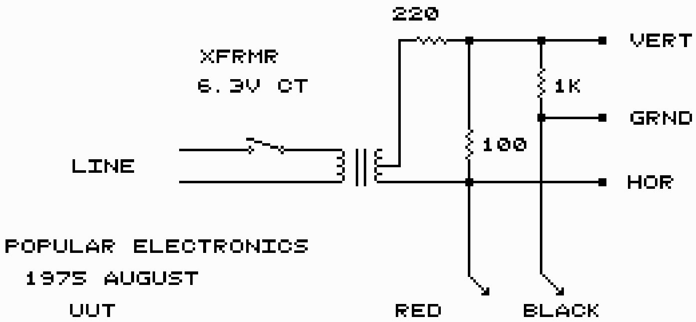
-- end V2.41a --

SEMICONDUCTOR AND COMPONENT
CURVE DISPLAY



Notes on the Troubleshooting and Repair of Small Household Appliances and Power Tools

Version 2.66

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Although working on small appliances is generally less risky than dealing with equipment like microwave ovens, TVs, and computer monitors, those that plug into the wall can still produce a very lethal electric shock as well cause a fire from incorrect or careless repairs both during servicing or later on. It is essential that you read, understand, and follow all safety guidelines contained in this document and in the document: Safety Guidelines for High Voltage and/or Line Powered Equipment.

Improper repair of battery operated devices can also result in bad consequences for you, the device, and any equipment attached to it.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Introduction

Note: The chapters: "AC Adapters" and "Batteries" have been relocated to the document: Notes on the Troubleshooting and Repair of AC Adapters, Power Supplies, and Battery Packs.

Where do you keep your dead appliances?

If you have ever tried to get a small household appliance or portable power tool repaired, you understand why all that stuff is likely to be gathering dust in your attic or basement closet or junk box. It does not pay! This may be partially by design. However, to be fair, it may take just as much time to diagnose and repair a problem with a $20 toaster as a $300 VCR and time is money for a repair shop. It is often not even economical to repair the more expensive equipment let alone a $40 electric heater. The cost of the estimate alone would probably buy at least one new unit and possibly many more.

However, if you can do the repair yourself, the equation changes dramatically as your parts costs will be 1/2 to 1/4 of what a professional will charge and of course your time is free. The educational aspects may also be appealing. You will learn a lot in the process. Many problems can be solved quickly and inexpensively. Fixing an old vacuum cleaner to keep in the rec room may just make sense after all.

This document provides maintenance and repair information for a large number of small household appliances and portable power tools. The repair of consumer electronic equipment is dealt with by other documents in the "Notes on the Troubleshooting and Repair of..." series. Suggestions for additions (and, of course, correction) are always welcome.

You will be able to diagnose problems and in most cases, correct them as well. Most problems with household appliances are either mechanical (e.g., dirt, lack of or gummed up lubrication, deteriorated rubber parts, broken doohickies) or obvious electrical (e.g., broken or corroded connections, short circuits, faulty heating elements) in nature. With minor exceptions, specific manufacturers and models will not be covered as there are so many variations that such a treatment would require a huge and very detailed text. Rather, the most common problems will be addressed and enough basic principles of operation will be provided to enable you to narrow the problem down and likely determine a course of action for repair. In many cases, you will be able to do what is required for a fraction of the cost that would be charged by a repair center - or - be able to revive something that would otherwise have gone into the dumpster - or remained in that closet until you moved out of your house (or longer)!

Since so many appliances are variations on a theme - heating, blowing, sucking, rotating, etc. - it is likely that even if your exact device does not have a section here, a very similar one does. Furthermore, with your understanding of the basic principles of operation, you should be able to identify what is common and utilize info in other sections to complete a repair.

Should you still not be able to find a solution, you will have learned a great deal and be able to ask appropriate questions and supply relevant information if you decide to post to sci.electronics.repair (recommended), alt.home.repair, or misc.consumers.house. It will also be easier to do further research using a repair textbook. In any case, you will have the satisfaction of knowing you did as much as you could before finally giving up or (if it is worthwhile cost-wise) taking it in for professional repair. With your newly gathered knowledge, you will have the upper hand and will not easily be snowed by a dishonest or incompetent technician.

Some Tidbits

You may not realize the following:

- Virtually any table lamp can be restored to a like-new condition electrically for less than $5 in parts.

- The cause of a vacuum cleaner that starts blowing instead of sucking is likely a dirt clog somewhere. It is virtually impossible for the motor to spin in the wrong direction and even if it did, the vacuum would still have some suction due to the type of blower that is commonly used.

- Many diagnoses of burned out motors are incorrect. Very often motor problems are actually something else - and minor. A truly burned out motor will often have died spectacularly and under adverse conditions. It will likely be smelly, charred, or may have created lots of sparks, tripped a circuit breaker or blew a fuse. A motor that just stopped working may be due to worn or gummed up (carbon) brushes, dirt, or a fault elsewhere in the appliance like a bad connection or switch or circuit - or the AC outlet might be bad. The most likely cause of a vacuum cleaner or other similar appliance that just stopped working is a break in a wire of the power cord - probably at the plug - due to continual stress from being dragged around by its tail!

- Fluorescent lamps use only 1/3 to 1/2 of the power of an incandescent lamp of similar light output. With all the lighting used in an average household, this can add up particularly for high power ceiling fixtures. However, fluorescent light color and quality may not be as aesthetically pleasing and fixtures or lamps may produce Radio Frequency Interference (RFI) causing problems with TV or radio reception. Dimmers can usually not be used unless they are specifically designed for fluorescent fixtures. Compact fluorescent lamps do indeed save energy but they can break just like any other light bulb!

- The initial inrush current to an incandescent bulb may be 10 times the operating current. This is hard on switches and dimmers and is part of the reason behind why bulbs tend to burn out when switched on and not while just sitting there providing illumination. Furthermore, an erratic switch or loose connection can shorten the life of an incandescent bulb due to repeated thermal shock. And, these are not due to short circuits but bad intermittent connections. True short circuits are less common and should result in a blown fuse or tripped circuit breaker.

- Bulb Savers and other devices claiming to extend the life of incandescent light bulbs may work but do so mostly by reducing power to the bulb at the expense of some decrease in light output and reduced efficiency. It is estimated that soft start alone (without the usual associated reduction in power) does not prolong the life of a typical bulb by more than a few hours.

  Thus, in the end, these device increase costs if you need to use more or larger bulbs to make up for the reduced light output. The major life cycle expense for incandescent lighting is not the cost of the bulbs but the cost of the electricity - by a factor of 25 to 50! For example, it costs about $10 in electricity to run a 100 W bulb costing 25 cents over the course of its 1000 hour life. However, these devices (or the use of 130 V bulbs) may make sense for use in hard-to-reach locations. Better yet, consider compact or normal fluorescent bulbs or fixtures which last much longer and are much more efficient than incandescents (including halogen).

- Smart bulbs are legitimate technology with built in automatic off, dimmers, blink capability, and other 'wizzy' features but they burn out and break just like ordinary bulbs. Thus, it hardly makes sense to spend $5 to $10 for something that will last 1000 to 1500 hours. Install a proper dimmer, automatic switch, or external blinker instead.

- A Ground Fault Circuit Interrupter (GFCI) protects people against shock but does not necessarily protect appliances from damage due to electrical faults. This is the function of fuses, circuit breakers, and thermal protectors. A GFCI *can* generally be installed in place of a 2-wire ungrounded outlet to protect it and any outlets downstream. Check your local electrical Code to be sure if this is permitted.

- Don't waste your money on products like the 'Green Plug', magnetic water softeners, whole house TV antennas that plug into the wall socket, and other items of the ''it sounds too good to be true' variety. These are very effective only at transferring money out of your wallet but rarely work as advertised.

    - The Green Plug will not achieve anywhere near the claimed savings and may actually damage or destroy certain types of appliances like, guess what?: refrigerators and other induction motor loads. Ever seen the demo?

      The Green Plug is supposed to reduce reactive power (V and I out of phase due to inductive or capacitive loads) but residential users don't pay for reactive power anyway, only the real power they use. In addition, this is a minor concern for modern appliances.

      The demo you see in the store that shows a utility meter slowing down substantially when the Green Plug is put in the circuit is bogus for two reasons: (1) The motor being powered is totally unloaded resulting in a high ratio of reactive to real power. Under normal use with a motor driving a load, the reduction in electricity use would be negligible. (2) The meter is wired to include reactive power in its measurement which, as noted above, is not the case with residential customers.

    - Magnetic and radio frequency water softeners are almost certainly 100% scams. They cloak absolutely useless technology in so much 'technobabble' that even Ph.D. scientists and engineers have trouble sorting it all out. The latest wrinkle adds advanced microprocessor control optimized for each potential mineral deposit. Yeh, sure.

      Mention the word 'magnetism' and somehow, people will pay $300 for $2 worth of magnets that do nothing - and then be utterly convinced of their effectiveness. They forget that perhaps the instruction manual suggested changes in their water use habits - which was the true reason for any improvement. Perhaps the magnets can be used to stick papers on the refrigerator once you discover they don't do anything for the water.

      BTW, the same goes for magnetic wine flavor enhancers. :-)

    - Whole house TV antennas are great for picking up signals with ghosts, noise, and other distorting effects. The premise that 'more is better' is fundamentally flawed when it comes to TV reception. In rare cases they may produce a marginally viewable picture in an otherwise unfavorable location but these are the exceptions. A pair of set-top rabbit ears will generally be superior.

I will be happy to revise these comments if someone can provide the results of evaluations of any of these devices conducted by a recognized independent testing laboratory. However, I won't hold my breath waiting.

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Basic Appliance Theory

What is inside an appliance?

There isn't much rocket science in the typical small appliance (though that is changing to some extent with the use of microcomputer and fuzzy logic control). Everything represents variations on a relatively small number of basic themes:

* Heating - a resistance element similar to what you can see inside a toaster provides heat to air, liquids, or solids by convections, conduction, or direct radiant (IR) heat.

* Rotation, blowing, sucking - a motor provides power to move air as in a fan or vacuum cleaner, water as in a sump pump, or provide drive as in an electric pencil sharpener, food mixer, or floor polisher.

* Control - switches and selectors, thermostats and speed regulators, and microcomputers determine what happens, when, how much, and assure safe operation.

Basic electrical principles

Relax! This is not going to be a tutorial on computer design. Appliances are simple devices. It is possible to repair many appliance faults without any knowledge beyond 'a broken wire is probably a problem' or 'this part is probably bad because it is charred and broken in half'. However, a very basic understanding of electrical principles will enable you to more fully understand what you are doing. Don't worry, there will be no heavy math. The most complicated equations will be variations on Ohm's law: V=I*R and P=V*V/R.

Voltage, current, and resistance

If you have any sort of background in electricity or electronics, then you can probably skip the following introductory description - or have some laughs at my expense.

The easiest way to explain basic electrical theory without serious math is with a hydraulic analogy. This is of the plumbing system in your house:

Water is supplied by a pipe in the street from the municipal water company or by a ground water pump. The water has a certain pressure trying to push it through your pipes. With electric circuits, voltage is the analog to pressure. Current is analogous to flow rate. Resistance is analogous the difficulty in overcoming narrow or obstructed pipes or partially open valves.

Intuitively, then, the higher the voltage (pressure), the higher the current (flow rate). Increase the resistance (partially close a valve or use a narrower pipe) and for a fixed voltage (constant pressure), the current (flow rate) will decrease.

With electricity, this relationship is what is known as linear: double the voltage and all other factors remaining unchanged, the current will double as well. Increase it by a factor of 3 and the current will triple. Halve the resistance and for a constant voltage source, the current will double. (For you who are hydraulic engineers, this is not quite true with plumbing as turbulent flow sets in, but this is just an analogy, so bear with me.)

Note: for the following 4 items whether the source is Direct Current (DC) such as a battery or Alternating Current (AC) from a wall outlet does not matter. The differences between DC and AC will be explained later.

The simplest electrical circuit will consist of several electrical components in series - the current must flow through all of them to flow through any of them. Think of a string of Christmas lights - if one burns out, they all go out because the electricity cannot pass through the broken filament in the burned out bulb.

Note the term 'circuit'. A circuit is a complete loop. In order for electricity to flow, a complete circuit is needed.

```
                    Switch (3)
         _____________/ ______________
        |                             |
        | (1)                         | (4)
+-------+--------+                +---+----+
|  Power Source  |                |  Load  |
+-------+--------+                +---+----+
        |           Wiring (2)        |
        |_____________________________|
```

1. Power source - a battery, generator, or wall outlet. The hydraulic equivalent is a pump or dam (which is like a storage battery). The water supply pipe in the street is actually only 'wiring' (analogous to the electric company's distribution system) from the water company's reservoir and pumps.

2. Conductors - the wiring. Similar to pipes and aqueducts. Electricity flows easily in good conductors like copper and aluminum. These are like the insides of pipes. To prevent electricity from escaping, an insulator like plastic or rubber is used to cover the wires. Air is a pretty good insulator and is used with high power wiring such as the power company's high voltage lines but plastic and rubber are much more convenient as they allow wires to be bundled closely together.

3. Switch - turns current on or off. These are similar to valves which do not have intermediate positions, just on and off. A switch is not actually required in a basic circuit but will almost always be present.

4. Load - a light bulb, resistance heater, motor, solenoid, etc. In true hydraulic systems such as used to control the flight surfaces of an aircraft, there are hydraulic motors and actuators, for example.

   With household water we usually don't think of the load. However, things like lawn sprinklers, dishwasher rotating arms, pool sweepers, and the like do convert water flow to mechanical work in the home (some homes, at least!). Hydraulic motors are used to aircraft and spacecraft, large industrial robots, and all sorts of other applications.

Here are 3 of the simplest appliances:

- Flashlight: battery (1), case and wiring (2), switch (3), light bulb (4).

- Table lamp: wall outlet (1), line cord and internal wiring (2), power switch (3), light bulb (4).

- Electric fan, vacuum cleaner, garbage disposer: wall outlet (1), line cord and internal wiring (2), power switch (3), motor (4).

Now we can add one type of simple control device:

5. Thermostat - a switch that is sensitive to temperature. This is like an automatic water valve which shuts off if a set temperature is exceeded. Most thermostats are designed to open the circuit when a fixed or variable temperature is

exceeded. However, air conditioners, refrigerators, and freezers do the opposite - the thermostat switches on when the temperature goes too high. Some are there only to protect against a failure elsewhere due to a bad part or improper use that would allow the temperature to go too high and start a fire. Others are adjustable by the user and provide the ability to control the temperature of the appliance.

With the addition of a thermostat, many more appliances can be constructed including (this is a small subset):

- Electric space heater (radiant), broiler, waffle iron: wall outlet (1), line cord and internal wiring (2), power switch (3) and/or thermostat (5), load (heavy duty heating element).

- Electric heater (convection), hair dryer: wall outlet (1), line cord and internal wiring (2), power switch (3) and/or thermostat (5), loads (4) (heating element and motor).

Electric heaters and cooking appliances usually have adjustable thermostats.

Hair dryers may simply have several settings which adjust heater power and fan speed (we will get into how later). The thermostat may be fixed and to protect against excessive temperatures only.

That's it! You now understand the basic operating principle of nearly all small appliances. Most are simply variations (though some may be quite complex) on these basic themes. Everything else is just details.

For example, a blender with 38 speeds just has a set of buttons (switches) to select various combinations of motor windings and other parts to give you complete control (as if you need 38 speeds!). Toasters have a timer or thermostat activate a solenoid (electromagnet) to pop your bread at (hopefully) the right time.

6. Resistances - both unavoidable and functional. Except for superconductors, all materials have resistance. Metals like copper, aluminum, silver, and gold have low resistance - they are good conductors. Many other metals like iron or steel are fair but not quite as good as these four. One, NiChrome - an alloy of nickel and chromium - is used for heating elements because it does not deteriorate (oxidize) in air even at relatively high temperatures.

   A significant amount of the power the electric company produces is lost to heating of the transmission lines due to resistance and heating.

   However, in an electric heater, this is put to good use. In a flashlight or table lamp, the resistance inside the light bulb gets so hot that it provides a useful amount of light.

   A bad connection or overloaded extension cord, on the other hand, may become excessively hot and start a fire.

The following is more advanced - save for later if you like.

7. Capacitors - energy storage devices. These are like water storage tanks (and similar is some ways to rechargeable batteries). Or, a system consisting of a a rubber diaphragm separating the water from a volume of trapped air. As water is pumped in, energy is stored as the air is compressed as in the captive air or expansion tanks found in home heating systems or well water storage tanks.

   Capacitors are not that common in small appliances but may be used with some types of motors and in RFI - Radio Frequency Interference - filters as capacitors can buffer - bypass - interference to ground. The energy to power an electronic flash unit is stored in a capacitor, for example. Because they act like reservoirs - buffers - capacitors are found in the power supplies of most electronic equipment to smooth out the various DC voltages required for each device.

8. Inductors - their actual behavior is like the mass of water as it flows. Turn off a water faucet suddenly and you are

likely to hear the pipes banging or vibrating. This is due to the inertia of the water - it tends to want to keep moving. Electricity doesn't have inertia but when wires are wound into tight coils, the magnetic field generated by electric current is concentrated and tends to result in a similar effect. Current tends to want to continue to flow where inductance is present. (For the more technical reader, the air chamber used to prevent/minimize the water hammer effect is the equivalent of an RC snubber!)

The windings of motors and transformers have significant inductance but the use of additional inductance devices is rare in home appliances except for RFI - since inductance tends to prevent current from changing, it can also be used to prevent interference from getting in or out.

9. Controls - rheostats and potentiometers allow variable control of current or voltage. A water faucet is like a variable resistor which can be varied from near 0 ohms (when on fully) to infinite ohms (when off).

Ohm's Law

The relationships that govern the flow of current in basic circuits (without capacitance or inductance - which is the case with many appliances) are contained in a very simple set of equations known an Ohm's Law.

The simplest of these are:

```
V = I * R (1)
I = V / R (2)
R = V / I (3)
```

Where:

- V is Voltage in Volts (or millivolts - mV or kilovolts - kV).
- I is current in amperes (A) or milliamps (mA)
- R is resistance in Ohms (ohms), kilo-Ohms (K Ohms), or mega-Ohms (M Ohms).

Power in watts (W) is equal to voltage times current in a resistive circuit (no capacitance or inductance). Therefore, rearranging the equations above, we also obtain:

```
P = V * I      (4)
P = V * V / R  (5)
P = I * I * R  (6)
```

For example:

- For a flashlight with a pair of Alkaline batteries (3 V) and a light bulb with a resistance of 10 ohms, we can use (2) to find that the current is I = (3 V) / (10 ohms) = .3 A. The from (4) we find that the power is: P = (3 V * .3 A) = .9 W.

- For a blow-dryer rated at 1000 W, the current drawn from a 120 V line would be: I = P / V (by rearranging (4) = 1000 W / 120 V = 8.33 A.

As noted above:

- Increase voltage -> higher current. (If the water company increases the pressure, your shower used more water in a given time.)

- Decrease resistance -> higher current. (You have a new wider pipe installed between the street and your house. Or, you open the shower valve wider.)

(Note that the common use of the term 'water pressure' is actually not correct. The most likely cause of what is normally described as low water pressure is actually high resistance in the piping between your residence and the street. There is a pressure drop in this piping just as there would be a voltage drop across a high value resistor.)

DC and AC

While electricity can vary in any way imaginable, the most common forms for providing power are direct current and alternating current:

A direct current source is at a constant voltage. Displaying the voltage versus time plot for such a source would show a flat line at a constant level. Some examples:

- Alkaline AA battery - 1.5 V (when new).
- Automotive battery - 12 V (fully charged).
- Camcorder battery - 7.2 V (charged).
- Discman AC adapter - 9 VDC (fully loaded).
- Electric knife AC adapter - 3.6 VDC.

An Alternating Current (AC) source provides a voltage that is varying periodically usually at 60 Hz (U.S.) or 50 Hz (many other countries). Note that 1 Hz = 1 cycle per second. Therefore, a 60 Hz AC voltage goes through 60 complete cycles in each second. For power, the shape of the voltage is a sinusoid which is the smoothest way that anything can vary periodically between two levels.

The nominal voltage from an AC outlet in the U.S. is around 115 VAC. This is the RMS (Root Mean Square) value, not the peak (0 to maximum). In simple terms, the RMS value of an AC voltage and the same value of a DC voltage will result in identical heating (power) to a resistive load. For example, 115 VAC RMS will result in the same heat output of a broiler as 115 VDC.

Direct current is used for many small motor driven appliances particularly when battery power is an option since changing DC into AC requires some additional circuitry. All electronic equipment require various DC voltages for their operation. Even when plugged into an AC outlet, the first thing that is done internally (or in the AC adapter in many cases) is to convert the AC to various DC voltages.

The beauty of AC is that a very simple device - a transformer - can convert one voltage into another. This is essential to long distance power distribution where a high voltage and low current is desirable to minimize power loss (since it depends on the current). You can see transformers atop the power poles in your neighborhood reducing the 2,000 VAC or so from a local distribution transformer to your 115 VAC (actually, 115-0-115 were the total will be used by large appliances like electric ranges and clothes dryers). That 2,000 VAC was stepped down by a larger transformer from around 12,000 VAC provided by the local substation. This, in turn, was stepped down from the 230,000 VAC or more used for long distance electricity transmission. Some long distance lines are over 1,000,000 volts (MV).

When converting between one voltage and another with a transformer, the amount of current (amps) changes in the inverse ratio. So, using 230 kV for long distance power transmission results in far fewer heating losses as the current flow is reduced by a factor of 2,000 over what it would be if the voltage was only 115 V, for example. Recall that power loss from P=I*I*R is proportional to the square of the current and thus in this example is reduced by a factor of 4,000,000!

Many small appliances include power transformers to reduce the 115 VAC to various lower voltages used by motors or or electrical components. Common AC adapters - often simply called transformers or wall warts - include a small transformer as well. Where their output is AC, this is the only internal component other than a fuse or thermal fuse for protection.

Where their output is DC, additional components convert the low voltage AC from the transformer to DC and a capacitor smoothes it out.

Series and parallel circuits

Up until now, we have been dealing with the series circuit - all parts are in a single line from power source, wiring, switches, load, and anything else. In a series circuit, the current must be the same through all components. The light bulb and switch in a flashlight pass exactly the same value of amperes. If there were two light bulbs instead of one and they were connected in series - as in a Christmas tree light set - then the current must be equal in all the bulbs but the voltages across each one would be reduced.

The loads, say resistance heating elements, are now drawn with the schematic symbol (as best as can be done using ASCII) for a resistor.

```
                     Switch
            _____________/ __________________
           |                I -->             |
           |                      ^    ^      |
           |                      |    |     / R1
           |                      |   V1     \ Load 1
   +-------+--------+             |    |     /
   |  Power Source  |                  v__   |
   +-------+--------+            V(S)  ^      |
           |                           |     / R2
           |                      |   V2     \ Load 2
           |                      |    |     /
           |                      v    v      |
           |__________________________________|
```

The total resistance, R(T), of the resistors in this series circuit is:

```
                    R(T) = R1 + R2                (7)
```

The voltage across each of the resistors would be given by:

```
                    V1 = V(S) * R1 / (R1 + R2)    (8)
                    V2 = V(S) * R2 / (R1 + R2)    (9)
```

The current is given by:

```
                    I = V(S)  / (R1 + R2)        (10)
```

However, another basic configuration, is also possible. With a parallel circuit, components are connected not one after the other but next to one another as shown below:

```
                     Switch
            _____________/ ___________________________
           |                     I -->  |            |
           |                 ^          |            |
```

```
   +-------+--------+          |           / R1         / R2
   |  Power Source  |        V(S)          \ Load 1     \ Load 2
   +-------+--------+          |           /            /
           |                   v           |v I(1)      |v I(2)
           |_____________________________|____________|
```

Now, the voltages across each of the loads is necessarily equal but the individual currents divide according to the relative resistances of each load.

The total resistance, R(T), of the parallel resistors in this circuit is:

```
                    R(T) = (R1 * R2) / (R1 + R2)  (11)
```

The currents through each of the loads would be given by:

```
                    I1 = V(S)/R1                  (12)
                    I2 = V(S)/R2                  (13)
```

The total current is given by:

```
                    I = I1 + I2                   (14)
```

Many variations on these basic arrangements are possible but nearly all can be reduced systematically to a combination of series or parallel circuits.

On-line educational resources

> The How Stuff Works Web site has some really nice introductory material (with graphics) on a variety of topics relating to technology in the modern world. Of relevance to this document are articles on motors, power adapters, relays, batteries, etc.

Check out Sam's Neat, Nifty, and Handy Bookmarks in the "Education and Tutorials" area for links to introductory material on electronics and other related fields.

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Appliance Troubleshooting

SAFETY

Appliances run on either AC line power or batteries. In the latter case, there is little danger to you except possibly from burns due to short circuits and heating effect or irritation from the caustic chemicals from old leaky batteries.

However, AC line power can be lethal. Proper safety procedures must be followed whenever working on live equipment (as well as devices which may have high energy storage capacitors like TVs, monitors, and microwave ovens). AC line power due to its potentially very high current is actually considerably more dangerous than the 30 kV found in a large screen color TV!

These guidelines are to protect you from potentially deadly electrical shock hazards as well as the equipment from accidental damage.

Note that the danger to you is not only in your body providing a conducting path, particularly through your heart. Any involuntary muscle contractions caused by a shock, while perhaps harmless in themselves, may cause collateral damage - there are many sharp edges inside this type of equipment as well as other electrically live parts you may contact accidentally.

Safety myths

For nearly all the appliances we will be covering, there is absolutely no danger of electrical shock once the unit is unplugged from the wall socket (not, however, just turned off - the plug should be removed from the wall socket).

You may have heard warnings about dangers from unplugged appliances. Perhaps, these were passed down from your great great grandparents or from local bar room conversation.

Except for devices with large high voltage capacitors connected to the line or elsewhere, there is nothing inside an appliance to store a painful or dangerous charge. Even these situations are only present in microwave ovens, fluorescent lamps and fixtures with electronic ballasts, universal power packs for camcorders or portable computers, or appliances with large motors. Other than these, once an appliance is unplugged all parts are safe to touch - electrically that is. There may still be elements or metal brackets that are burning hot as metal will tend to retain heat for quite a while in appliances like toasters or waffle irons. Just give them time to cool. There are often many sharp edges on sheetmetal as well. Take your time and look before you leap or grab anything.

Safety guidelines

The purpose of this set of guidelines is not to frighten you but rather to make you aware of the appropriate precautions. Appliance repair can be both rewarding and economical. Just be sure that it is also safe!

- Don't work alone - in the event of an emergency another person's presence may be essential.
- Always keep one hand in your pocket when anywhere around a powered line-connected or high voltage system.
- Wear rubber bottom shoes or sneakers.
- Wear eye protection - large plastic lensed eyeglasses or safety goggles.
- Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current, or get caught in moving parts.
- Set up your work area away from possible grounds that you may accidentally contact.
- Know your equipment: small appliances with 2 prong plugs do not use any part of the outside case for carrying current. Any metal parts of the case will either be totally isolated or possibly connected to one side of the line through a very high value resistor and/or very low value capacitor. However, there may be exceptions. And, failures may occur. Appliances with 3 prong plugs will have the case and any exposed metal parts connected to the safety ground.
- If circuit boards or other subassemblies need to be removed from their mountings, put insulating material between them and anything they may short to. Hold them in place with string or electrical tape. Prop them up with insulation

sticks - plastic or wood.

- Parts of heating appliances can get very hot very quickly. Always carefully test before grabbing hold of something you will be sorry about later.

- If you need to probe, solder, or otherwise touch circuits with power off, discharge (across) large power supply filter capacitors with a 2 W or greater resistor of 100-500 ohms/V approximate value (e.g., for a 200 V capacitor use a 50 K ohm resistor). The only places you are likely to find large capacitors in small appliance repair are in induction motor starting or running circuitry or the electronic ballasts of fluorescent fixtures.

- Connect/disconnect any test leads with the equipment unpowered and unplugged. Use clip leads or solder temporary wires to reach cramped locations or difficult to access locations.

- Perform as many tests as possible with the device unplugged. Even with the power switch supposedly off, if the unit is plugged into a live outlet, line voltage may be present in unexpected places or probing may activate a motor due to accidentally pressing a microswitch. Most parts in household appliances and power tools can be can be tested using only an ohmmeter or continuity checker.

- If you must probe live, put electrical tape over all but the last 1/16" of the test probes to avoid the possibility of an accidental short which could cause damage to various components. Clip the reference end of the meter or scope to the appropriate ground return so that you need to only probe with one hand.

- Use an isolation transformer if there is any chance of contacting line connected circuits. A Variac(tm) is not an isolation transformer!

  The use of a GFCI (Ground Fault Circuit Interrupter) protected outlet is a good idea but will not protect you from shock from many points in a line connected TV or monitor, or the high voltage side of a microwave oven, for example. (Note however, that, a GFCI may nuisance trip at power-on or at other random times due to leakage paths (like your scope probe ground) or the highly capacitive or inductive input characteristics of line powered equipment.) A fuse or circuit breaker is too slow and insensitive to provide any protection for you or in many cases, your equipment. However, these devices may save your scope probe ground wire should you accidentally connect it to a live chassis.

- Don't attempt repair work when you are tired. Not only will you be more careless, but your primary diagnostic tool - deductive reasoning - will not be operating at full capacity.

- Finally, never assume anything without checking it out for yourself! Don't take shortcuts!

Should I unplug appliances when not in use?

There is no hard and fast rule. Personally, I do unplug heating appliances when I am done with them. The quality of internal construction is not always that great and this is a minor annoyance to avoid a possible fire hazard should something fail or should such an appliance accidentally be left on.

BTW, electronic equipment should always be unplugged during lightning storms since it may be very susceptible to power surge and lightning damage. Don't forget the telephones and computer modems as well. This is not as much of a problem with small appliances that do not include electronic controllers as except for direct lightning strikes, the power switch will provide protection.

Troubleshooting tips

Many problems have simple solutions. Don't immediately assume that your problem is some combination of esoteric complex convoluted failures. For a dead appliance, the most likely cause might just be a bad line cord or plug! Try to remember that the problems with the most catastrophic impact on operation (an appliance that blows fuses) usually have the simplest causes (a wire shorting due to frayed insulation).

If you get stuck, sleep on it. Sometimes, just letting the problem bounce around in your head will lead to a different more successful approach or solution. Don't work when you are really tired - it is both dangerous and mostly non-productive (or possibly destructive - especially with AC line powered appliances).

Whenever working on precision equipment, make copious notes and diagrams. Yes, I know, a toaster may not exactly be precision equipment, but trust me. You will be eternally grateful when the time comes to reassemble the unit. Most connectors are keyed against incorrect insertion or interchange of cables, but not always. Apparently identical screws may be of differing lengths or have slightly different thread types. Little parts may fit in more than one place or orientation. Etc. Etc.

Pill bottles, film canisters, and plastic ice cube trays come in handy for sorting and storing screws and other small parts after disassembly.

Select a work area which is well lighted and where dropped parts can be located - not on a deep pile shag rug. Something like a large plastic tray with a slight lip may come in handy as it prevents small parts from rolling off of the work table. The best location will also be relatively dust free and allow you to suspend your troubleshooting to eat or sleep or think without having to pile everything into a cardboard box to eat dinner.

Basic hand tools

A basic set of precision hand tools will be all you need to work on most appliances. These do not need to be really expensive but poor quality tools are worse than useless and can cause damage. Stanley and Craftsman tools are fine. Needed tools include a selection of Philips and straight blade screwdrivers, socket drivers, open end or adjustable wrenches of various sizes, needlenose pliers, wire cutters, tweezers, and dental picks.

An electric drill or drill press with a set of small (1/16" to 1/4") high quality high speed drill bits is handy for some types of restoration where new holes need to be provided. A set of machine screw taps is also useful at times.

A medium power soldering iron and rosin core solder (never never use acid core solder or the stuff for sweating copper pipes on electrical or electronic repairs!) will be required if you need to make or replace any soldered connections. A soldering gun is desirable for any really beefy soldering. See the section: Soldering techniques.

A crimping tool and an assortment of solderless connectors often called 'lugs' will be needed to replace damaged or melted terminals in small appliances. See the section: Solderless connectors.

Old dead appliances can often be valuable sources of hardware and sometimes even components like switches and heating elements. While not advocating being a pack rat, this does have its advantages at times.

Soldering techniques

Soldering is a skill that is handy to know for many types of construction and repair. For modern small appliances, it is less important than it once was as solderless connectors have virtually replaced solder for internal wiring. However, there are times where soldering is more convenient - for example, when performing repairs at 1 AM and a replacement crimp lug is not available.

Use of the proper technique is critical to reliability and safety. A good solder connection is not just a bunch of wires and terminals with solder dribbled over them. When done correctly, the solder actually bonds to the surface of the metal (usually copper) parts.

CAUTION: You can easily turn a simple repair (e.g., bad solder connections) into an expensive mess if you use inappropriate soldering equipment and/or lack the soldering skills to go along with it. If in doubt, find someone else to do the soldering or at least practice, practice, practice, soldering and desoldering on a junk unit first!

Effective soldering is by no means difficult but some practice may be needed to perfect your technique.

The following guidelines will assure reliable solder joints:

- Only use rosin core solder (e.g., 60/40 tin/lead) for electronics work. A 1 pound spool will last a long time and costs about $10. Suggested diameter is .030 to .060 inches for appliances. The smaller size is preferred as it will be useful for other types of precision electronics repairs or construction as well. The rosin is used as a flux to clean the metal surface to assure a secure bond. NEVER use acid core solder or the stuff used to sweat copper pipes! The flux is corrosive and it is not possible to adequately clean up the connections afterward to remove all residue.

- Keep the tip of the soldering iron or gun clean and tinned. Buy tips that are permanently tinned - they are coated and will outlast countless normal copper tips. A quick wipe on a wet sponge when hot and a bit of solder and they will be as good as new for a long time. (These should never be filed or sanded).

- Make sure every part to be soldered - terminal, wire, component leads - is free of any surface film, insulation, or oxidation. Fine sandpaper or an Xacto knife may be used, for example, to clean the surfaces. The secret to a good solder joint is to make sure everything is perfectly clean and shiny and not depend on the flux alone to accomplish this. Just make sure the scrapings are cleared away so they don't cause short circuits.

- Start with a strong mechanical joint. Don't depend on the solder to hold the connection together. If possible, loop each wire or component lead through the hole in the terminal. If there is no hole, wrap them once around the terminal. Gently anchor them with a pair of needlenose pliers.

- Use a properly sized soldering iron or gun: 20-25 W iron for fine circuit board work; 25-50 W iron for general soldering of terminals and wires and power circuit boards; 100-200 W soldering gun for chassis and large area circuit planes. With a properly sized iron or gun, the task will be fast - 1 to 2 seconds for a typical connection - and will result in little or no damage to the circuit board, plastic switch housings, insulation, etc. Large soldering jobs will take longer but no more than 5 to 10 seconds for a large expanse of copper. If it is taking too long, your iron is undersized for the task, is dirty, or has not reached operating temperature. For appliance work there is no need for a fancy soldering station - a less than $10 soldering iron or $25 soldering gun as appropriate will be all that is required.

- Heat the parts to be soldered, not the solder. Touch the end of the solder to the parts, not the soldering iron or gun. Once the terminal, wires, or component leads are hot, the solder will flow via capillary action, fill all voids, and make a secure mechanical and electrical bond. Sometimes, applying a little from each side will more effectively reach all nooks and crannies.

- Don't overdo it. Only enough solder is needed to fill all voids. The resulting surface should be concave between the wires and terminal, not bulging with excess solder.

- Keep everything absolutely still for the few seconds it takes the solder to solidify. Otherwise, you will end up with a bad connection - what is called a 'cold solder joint'.

- A good solder connection will be quite shiny - not dull gray or granular. If your result is less than perfect reheat it and add a bit of new solder with flux to help it reflow.

Practice on some scrap wire and electronic parts. It should take you about 3 minutes to master the technique!

Desoldering techniques

Occasionally, it will be necessary to remove solder - either excess or to replace wires or components. A variety of tools are available for this purpose. The one I recommend is a vacuum solder pump called 'SoldaPullet' (about $20). Cock the pump, heat the joint to be cleared, and press the trigger. Molten solder is sucked up into the barrel of the device leaving the terminal nearly free of solder. Then use a pair of needlenose pliers and a dental pick to gently free the wires or component. Other approaches that may be used in place of or in addition to this: Solder Wick which is a copper braid that absorbs solder via capillary action; rubber bulb type solder pumps, and motor driven vacuum solder rework stations (pricey).

See the document: Troubleshooting and Repair of Consumer Electronic Equipment for additional info on desoldering of electronic components.

Soldering pins in plastic connectors

The thermoplastic used to mold many common cheap connectors softens or melts at relatively low temperatures. This can result in the pins popping out or shifting position (even shorting) as you attempt to solder to them to replace a bad connection, for example.

One approach that works in some cases is to use the mating socket to stabilize the pins so they remain in position as you solder. The plastic will still melt - not as much if you use an adequately sized iron since the socket will act as a heat sink - but will not move.

An important consideration is using the proper soldering iron. In some cases, a larger iron is better - you get in and out more quickly without heating up everything in the neighborhood.

Solderless connectors

Most internal connections in small appliances are made using solderless connectors. These include twist on WireNuts(tm) and crimped terminal lugs of various sizes and configurations.

WireNuts allow multiple wires to be joined by stripping the ends and then 'screwing' an insulated thimble shaped plastic nut onto the grouped ends of the wires. A coiled spring (usually) inside tightly grips the bare wires and results in a mechanically and electrically secure joint. For appliance repair, the required WireNuts will almost always already be present since they can usually be reused. If you need to purchase any, they come in various sizes depending on the number and size of the wires that can be handled. It is best to twist the individual conductor strands of each wire together and then twist the wires together slightly before applying the WireNut.

Crimped connectors, called lugs, are very common in small appliances. One reason is that it is easier, faster, and more reliable, to make connections using these lugs with the proper crimping equipment than with solder.

A lug consists of a metal sleeve which gets crimped over one or more wires, an insulating sleeve (usually, not all lugs have these), and a terminal connection: ring, spade, or push-on are typical.

Lugs connect one or more wires to the fixed terminals found on switches, motors, thermostats, and so forth.

There are several varieties:

- Ring lugs - the end looks like an 'O' and must be installed on a threaded terminal of similar size to the opening in the ring. The screw or nut must be removed to replace a ring lug.

- Spade lugs - the end looks like a 'U' and must be installed on a threaded terminal of similar size to the opening in the spade. These can be slipped on and off without entirely removing the screw or nut.

- Push-on lugs - called 'FastOns' by one manufacturer. The push-on terminal makes a tight fit with a (usually) fixed 'flag'. There may also be a latch involved but usually just a pressure fit keeps the connection secure. However, excessive heat over time may weaken these types of connections, resulting in increased resistance, additional heating, and a bad connection or melt-down.

The push-on variety are most common in small appliances.

In the factory, the lugs are installed on the wires with fancy expensive equipment. For replacements, an inexpensive crimping tool and an assortment of lugs will suffice. The crimping tool looks like a pair of long pliers and usually combines a wire stripper and bolt cutter with the crimping function. It should cost about $6-10.

The crimping tool 'squashes' the metal sleeve around the stripped ends of the wires to be joined. A proper crimp will not come apart if an attempt is made to pull the wires free - the wires will break somewhere else first. It is gas-tight - corrosion (within reason) will not affect the connection.

Crimping guidelines:

- Use the proper sized lug. Both the end that accepts the wire(s) and the end that screws or pushes on must be sized correctly. Easiest is to use a replacement that is identical to the original. Where this is not possible, match up the wire size and terminal end as closely as possible. There will be a minimum and maximum total wire cross sectional area that is acceptable for each size. Avoid the temptation to trim individual conductor strands from wires that will not fit - use a larger size lug. Although not really recommended, the bare wires can be doubled over to thicken them for use with a lug that is slightly oversize.

- For heating appliances, use only high temperature lugs. This will assure that the connections do not degrade with repeated temperature cycles.

- Strip the wire(s) so that they fit into the lug with just a bit showing out the other (screw or push-on) end. Too long and your risk interference with the terminals and/or shorting to other terminals. Too short and it is possible that one or more wires will not be properly positioned, will not be properly crimped, and may pull out or make a poor connection. The insulation of the wires should be within the insulating sleeve - there should be no bare wire showing behind the lug.

- Crimp securely but don't use so much force that the insulating sleeve or metal sleeve is severed. Usually 1 or 2 crimps for the actual wire connection and 1 crimp to compress the insulating sleeve will be needed.

- Test the crimp when complete - there should be no detectable movement of the wires. If there is, you didn't crimp hard enough or the lug is too large for your wires.

Wire stripping

In order to make most connections, the plastic or other insulating covering must be removed to expose the bare copper conductors inside. The best way to do this is with a proper wire stripper which is either adjustable or has dedicated positions for each wire size. It is extremely important that the internal conductor (single wire or multiple strands) are undamaged. Nicks or loss of some strands reduces the mechanical and electrical integrity of the connection. In particular, a seriously nicked wire may break off at a later time - requiring an additional repair or resulting in a safety hazard or additional damage. The use of a proper wire stripper will greatly minimize such potential problems.

A pen knife or Xacto knife can be used in a pinch but a wire stripper is really much much easier.

Attaching wires to screw terminals

Screw terminals are often seen in appliances. In most cases, lugs are used to attach one or more wires to each terminal and when properly done, this usually is the best solution. However, in most cases, you can attach the wire(s) directly if a lug is not available:

1. The best mechanical arrangement is to put the wire under a machine screw or nut, lock washer, and flat washer. However, you will often see just the screw or nut (as in a lamp switch or wall socket). For most applications, this is satisfactory.

2. Avoid the temptation to put multiple wires around a single terminal unless you separate each one with a flat washer.

3. Strip enough of the wire to allow the bare wire to be wrapped once around the terminal. To much and some will poke out and might short to something; too little and a firm mechanical joint and electrical connection may be impossible.

4. For multistranded wire, tightly twist the strands of stripped wire together in a clockwise direction as viewed from the wire end.

5. Wrap the stripped end of the wire **clockwise** around the terminal post (screw or stud) so that it will be fully covered by the screw head, nut, or flat washer. This will insure that the wire is grabbed as the screw or nut is tightened. A pair of small needlenose pliers may help.

6. Hold onto the wire to keep it from being sucked in as the screw or nut is tightened. Don't overdo it - you don't need to sheer off the head of the screw to make a secure reliable connection.

7. Inspect the terminal connection: the bare wire should be fully covered by the head of the screw, nut, or flat washer. Gently tug on the wire to confirm that it is securely fastened.

Test equipment

Very little test equipment is needed for most household appliance repair.

First, start with some analytical thinking. Many problems associated with household appliances do not require a schematic. Since the internal wiring of many appliances is so simple, you will be able to create your own by tracing the circuits in any case. However, for more complex appliances, a schematic may be useful as wires may run behind and under other parts and the operation of some custom switches may not obvious. The causes for the majority of problems will be self evident once you gain access to the interior - loose connections or broken wires, bad switches, open heating element, worn motor brushes, dry bearings. All you will need are some basic hand tools, a circuit and continuity tester, light oil and grease, and your powers of observation (and a little experience). Your built in senses and that stuff between your ears represents the most important test equipment you have.

The following will be highly desirable for all but the most obvious problems:

1. Circuit tester (neon light) - This is used to test for AC power or confirm that it is off. For safety, nothing can beat the simplicity of a neon tester. Its use is foolproof as there are no mode settings or range selections to contend with. Touch its two probes to a circuit and if it lights, there is power. (This can also take the place of an Outlet tester but it is not as convenient (see below). Cost: $2-$3.

2. Outlet tester (grounds and miswiring) - This will confirm that a 3 prong outlet is correctly wired with respect to Hot, Neutral, and Ground. While not 100% assured of correct wiring if the test passes, the screwup would need to be quite spectacular. This simple device instantly finds missing Grounds and interchanged Hot and Neutral - the most common wiring mistakes. Just plug it into an outlet and if the proper two neon light are lit at full brightness, the outlet is most likely wired correctly. Cost: about $6.

   These are just a set of 3 neon bulbs+resistors across each pair of wires. If the correct bulbs light at full brightness - H-N, H-G - then the circuit is likely wired correctly. If the H-G light is dim or out or if both the H-G and G-N are dim, then you have no ground. If the N-G light is on and the H-G light is off, you have reversed H and N, etc.

   What it won't catch: Reversed N and G (unlikely unless someone really screwed up) and marginal connections since the neon bulbs doesn't use much current. For this (particularly important for the G since it won't do any good if its resistance back to the service panel is too high) you need a real load like a 100 W light bulb. Or, build a tester consisting of 100 W light bulbs (instead of neon lamps) wired between each of the prongs.

   It also won't distinguish between 110 VAC and 220 VAC circuits except that the neon bulbs will glow much brighter on 220 VAC but without a direct comparison, this could be missed.

   For something that appears to test for everything but next week's weather:

   (From: Bill Harnell (bharne@adss.on.ca).)

   Get an ECOS 7105 tester! (ECOS Electronics Corporation, Oak Park, Illinois, 708-383-2505). Not cheap, however. It sold for $59.95 in 1985 when I purchased somewhere around 600 of them for use by our Customer Engineers for safety purposes!

   It tests for:

   Correct wiring, reversed polarity, open Ground, open Neutral, open Hot, Hot & Ground reversed, Hot on neutral, Hot unwired, other errors, over voltage (130 VAC+), under voltage (105 VAC-), Neutral to Ground short, Neutral to Ground reversal, Ground impedance test (2 Ohms or less ground impedance - in the equipment ground conductor).

   Their less expensive 7106 tester performs almost all of the above tests.

   FWIW, I have no interest in the ECOS Corporation of any kind. Am just a very happy customer.

3. Continuity tester (buzzer or light) - Since most problems with appliances boil down to broken connections, open heating elements, defective switches, shorted wires, and bad motor windings, a continuity tester is all that is needed for most troubleshooting. A simple battery operated buzzer or light bulb quickly identifies problems. If a connection is complete, the buzzer will sound or the light will come on. Note that a dedicated continuity tester is preferred over a similar mode on a multimeter because it will operate only at very low resistance. The buzzer on a multimeter sounds whenever the resistance is less than about 200 ohms - a virtual open circuit for much appliance wiring.

   A continuity tester can be constructed very easily from an Alkaline battery, light bulb or buzzer, some wire, and a set of test leads with probes. All of these parts are available at Radio Shack.

```
                   AA, C, or D cell    1.5 V flashlight bulb or buzzer
                            +|  -             +------------------+
  Test probe 1  o-----------| |--------------|  Bulb or buzzer  |-------+
                             |                +------------------+       |
                                                                         |
```

```
    Test probe 2  o-------------------------------------------------+
```

CAUTION: Do not use this simple continuity tester on electronic equipment as there is a slight possibility that the current provided by the battery will be too high and cause damage. It is fine for most appliances.

4. GFCI tester - outlets installed in potentially wet or outdoor areas should be protected by a Ground Fault Circuit Interrupter (GFCI). A GFCI is now required by the NEC (Code) in most such areas. This tester will confirm that any outlets protected by a GFCI actually will trip the device if there is a fault. It is useful for checking the GFCI (though the test button should do an adequate job of this on its own) as well as identifying or testing any outlets downstream of the GFCI for protection.

   Wire a 3 prong plug with a 15 K ohm 1 W resistor between H and G. Insulate and label it! This should trip a GFCI protected outlet as soon as it is plugged in since it will produce a fault current of about 7 mA.

   Note that this device will only work if there is an actual Safety Ground connection to the outlet being tested. A GFCI retrofitted into a 2 wire installation without a Ground cannot be tested in this way since a GFCI does not create a Ground. However, jumpering this rig between the H and and a suitable earth ground (e.g., a cold water in an all copper plumbing system) should trip the GFCI. Therefore, first use an Outlet Tester (above) to confirm that there is a Safety Ground present.

   The test button works because it passes an additional current through the sense coil between Hot and Neutral tapped off the wiring at the line side of the GFCI and therefore doesn't depend on having a Ground.

   If you want to be fancier, you can build a combination outlet and GFCI tester. Wire up a neon indicator with current limiting resistor) across each pair of wires. Add a 15K ohm 1 W resistor in series with a pushbutton switch between H and G. If the H-G neon is lit (indicating a proper Ground connection), pressing the button should trip the GFCI.

5. Multimeter (VOM or DMM) - This is necessary for actually measuring voltages and resistances. Almost any type will do - even the $14.95 special from Sears. Accuracy is not critical for household appliance repair but reliability is important - for your safety if no other reason. It doesn't really matter whether it is a Digital MultiMeter (DMM) or analog Volt Ohm Meter (VOM). A DMM may be a little more robust should you accidentally put it on an incorrect scale. However, they both serve the same purpose. A cheap DMM is also not necessarily more accurate than a VOM just because it has digits instead of a meter needle. A good quality well insulated set of test leads and probes is essential. What comes with inexpensive multimeters may be too thin or flimsy. Replacements are available. Cost: $15-$50 for a multimeter that is perfectly adequate for home appliance repair.

   Note: For testing of household electrical wiring, a VOM or DMM can indicate voltage between wires which is actually of no consequence. This is due to the very high input resistance/impedance of the instrument. The voltage would read zero with any sort of load. See the section: Phantom voltage measurements of electrical wiring.

Once you get into electronic troubleshooting, an oscilloscope, signal generator, and other advanced (and expensive) test equipment will be useful. For basic appliance repair, such equipment would just gather dust.

Getting inside consumer electronic equipment

Yes, you will void the warranty, but you knew this already.

Appliance manufacturers seem to take great pride in being very mysterious as to how to open their equipment. Not always, but this is too common to just be a coincidence.

A variety of techniques are used to secure the covers on consumer electronic equipment:

1. **Screws:** Yes, many still use this somewhat antiquated technique. Sometimes, there are even embossed arrows on the case indicating which screws need to be removed to get at the guts. In addition to obvious screw holes, there may be some that are only accessible when a battery compartment is opened or a trim panel is popped off.

   These are almost always of the Philips variety though more and more appliances are using Torx or security Torx type screws. Many of these are hybrid types - a slotted screwdriver may also work but the Philips or Torx is a whole lot more convenient.

   A precision jeweler's screwdriver set including miniature Philips head drivers is a must for repair of miniature portable devices.

2. **Hidden screws:** These will require prying up a plug or peeling off a decorative decal. It will be obvious that you were tinkering - it is virtually impossible to put a decal back in an undetectable way. Sometimes the rubber feet can be pryed out revealing screw holes. For a stick-on label, rubbing your finger over it may permit you to locate a hidden screw hole. Just puncture the label to access the screw as this may be less messy then attempting to peel it off.

3. **Snaps:** Look around the seam between the two halves. You may (if you are lucky) see points at which gently (or forcibly) pressing with a screwdriver will unlock the covers. Sometimes, just going around the seam with a butter knife will pop the cover at one location which will then reveal the locations of the other snaps.

4. **Glue:** Or more likely, the plastic is fused together. This is particularly common with AC adapters (wall warts). In this case, I usually carefully go around the seam with a hacksaw blade taking extreme care not to go through and damage internal components. Reassemble with plastic electrical tape.

5. It isn't designed for repair. Don't laugh. I feel we will see more and more of this in our disposable society. Some devices are totally potted in Epoxy and are 'throwaways'. With others, the only way to open them non-destructively is from the inside.

Don't force anything unless you are sure there is no alternative - most of the time, once you determine the method of fastening, covers will come apart easily. If they get hung up, there may be an undetected screw or snap still in place. However, sometimes it is just impossible (by design) to disassemble an appliance without doing some damage. That's life (and aids the manufacturer's bottom line!).

When reinstalling the screws, first turn them in a counter-clockwise direction with very slight pressure. You will feel them "click" as they fall into the already formed threads. Gently turn clockwise and see if they turn easily. If they do not, you haven't hit the previously formed threads - try again. Then just run them in as you normally would. You can always tell when you have them into the formed threads because they turn very easily for nearly the entire depth. Otherwise, you will create new threads which will quickly chew up the soft plastic. Note: these are often high pitch screws - one turn is more than one thread - and the threads are not all equal.

The most annoying (to be polite) situation is when after removing the 18 screws holding the case together (losing 3 of them entirely and mangling the heads on 2 others), removing three subassemblies, and two other circuit boards, you find that the adjustment you wanted was accessible through a hole in the case just by partially peeling back a rubber hand grip! (It has happened to me).

When reassembling the equipment make sure to route cables and other wiring such that they will not get pinched or snagged and possibly broken or have their insulation nicked or pierced and that they will not get caught in moving parts. This is particularly critical for AC line operated appliances and those with motors to minimize fire and shock hazard and future damage to the device itself. Replace any cable ties that were cut or removed during disassembly and add additional ones of your own if needed. Some electrical tape may sometimes come in handy to provide insulation insurance as well. As long as it does not get in the way, additional layers of tape will not hurt and can provide some added insurance against future problems. I often put a layer of electrical tape around connections joined with WireNuts(tm) as well just to be sure that they will not come off or that any exposed wire will not short to anything.

Getting built up dust and dirt out of a equipment

This should be the first step in any inspection and cleaning procedure.

Appliances containing fans or blowers seem to be dust magnets - an incredible amount of disgusting fluffy stuff can build up in a short time - even with built-in filters.

Use a soft brush (like a new cheap paint brush) to remove as much dirt, dust, and crud, as possible without disturbing anything excessively. Some gentle blowing (but no high pressure air) may be helpful in dislodged hard to get at dirt - but wear a dust mask.

Don't use compressed air on intricate mechanisms, however, as it might dislodge dirt and dust which may then settle on lubricated parts and contaminating them. High pressure air could move oil or grease from where it is to where it should not be. If you are talking about a shop air line, the pressure may be much much too high and there may be contaminants as well.

A Q-tip (cotton swab) moistened with politically correct alcohol can be used to remove dust and dirt from various hard to get at surfaces.

Lubrication of appliances and electronic equipment

The short recommendation is: Don't add any oil or grease unless you are positively sure it is needed. Most parts are lubricated at the factory and do not need any further lubrication over their lifetime. Too much lubrication is worse then too little. It is easy to add a drop of oil but difficult and time consuming to restore a tape deck that has taken a swim.

NEVER, ever, use WD40! WD40 is not a good lubricant despite the claims on the label. Legend has it that the WD stands for Water Displacer - which is one of the functions of WD40 when used to coat tools for rust prevention. WD40 is much too thin to do any good as a general lubricant and will quickly collect dirt and dry up. It is also quite flammable and a pretty good solvent - there is no telling what will be affected by this.

A light machine oil like electric motor or sewing machine oil should be used for gear or wheel shafts. A plastic safe grease like silicone grease or Molylube is suitable for gears, cams, or mechanical (piano key) type mode selectors. Never use oil or grease on electrical contacts.

One should also NOT use a detergent oil. This includes most automotive engine oils which also have multiple additives which are not needed and are undesirable for non-internal combustion engine applications.

3-In-One(tm) isn't too bad if that is all you have on hand and the future of the universe depends on your fan running smoothly. However, for things that don't get a lot of use, it may gum up over time. I don't know whether it actually decomposes or just the lighter fractions (of the 3) evaporate.

Unless the unit was not properly lubricated at the factory (which is quite possible), don't add any unless your inspection reveals the specific need. Sometimes you will find a dry bearing, motor, lever, or gear shaft. If possible, disassemble and clean out the old lubricant before adding fresh oil or grease.

Note that in most cases, oil is for plain bearings (not ball or roller) and pivots while grease is used on sliding parts and gear teeth.

In general, do not lubricate anything unless you know there is a need. Never 'shotgun' a problem by lubricating everything in sight! You might as well literally use a shotgun on the equipment!

Common appliance problems

Despite the wide variety of appliances and uses to which they are put, the vast majority of problems are going to be covered in the following short list:

1. Broken wiring inside cordset - internal breaks in the conductors of cordsets or other connecting cords caused by flexing, pulling, or other long term abuse. This is one of the most common problem with vacuum cleaners which tend to be dragged around by their tails.

   Testing: If the problem is intermittent, (or even if it is not), plug the appliance in and turn it on. Then try bending or pushing the wire toward the plug or appliance connector end to see if you can make the internal conductors touch at least momentarily. Ii the cordset is removable, test between ends with a continuity checker or multimeter on the low ohms scale. If it is not detachable, open the appliance to perform this test.

2. Bad internal connections - broken wires, corroded or loosened terminals. Wires may break from vibration, corrosion, poor manufacturing, as well as thermal fatigue. The break may be in a heating element or other subassembly. In many cases, failure will be total as in when one of the AC line connections falls off. At other times, operation will be intermittent or erratic - or parts of the appliance will not function. For example, with a blow dryer, the heating element could open up but the fan may continue to run properly.

   Testing: In many cases, a visual inspection with some careful flexing and prodding will reveal the location of the bad connection. If it is an intermittent, this may need to be done with a well insulated stick while the appliance is on and running (or attempting to run). When all else fails, the use of a continuity checker or multimeter on the low ohms scale can identify broken connections which are not obviously wires visibly broken in two. For testing heating elements, use the multimeter as a continuity checker may not be sensitive enough since the element normally has some resistance.

3. Short circuits. While much less frequent than broken or intermittent connections, two wires touching or contacting the metal case of an appliance happens all too often. Partially, this is due to the shoddy manufacturing quality of many small appliances like toaster ovens. These also have metal (mostly) cabinets and many metal interior parts with sharp edges which can readily eat through wire insulation due to repeated vibrations, heating and cooling cycles, and the like. Many appliances are apparently designed by engineers (this is being generous) who do not have any idea of how to build or repair them. Thus, final assembly, for example, must sometimes be done blind - the wires get stuffed in and covers fastened - which may end up nicking or pinching wires between sharp metal parts. The appliance passes the final inspection and tests but fails down the road.

   A short circuit may develop with no operational problems - but the case of the appliance will be electrically 'hot'. This is a dangerous situation. Large appliances with 3 wire plugs - plugged into a properly grounded 3 wire circuit - would then blow a fuse or trip a circuit breaker. However, small appliances like toaster, broilers, irons, etc., have two wire plugs and will just set there with a live cabinet.

   Testing: Visually inspect for bare wires or wires with frayed or worn insulation touching metal parts, terminals they should not be connected to, or other wires. Use a multimeter on the high ohms scale to check between both prongs of the AC plug and any exposed metal parts. Try all positions of any power or selector switches. Any resistance measurement less than 100K ohms or so is cause for concern - and further checking. Also test between internal terminals and wires that should not be connected together.

   Too many people like to blame everything from blown light bulbs to strange noises on short circuits. A 'slight', slow, or marginal short circuit is extremely rare. Most short circuits in electrical wiring between live and neutral or ground (as opposed to inside appliances where other paths are possible) will blow a fuse or trip a breaker. Bad connections (grounds, neutral, live), on the other hand, are much much more common.

4. Worn, dirty, or broken switches or thermostat contacts. These will result in erratic or no action when the switch is flipped or thermostat knob is turned. In many cases, the part will feel bad - it won't have that 'click' it had when new or may be hard to turn or flip. Often, however, operation will just be erratic - jiggling the switch or knob will make the motor or light go on or off, for example.

   Testing: Where there is a changed feel to the switch or thermostat with an associated operational problem, there is little doubt that the part is bad and must be replaced. Where this is not the case, label the connections to the switch or thermostat and then remove the wires. Use the continuity checker or ohmmeter across each set of contacts. They should be 0 ohms or open depending on the position of the switch or knob and nothing in between. In most cases, you should be able to obtain both readings. The exception is with respect to thermostats where room temperature is off one end of their range. Inability to make the contacts open or close (except as noted above) or erratic intermediate resistances which are affected by tapping or jiggling are a sure sign of a bad set of contacts.

5. Gummed up lubrication, or worn or dry bearings. Most modern appliances with motors are supposedly lubricated for life. Don't believe it! Often, due to environmental conditions (dust, dirt, humidity) or just poor quality control during manufacture (they forgot the oil), a motor or fan bearing will gum up or become dry resulting in sluggish and/or noisy operation and overheating. In extreme cases, the bearing may seize resulting in a totally stopped motor. If not detected, this may result in a blown fuse (at the least) and possibly a burnt out motor from the overheating.

   Testing: If the appliance does not run but there is a hum (AC line operated appliances) or runs sluggishly or with less power than you recall when new, lubrication problems are likely. With the appliance unplugged, check for free rotation of the motor(s). In general, the shaft sticking out of the motor itself should turn freely with very little resistance. If it is difficult to turn, the motor bearings themselves may need attention or the mechanism attached to the motor may be filled with crud. In most cases, a thorough cleaning to remove all the old dried up and contaminated oil or grease followed by relubing with similar oil or grease as appropriate will return the appliance to good health. Don't skimp on the disassembly - total cleaning will be best. Even the motor should be carefully removed and broken down to its component parts - end plates, rotor, stator, brushes (if any) in order to properly clean and lubricate its bearings. See the appropriate section of the chapter: Motors 101 for the motor type in your appliance.

6. Broken or worn drive belts or gears - rotating parts do not rotate or turn slowly or with little power even through the motor is revving its little head off. When the brush drive belt in an upright vacuum cleaner breaks, the results are obvious and the broken belt often falls to the ground (to be eaten by the dog or mistaken for a mouse tail - Eeek!) However, there are often other belts inside appliances which will result in less obvious consequences when they loosen with age or fail completely.

   Testing: Except for the case of a vacuum cleaner where the belt is readily accessible, open the appliance (unplugged!). A good rubber belt will be perfectly elastic and will return to its relaxed length instantly when stretched by 25 percent and let go. It will not be cracked, shiny, hard, or brittle. A V-type belt should be dry (no oil coating), undamaged (not cracked, brittle, or frayed), and tight (it should deflect 1/4" to 1/2" when pressed firmly halfway between the pulleys).

   Sometimes all that is needed is a thorough cleaning with soap and water to remove accumulated oil or grease. However, replacement will be required for most of these symptoms. Belts are readily available and an exact match is rarely essential.

7. Broken parts - plastic or metal castings, linkages, washers, and other 'doodads' are often not constructed quite the way they used to be. When any of these fail, they can bring a complicated appliance to its knees. Failure may be caused by normal wear and tear, improper use (you tried to vacuum nuts and bolts just like on TV), accidents (why

was your 3 year old using the toaster oven as a step stool?), or shoddy manufacturing.

Testing: In many cases, the problem will be obvious. Where it is not, some careful detective work - putting the various mechanisms through their paces - should reveal what is not functioning. Although replacement parts may be available, you can be sure that their cost will be excessive and improvisation may ultimately be the best approach to repair. See the section: Fil's tips on improvised parts repair.

8. Insect damage. Many appliance make inviting homes for all sort of multi- legged creatures. Evidence of their visits or extended stays will be obvious including frayed insulation, short circuits caused by bodily fluids or entire bodies, remains of food and droppings. Even the smallest ventilation hole can be a front door.

   The result may be any of the items listed in (1) to (7) above. Once the actual contamination has been removed and the area cleaned thoroughly, inspect for damage and repair as needed. If the appliance failed while powered, you may also have damage to wiring or electronic components due to any short circuits that were created by the intruders' activities.

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Types of Parts Found in Small Appliances

So many, so few

While there are an almost unlimited variety of small appliances and power tools, they are nearly all constructed from under two dozen basic types of parts. And, even with these, there is a lot of overlap.

The following types of parts are found in line powered appliances:

- Cordsets - wire and plug.
- Internal wiring - cables and connectors.
- Switches - power, mode, or speed selection.
- Relays - electrically activated switches for power or control.
- Electrical overload protection devices - fuses and circuit breakers.
- Thermal protection devices - thermal fuses and thermal switches.
- Controls 1 - adjustable thermostats and humidistats.
- Controls 2 - rheostats and potentiometers.
- Interlocks - prevent operation with case or door open.
- Light bulbs - incandescent and fluorescent.
- Indicators - incandescent or neon light bulbs or LEDs.
- Heating elements - NiChrome coils or ribbon, Calrod, Quartz.
- Solenoids - small and large.
- Small electronic components - resistors, capacitors, diodes.
- Transformers - low voltage, high voltage.
- Motors - universal, induction, DC, timing.
- Fans and Blowers - bladed or centrifugal.
- Bearings and bushings.
- Mechanical controllers - timing motors and cam switches.
- Electronic controllers - simple delay or microprocessor based.

Battery and AC adapter powered appliance use most of the same types of parts but they tend to be smaller and lower power than their line powered counterparts. For example, motors in line powered devices tend to be larger, more powerful, and of different design (universal or induction compared to permanent magnet DC type). So, we add the following:

- Batteries - Alkaline, Lithium, Nickel-Cadmium, Lead-acid.
- AC adapters and chargers - wall 'warts' with AC or DC outputs.

The only major category of devices that these parts do not cover are gas discharge lamps and lighting fixtures (fluorescent, neon, mercury, and sodium), which we will discuss in a separate chapters.

Cordsets - wire and plug

A 'cordset' is a combination of the cord consisting of 2 or 3 insulated wires and a plug with 2 or 3 prongs. Cord length varies from 12 inches (or less) for some appliances like toasters to 25 feet or more for vacuum cleaners. Most common length is 6-8 feet. The size of the wire and type of insulation also are important in matching a replacement cordset to an appliance.

CAUTION: Some cordsets are more than what meets the eye. See the section: When a cordset is more than a cord and plug.

Most plug-in appliances in the U.S. will have one of 3 types of line cord/plug combinations:

1. **Non-polarized 2 prong:** The 2 prongs are of equal width so the plug may be inserted in either direction. These are almost universal on older appliances but may be found on modern appliances as well which are double insulated or where polarity does not matter. (Note: it **must** not matter for user safety in any case. The only time it can matter otherwise is with respect to (1) possible RFI (Radio Frequency Interference) generation or (2) service safety (this would put the center contact of a light bulb socket or internal switch and fuse on the Hot wire).

2. **Polarized 2 prong:** The prong that is supposed to be plugged into the Neutral slot of the outlet is wider. All outlets since sometime around the 1950s (???) have been constructed to accept polarized plugs only one way. While no appliance should ever be designed where the way it is plugged in can result in a user safety hazard, a lamp socket where the shell - the screw thread part - is plugged into Neutral is less hazardous when changing a light bulb. In addition, when servicing a small appliance with the cover removed, the Hot wire with a polarized plug should go to the switch and fuse and thus most of the circuitry will be disconnected with the switch off or fuse pulled.

   Thus, if you are replacing a plug and don't know (or didn't label) how the old one was hooked up, the narrow prong should go to the fuse, switch, thermostat or other control, center of the socket, etc. Since you may have trouble finding non-polarized plugs these days, this applies to older appliances as well and there is really no problem in replacing a non-polarized plug with a polarized one on an appliance.

3. **Grounded 3 prong:** In addition to Hot and Neutral, a third grounding prong is provided to connect the case of the equipment to safety Ground. This provides added protection should internal wiring accidentally short to a user accessible metal cabinet or control. In this situation, the short circuit will (or is supposed to) blow a fuse or trip a circuit breaker or GFCI rather than present a shock hazard. DO NOT just cut off the third prong if your outlet does not have a hole for it. Have the outlet replaced with a properly grounded one (which may require pulling a new wire from the service panel). As a short term solution, the use of a '3 to 2' prong adapter is acceptable IF AND ONLY IF the outlet box is securely connected to safety Ground already (BX or Romex cable with ground). Grounding also is essential for surge suppressors to operate properly (to the extent that they ever do) and may reduce RFI susceptibility and emissions if line filters are included (as with computer equipment and consumer electronics). Power conditioners require the Ground connection for line filtering as well.

Each of these may be light duty (less than 5 Amps or 600 Watts), medium duty (8 A or 1000 W) or heavy duty (up to 15 A or 1800 W). The rating is usually required to be stamped on the cord itself or on a label attached to the cord. Thickness of the cord is not a reliable indication of its power rating! (Note: U.S. 115 VAC 15 amp circuits are assumed throughout this document unless otherwise noted.)

Light duty cordsets are acceptable for most appliances without high power heating elements or heavy duty electric motors. These include table lamps, TVs, VCRs, stereo components, computers, dot matrix and inkjet printers, thermal fax machines, monitors, fans, can openers, etc. Electric blankets, heating pads, electric brooms, and food mixers are also low power and light duty cordsets are acceptable. The internal wires used is #18 AWG which is the minimum acceptable wire size (highest AWG number) for any AC line powered device.

Medium or heavy duty cordsets are REQUIRED for heating appliances like electric heaters (both radiant and convection), toasters, broilers, steam and dry irons, coffee makers and electric kettles, microwave and convection ovens, laser printers, photocopiers, Xerographic based fax machines, canister and upright vacuum cleaners and shop vacs, floor polishers, many portable and most stationary power tools. The internal wires used will be #16 AWG (medium duty) or #14 AWG (heavy duty).

For replacement, always check the nameplate amps or wattage rating and use a cordset which has a capacity at least equal to this. The use of an inadequate cordset represents a serious fire hazard.

Three prong grounded cordsets are required for most computer equipment, heavy appliances, and anything which is not double insulated and has metal parts that may be touched in normal operation (i.e., without disassembly).

The individual wires in all cordsets except for unpolarized types (e.g., older lamp cord) will be identified in some way. For sheathed cables, color coding is used. Generally, in keeping with the NEC (Code), black will be Hot, white will be Neutral, and green will be Safety Ground. You may also find brown for Hot, blue for Neutral, and green with a yellow stripe for Safety Ground. This is used internationally and is quite common for the cordsets of appliances and electronic equipment.

For zip cord with a polarized plug, one of the wires will be tagged with with a colored thread or a ridge on the outer insulation to indicate that it is the Neutral wire. For unpolarized types, no identification is needed (though there still may be some) as the wires and prongs of the plug are identical. However, fewer and fewer devices use non-polarized cords/plugs now so you are more likely to see this with older ones.

In general, when replacement is needed, use the same configuration and length and a heavy duty type if the original was heavy duty.

- Substituting a heavy duty cordset for a light duty one is acceptable as long as the additional stiffness is acceptable in terms of convenience.

- A shorter cord can usually be used if desired. In most cases, a longer cord (within reason) can be substituted as well. However, performance of heavy duty high current high wattage appliances may suffer if a really long cord (or extension cord) is used voltage drop from the wire resistance. For a modest increase in length, use the next larger wire size (heavy duty instead of medium duty, #14 instead of #16, for example).

- Where the old one was non-polarized, a polarized replacement is fine and usually preferred, for example, if:

    - It is an incandescent fixture. Connect the Neutral (wide prong/ridged wire) to the shells of the light bulb sockets.

    - It has an on/off switch or fuse in-line with the power. Connect the Hot wire to that side of the input.

    - There is a high value resistor and/or capacitor network between one side of the line and the case (for RFI suppression). Connect this to the Neutral.

  If the input is completely symmetric (e.g., it goes into a power transformer and no where else), then the polarity doesn't matter.

Before disconnecting the old cord, label connections or make a diagram and then match the color code or other wire identifying information. In all cases, it is best to confirm your final wiring with a continuity tester or multimeter on the low ohms scale. Mistakes on your part or the manufacturer of the new cord are not unheard of!

Common problems: internal wiring conductors broken at flex points (appliance or plug). With yard tools, cutting the entire cord is common. The connections at the plug may corrode as well resulting in heating or a broken connection.

Testing: Appliance cordsets can always be tested with a continuity checker or multimeter on a the low ohms scale.

Squeeze, press, spindle, fold, mutilate the cord particularly at both ends as while testing to locate intermittent problems.

If you are too lazy to open the appliance (or this requires the removal of 29 screws), an induction type of tester such as used to locate breaks in Christmas tree light strings can be used to confirm continuity by plugging the cord in both ways and checked along its length to see if a point of discontinuity can be located. A permanent bench setup with a pair of outlets (one wired with reverse polarity and clearly marked: FOR TESTING ONLY) can be provided to facilitate connecting to either of the wires of the cordset when using an induction type tester.

Note: broken wires inside the cordset at either the plug or appliance end are among the most common causes of a dead vacuum cleaner due to abuse it gets - being tugged from the outlet, vacuum being dragged around by the cord, etc. Many other types of appliances suffer the same fate. Therefore, checking the cord and plug should be the first step in troubleshooting any dead appliance.

If the cord is broken at the plug end, the easiest thing to do is to replace just the plug. A wide variety of replacement plugs are available of three basic types: clamp-on/insulation piercing, screw terminals, and wire compression.

- Clamp-on/insulation piercing plugs are installed as follows: First, the cord is cleanly cut but not stripped and inserted into the body of the plug. A lid or clamping bar is then closed which internally pierces the insulation and makes contact with the prongs. When used with the proper size wire, these are fairly reliable for light duty use - table lamps and other low power appliances. However, they can lead to problems of intermittent or bad connections if the wire insulation thickness does not precisely match what the plug expects.

- Plugs with screw terminals make a much more secure robust connections but require a bit more time and care in assembly to assure a proper connection and avoid stray wire strands causing short circuits or sticking out and representing a shock hazard. Tightly twist the strands of the stripped wire together before wrapping around the screw in a clockwise direction before tightening. Don't forget to install the fiber insulator that is usually supplied with the plug.

- The best plugs have wire clamp terminals. The stripped end of the wire is inserted into a hole and a screw is tightened to clamp the wire in place. Usually, a molded plastic cover is then screwed over this assembly and includes a strain relief as well. These are nearly foolproof and consequently are used in the most demanding industrial and medical applications. They are, not surprisingly, also typically the most expensive.

Where damage is present at the appliance end of the cord, it may be possible to just cut off the bad portion and reinstall what remains inside of the appliance. As long as this is long enough and a means can be provided for adequate strain relief, this is an acceptable alternative to replacement of the entire cordset.

When a cordset is more than a cord and plug

While most appliances use normal cordsets, some, especially an increasing number of newer ones include various circuitry in the plug itself:

- Sometimes, the plugs themselves include built-in fuses which if blown, might result in an incorrect diagnosis of a bad cordset. And, replacing the cordset with a normal one would result in the loss of the prtection provided by the fuses.

- A variety of electronic equipment as well as rechargeable (and other) appliances now use switching power supply type wall adapters rather than the usual bulky, heavy wall transformer. These weigh almost nothing and are only slighly larger than a normal wall plug. However, they are an essential part of the unit since the AC line voltage is converted into a lower DC voltage inside the oversize plug! These are functionally equivalent to the more common type (probably better in fact in terms of regulation and efficiency) and both provide the essential line isolation required for safety. Neither the entire cordset nor the plug can be cut off and replaced. An exact replacement for that particular model must be installed.

- Some appliances include either a Ground Fault Circuit Interrupter (GFCI) or what I call a GFCK (Ground Fault Circuit Killer) in an oversize plug. These provide protection from shock for items like hair dryers that might contact or be dropped into water. A GFCI can be reset once the fault condition is removed (it is unplugged and dried out). A GFCK is a one time circuit breaker type device. If it is activated, the appliance will need to be repaired to reset it (which may not be worth the cost since it will require replacement of the special GFCK cordset). While the appliance will still work if the special plug or the entire cordset is replaced with a normal one, the protection will be lost and it should then ONLY be used in a GFCI protected outlet. See the sections: "What is a GFCI?" and "The Ground Fault Circuit Killer (GFCK)".

Appliance cord gets hot

This applies to all high current appliances, not just space heaters though these are most likely to be afflicted since they are likely to be run for extended periods of time.

Of course, if the problem is with an *extension* cord, then either it is overloaded or defective. In either case, the solution should be obvious.

Some cords will run warm just by design (or cheapness in design using undersized conductors).

However, if it is gets hot during use, this is a potential fire hazard.

If it is hot mainly at the plug end - get a heavy duty replacement plug - one designed for high current appliances using screw terminals - at a hardware store, home center, or electrical supply house. Cut the cord back a couple of inches.

If the entire cord gets warm, this is not unusual with a heater. If it gets really hot, the entire cord should be replaced. Sometimes with really old appliance, the copper wires in the cord oxidize even through the rubber insulation reducing their cross section and increasing resistance. This leads to excessive power dissipation in the cord. Replacement *heavy duty* cordsets are readily available.

Note that just because the cord itself gets warm does NOT mean that the wiring in the walls is heating significantly. The smallest allowable wiring size inside the walls is #14 which has a resistance of about 2.5 ohms per thousand feet. An appliance drawing 10 A through 50 feet of cable (100 total feet of wire going both ways) would result in a 2.5 V drop and 25 W dissipation. But since this is distributed over 50 feet of cable, heating in any location is minimal.

Extension cords

We treat extension cords too casually - abusing them and using underrated extension cords with heavy duty appliances. Both of these are serious fire and shock hazards. In addition, the use of a long inadequate extension will result in reduced voltage due to resistive losses at the far end. The appliance may not work at full capacity and in some cases may even be damaged by this reduced voltage.

Extension cord rules of use:

- The capacity must be at least equal to the SUM of the wattages or amperages of all the appliances plugged in at the far end. Larger is fine as well and is desirable for long extensions. Check the rating marked on the cord or a label attached to the cord. Thickness of the outside of the cord is not a reliable indication of power rating.

- Use a type which is the most restrictive of any appliances that will be plugged in (e.g., 3 prong if any are of this type, 2 prong polarized otherwise unless your outlets are non-polarized (old dwellings).

- Use only outdoor type extension cords (usually colored yellow or orange) outdoors if there is ANY chance of dampness or moisture contacting them. These are water proof (well, at least, water resistent). One should, of course, avoid working with electricity under wet conditions in any case!

- Use only as long an extension as required. For very long runs, use a higher capacity extension even if the power requirements are modest.

- NEVER run extensions under carpeting as damage is likely and this will go undetected. Never run extensions inside walls. Add new outlets where needed with properly installed building wire (Romex). This must be done in such a way that it meets the National Electric Code (NEC) in your area. It may need to be inspected if for no other reason than to guarantee that your homeowner's insurance won't give you a hard time should any 'problems' arise. Surface mount outlets and conduit are available to extend the reach of existing outlets with minimal construction if adding new ones is difficult or too costly.

- Don't use heavy duty extensions as a long term solution if possible. Similarly, don't use extensions with 'octopus' connections - install an outlet strip.

Extension cords of any type, capacity, and length can be easily constructed from components and wire sold at most hardware stores and home centers. This is rarely economical for light duty polarized types as these are readily available and very inexpensive. However, for heavy duty 3 prong extensions, a custom constructed one is likely to save money especially if an unusual length is required. Making up a heavy duty extension with a 'quad' electrical box with a pair of 15 amp duplex outlets is a very rugged convenient alternative to a simple 3 prong socket.

Common problems: internal wiring conductors broken at flex points (socket or plug). With yard tools, cutting the entire cord is common. The connections at the plug may corrode as well resulting in heating or a bad or intermittent connection.

Testing: Extension cords can always be tested with a continuity checker or multimeter on a the low ohms scale.

Extension cord repair

- For a $1 light duty extension cord, repair is generally not worth the effort. However, if you insist, a new plug or socket can be installed at the cut end.

- Where a heavy duty extension has been cut near one end (e.g., by an electric hedge clipper or lawn mower - usually the socket end), purchase a proper plug or socket designed for outdoor use (if appropriate) and attach it to the cut end. If both sections are long enough, you can make up two shorter extensions. There, now you have two extension cords where there was only one before. :-)

- I do NOT recommend splicing damaged or broken wires except possibly as a temporary measure. In that case, the wires should be reattached by soldering or with the use of solderless or crimp connectors and then thoroughly insulated and reinforced with multiple layers of plastic electrical tape to assure both the electrical and physical integrity.

Determining the location of a break in an extension cord

This isn't worth the time it would take to describe for a $.99 6 foot K-Mart special but it might make sense for a 100 foot heavy duty outdoor type. If the problem is near one end, a couple of feet can be cut off and a new plug or socket installed. If more towards the middle, the wires can be cut and spliced or two smaller cords could be made from the pieces.

But, how do you locate the break?

- Use a Time Domain Reflectometer (TDR). Oops, don't have one? And, you probably don't even know what this means! (Basically, a TDR sends a pulse down a wire and measures how long it takes for a reflected pulse to return from any discontinuities. The delay is a measure of distance.) Don't worry, there are alternatives that cost less than $20,000. :-)

- If there is no obvious damage - you didn't attempt to mow the cord by accident - the most likely location is at the end where the plug of socket strain relief joins the wire. Squeezing, squishing, pushing, etc., with the cord plugged into a live outlet and lamp or radio plugged into the other end may reveal the location by a momentary flash or blast of sound.

- Try a binary search with a probe attached to a straight pin. This works best with a cord where the wires are easily located - not the round double insulated type. Attach one probe of your multimeter to the prong of the plug attached to the broken wire. Start at the middle with your pin probe. If there is continuity move half the distance to the far end. If it is open, move half the distance toward near end. Then 1/4, 1/8, and so forth. It won't take long to located the break this way. Of course, there will be pin holes in the insulation so this is not recommeded for outdoor extension cords unless the holes are sealed.

- You may be able to use one of those gadgets for testing Christmas Tree light sets - these inexpensive devices sense the AC field in proximity to its probe. Plug the cord in so that the Hot of your AC line is connected to one of the wires you know is broken (from testing with an ohmmeter) and run the device along the cord until the light changes intensity.

  This also works for appliance cords where you are too lazy to go inside to check continuity. You may need to try both wires in the cord to locate the broken one.

- If you have a capacitance meter (or a DMM with a capacitance range), measure the capacitance between the bad wire and the other two wires at both ends. The ratio of capacitances will correspond to the ratio of distances of good wire and so will tell you approximately where the break is located.

- If you have some real test equipment (but not a TDR!) attach the output of a frequency generator to the prong of the plug for the wire you know is broken. Use an oscilloscope as a sensor - run the probe along the cord until the detected signal abruptly drops in intensity. You may need to ground the good wires to prevent them from picking up the signal and propagating it past the break.

  An AM or multiband radio may also be suitable as a detector.

Internal wiring - cables and connectors

Wiring isn't super glamorous but represents the essential network of roads that interconnect all of the appliance's internal parts and links it to the outside world.

Inside the appliance, individual wires (often multicolored to help identify function) or cables (groups of wires combined together in a single sheath or bundle) route power and control signals to the various components. Most are insulated with plastic or rubber coverings but occasionally you will find bare, tinned (solder coated), or plated copper wires. In high temperature appliances like space heaters and toasters, the insulation (if present) will be asbestos (older) or fiberglass. (Rigid uninsulated wires are also commonly found in such applications.) Particles flaking off from either of these materials are a health hazard if you come in contact, inhale, or ingest them. They are also quite fragile and susceptible to damage which may compromise their insulating properties so take care to avoid excessive flexing or repositioning of wires with this type of insulation. Fiberglass insulation is generally loose fitting and looks like woven fabric. Asbestos is light colored, soft, and powdery.

Color coding will often be used to make keeping track of the wires easier and to indicate function. However, there is no standard except for the input AC line. Generally, black will be used for Hot, white will be used for Neutral, and green or uninsulated wire will be used for Safety Ground. While this is part of the NEC (Code) for electrical wiring (in the U.S.), it is not always followed inside appliances. You may also find brown for Hot, blue for Neutral, and green with a yellow stripe for Safety Ground. This is used internationally and is quite common for the cordsets of appliances and electronic equipment.

Where a non-polarized plug (cordset) is used, either AC wire can be Hot and both wires will typically (but not always) be the same color.

Other colors may be used for switched Hot (e.g., red), thermostat control, motor start, solenoid 1, etc. Various combinations of colored stripes may be used as well. Unfortunately, in some cases, you will find that all the wiring is the same color and tracing the circuit becomes a pain in the you-know-what.

Where multiple wires need to go from point A to point B along the same path, they will often be combined into a single cable which is bundled using nylon or cloth tie-wraps or run inside a single large flexible plastic sheath. For electronic interconnects and low voltage control and signal wiring, molded flat cables are common (like those for the cables to the diskette and hard drives of your PC). These are quite reliable and can be manufactured at low cost by fully automatic machines.

The thickness of the insulation of a wire or cable is not a reliable indication of its capacity or voltage rating. A fat wire may actually have a very skinny central conductor and vice-versa. In some cases, the wire conductor size and voltage rating will be printed on the insulation but this not that common. If replacement is needed, this information will be essential. However, the ampacity (maximum current) can be determined from the size of the metal conductor and for any of the line powered appliances discussed in this document, wire with a 600 V rating should be more than adequate.

The type of insulation is critical in appliances that generate heat - including table lamps and other lighting fixtures. There is special high temperature insulated wire (fixture wire) which should be used when replacement is needed. For heating appliances like toasters, hair dryers, and deep friers, fiberglass or high temperature silicone based rubber insulated wire or insulating sleeves must be used should the original wiring need replacement. An appliance repair motor rebuilding shop would be the most likely source - common electronics distributors may not carry this stuff (especially if you only need a couple feet)!

Connections between individual wires and between individual wires and other components are most often made by crimp or screw terminals, welding, or press-in contacts. For cables, actual multipin and socket connectors may be used.

Common problems: internal wiring conductors broken, corroded, or deteriorated due to heat or moisture. Dirty, corroded, weakened, or damaged connector contacts are common requiring cleaning and reseating or replacement. Damage to insulation from vibration, heat, movement, or even improper manufacture or design is also possible. Careless reassembly during a previous repair could result in pinched broken wires or insulation as well as short circuits between wires, or wiring and sharp sheet metal parts.

Testing: Inspect for obvious breaks or wires that have pulled out of their terminations. Integrity of wiring can be determined with a continuity checker or multimeter on a the low ohms scale. Flexing and wiggling wires especially at connections while observing the meter will identify intermittents.

Switches - power, mode, or speed selection

Most appliances have at least one switch to turn the appliance on and off. In some cases, this may be combined with a thermostat or other control. However, switches serve a variety of functions as well.

- Power - Nearly all appliances that run on AC directly (no wall transformer) provide some means of completely disconnecting at least one side of the AC line when not in use. This may be a rocker, slide, push-push, trigger, toggle, rotary, or other separate switch. It may also be combined with another function like a speed control or thermostat.

- Selector, mode, function - these switches may be used to determine speed in a mixer or blender, or the heat or air-only setting on a blow-dryer, for example.

- Internal (not user accessible) - these perform functions like detecting the position of a mechanism (e.g., limit switch), cam operated timing, and other similar operations that are not directly performed by the user.

In all cases, the function of a switch is the same - to physically make (on) or break (off) the circuit or connect one signal to another.

- The most common type of switches have a set of metallic contacts (special materials to resist arcing and corrosion) which are brought together as a result of mechanical motion of a rocker, lever, etc. to complete the circuit There is usually some sort of snap action to assure rapid make and break of the circuit to minimize deterioration due to arcing.

- Mercury switches - found in thermostats, silent wall switches, and a variety of other places, use a small quantity of mercury (a metal which is a liquid at room temperature) to complete the circuit. Depending on the orientation of a glass or metal/insulator capsule, the mercury either contacts a set of terminals (on) or is separate from them (off). Since any arcing occurs in the liquid mercury, there is virtually no deterioration of internal parts of a mercury switch. Life is nearly infinite when used within its ratings. See the section: About mercury wall switches.

Common problems with switches include: dirt, worn, or melted contacts, broken plastic or fiber parts, bad connections to terminals.

Testing: Switches can always be tested with a continuity checker or a multimeter on a low ohms scale.

WARNING: Mercury is a heavy metal and is poisonous. I know it is fun to play with beads and globs of the stuff (and I have done it) but do not recommend it, at least not on a daily basis. Dispose of any from broken mercury switches or thermometers safely. If you insist on keeping it, use a piece of paper as a scoop and put the mercury in a bottle with a tightly sealed cap. See the section: Comments on mercury poisoning.

About mercury wall switches

The types of mercury switches used for wall switches are quite clever and provide in effect a snap action (called hysteresis) due to their construction and the surface tension of the liquid mercury itself. This despite the fact that the motion of the toggle lever is totally smooth and silent. It is not possible to put the lever in such a position that there could be marginal contact and random on-off cycles. The mercury capsule inside such a switch consists of a metallic shell with an insulating (glass or ceramic) spacer in between the two halves. Connection to the switch's wiring is made via sliding contacts to the metal portion of the capsule. There is a small hole toward one side in the spacer. Rotating the capsule results in the mercury flowing through the hole to make contact:

- In the off position, the hole is above the level of the liquid mercury.
- In the on position, the hole is below the level of the liquid mercury.
- When turning the switch on, the hole is rotated below the surface and as soon as the mercury touches, surface tension quickly pulls it together. There is no 'contact bounce'.
- When turning the switch off, the mercury pulls apart as the capsule is rotated to raise the hole. Eventually, surface tension is not sufficient to hold the two globs of mercury together and they part suddenly.

Problems are rare with these mercury switches. In fact, GE mercury switches used to carry a *50* year warranty! I don't know if they still do.

In principle, these are also the safest type of switch since any sparking or arcing takes place inside the sealed mercury capsule. However, the contact between the screw terminals and the capsule are via sliding contacts (the capsule is press fit between the metal strips to which the screws are attached) and with time, these can become dirty, worn, or loose. For this reason, some electricians do not like mercury switches, particularly for high current loads.

Comments on mercury poisoning

While I recognize the dangers of mercury poisoning, I was one of those who used to play with mercury quite extensively from broken thermometers, mercury switches, and any other sources I could find. In high school, I used to go through the back storage rooms in search of mercury. This was before the era of regulations protecting everyone from everything. I still have a couple pounds of the stuff, safely stored.

The danger isn't so much from occasional contact with metallic mercury as from mercury vapor which may build up in an enclosed spaces and from soluble mercury compounds. You get significant contact with metallic mercury from amalgam ("silver") tooth fillings and while there is controversy about their safety and some people have had their old fillings ripped out at great expense (and disconfort!), there is as far as I know, no conclusive scientific evidence linking mercury poisoning to amalgam fillings.

Having said that, I agree that it's probably a bad idea to be playing with mercury on a daily basis but pushing a few drops of it around or losing one drop to the floorboards isn't going to make everyone sick. If this were the case, half the houses in the World would be HAZMAT zones from broken fluorescent lamps - which have significant metallic mercury in them.

If anyone has evidence to the contrary, please cite refereed scientific publications and I will read them, not hyped popular press reports.

Relays - electrically activated switches for power or control

Relays are switches that are activated by an electrical signal rather than a button or toggle. They are used to switch power (as in an central air conditioning system) or control signals (as in a telephone or modem).

- The most common relays are electromechanical - an electromagnet is used to move a set of contacts like those in a regular switch.

- Solid state relays have no moving parts. They use components like thyristors or MOSFETs to do the switching.

For more information on relays, see the document: Notes on the Troubleshooting and Repair of Audio Equipment and other Miscellaneous Stuff.

Contact configurations

The arrangement of contacts on a switch is often abbreviated mPnT where:

- 'm' identifies the number of separate sets of contacts.
- 'P' stands for Poles or separate sets of contacts.
- 'n' identifies the number of contact positions.
- 'T' stands for Throw which means the number of contact positions.

In addition, you may see:

- NC (Normally Closed and NO (Normally Open) may be used to designate terminals when the switch is in the off or deactivated state. This applies to power switches where OFF would be down or released and ON would be up or pushed in. It also applies to momentary pushbutton switches and relays.
- MBB (Make Before Break) and BBM (Break Before Make) designate how the connections behave as the switch is thrown. Most switches found in small appliances will be of the BBM variety.

This also applies to relays except that the contact switching is activated by an electrical signal rather than a finger.

The most common types are:

- SPST - Single Pole Single Throw. Terminal (A) is connected to terminal (B) when the switch is on:

```
          A ______/ _______ B
```

  This is the normal light or power switch. For electrical (house) wiring, it may be called a '2-way' switch.

- DPST - Double Pole Single Throw. Terminal (A) is connected to terminal (B) and terminal (C) is connected to terminal (D) when the switch is on:

```
          A ______/ _______ B
                  :
          C ______/ _______ D
```

  This is often used as a power switch where both wires of the AC line are switched instead of just the Hot wire.

- SPDT - Single Pole Double Throw. A common terminal (C) is connected to either of two other terminals:

```
                   _______ NC
         C ______/
                   _______ NO
```

This is the same configuration as what is known as a '3-way' switch for electrical (house) wiring. Two of these are used to control a fixture from separate locations.

- DPDT - Double Pole Double Throw. Essentially 2 SPDT switches operated by a single button, rocker, toggle, or lever:

```
                   _______ NC1
      C1 ______/
               : _______ NO1
               :
               : _______ NC2
      C2 ______/
                 _______ NO2
```

- SP3T, SP4T, etc. - Single Pole selector switch. A common terminal (C) is connected to one of n contacts depending on position. An SP5T switch is shown below:

```
               _________ 1
                 _______ 2
       C ______/  ______ 3
                 _______ 4
               _________ 5
```

Electrical overload protection devices - fuses and circuit breakers

The purpose of fuses and circuit breakers is to protect both the wiring from heating and possible fire due to a short circuit or severe overload and to prevent damage to the equipment due to excess current resulting from a failed component or improper use (using a normal carpet vacuum to clear a flooded basement).

Fuses use a fine wire or strip (called the element) made from a metal which has enough resistance (more than for copper usually) to be heated by current flow and which melts at a relatively low well defined temperature. When the rated current is exceeded, this element heats up enough to melt (or vaporize). How quickly this happens depends on the extent of the overload and the type of fuse.

Fuses found in consumer electronic equipment are usually cartridge type - 1-1/4" mm x 1/4" or 20 mm x 5 mm, pico(tm) fuses that look like green 1/4 W resistors, or other miniature varieties. Typical circuit board markings are F or PR.

More than you could ever want to know about fuses can be found at the Littlefuse Web site. Go to Resouces->Reference Materials->Fusology to start.

Circuit breakers may be thermal, magnetic, or a combination of the two. Small (push button) circuit breakers for appliances are nearly always thermal - metal heats up due to current flow and breaks the circuit when its temperature exceeds a set value. The mechanism is often the bending action of a bimetal strip or disc - similar to the operation of a thermostat. Flip type circuit breakers are normally magnetic. An electromagnet pulls on a lever held from tripping by a calibrated spring. These are not usually common in consumer equipment (but are used at the electrical service panel).

At just over the rated current, it may take minutes to break the circuit. At 10 times rated current, the fuse may blow or circuit breaker may open in milliseconds.

The response time of a 'normal' or 'rapid action' fuse or circuit breaker depends on the instantaneous value of the overcurrent.

A 'slow blow' or 'delayed action' fuse or circuit breaker allows instantaneous overload (such as normal motor starting) but will interrupt the circuit quickly for significant extended overloads or short circuits. A large thermal mass delays the temperature rise so that momentary overloads are ignored. The magnetic type breaker adds a viscous damping fluid to slow down the movement of the tripping mechanism.

Common problems: fuses and circuit breakers occasionally fail for no reason or simply blow or trip due to a temporary condition such as a power surge. However, most of the time, there is some other fault with the appliance which will require attention like a bad motor or shorted wire. Dirty, corroded, or weak contacts (holding the fuse or circuit breaker) may get hot and contribute to nuisance tripping. Circuit breakers can also go bad just due to age (this particularly applies to those in the electrical service panel - one that buzzes and/or trips occasionally for no apparent reason may need replacement).

Testing: Fuses and circuit breakers can be tested for failure with a continuity checker or multimeter on the low ohms scale. A fuse that tests open is blown and must be replaced (generally, once the circuit problem is found and repaired.) Of course, if the fuse element is visible, a blown fuse is usually easy to identify without any test equipment. A circuit breaker that tests open or erratic after the reset button is pressed, will need replacement as well.

Note that in general, circuit breakers should **NOT** be used for repeated switching nor should they be reset on a circuit with any substantial load (or overload or short circuit). Their contacts are not designed for this type of operation. Here are some additional comments:

(From: Tom Hardy (th7675@istate.net).)

Many people use circuit breakers as switches (including my father-in-law!). The problem is that the contacts become burned, creating resistance and thus abnormal heating causing the breaker to be unable to carry its rated load. The other thing this does (especially with Square-D QO style breakers) through heating is causes the buss bar contact to loose it's spring tension (in reference to circuit breakers installed in an electrical service panel). This will (as happened to my father-in-law) burn up part of the buss bar and ruin the electric panel. Most people will just reset a breaker if it trips, without first removing the load. This also causes burned contacts as mentioned above. I have found many defective breakers before they go bad, usually feeding higher current appliances. Just turn on the appliance for 15 to 20 minutes and then feel the front of the breaker with your hand. If its warm or hot, there is usually reason to suspect future trouble if it's not replaced.

Fuse postmortem

Quite a bit can be inferred from the appearance of a blown fuse if the inside is visible as is the case with a glass cartridge type. One advantage to the use of fuses is that this diagnostic information is often available!

- A fuse which has an element that looks intact but tests open may have just become tired with age. Even if the fuse does not blow, continuous cycling at currents approaching its rating or instantaneous overloads results in repeated heating and cooling of the fuse element. It is quite common for the fuse to eventually fail when no actual fault is present.

- A fuse where the element is broken in a single or multiple locations blew due to an overload. The current was probably more than twice the fuse's rating but not a dead short.

- A fuse with a blackened or silvered discoloration on the glass where the entire element is likely vaporized blew due to a short circuit.

This information can be of use in directly further troubleshooting.

Fuse or circuit breaker replacement

As noted, sometimes a fuse will blow for no good reason. Replace fuse, end of story. In this situation, or after the problem is found, what are the rules of safe fuse replacement? It is inconvenient, to say the least, to have to wait a week until the proper fuse arrives or to tromp out to Radio Shack in the middle of the night.

Even with circuit breakers, a short circuit may so damage the contacts or totally melt the device that replacement will be needed.

Five major parameters characterizes a fuse or circuit breaker:

1. **Current rating:** This should not be exceeded (you have heard about not putting pennies in fuse boxes, right?) (The one exception to this rule is if all other testing fails to reveal which component caused the fuse to blow in the first place. Then, and only then, putting a larger fuse in or jumpering across the fuse **just for testing** will allow the faulty component to identify itself by smoking or blowing its top!) A smaller current rating can safely be used but depending on how close the original rating was to the actual current (or how much surge current there is on power-on), an underrated fuse may blow immediately.

   Some equipment may use fuses with strange current ratings like 1.65 A instead of 1.5 A. In such cases, it won't hurt to try a common lower current value like 1.5 A. The worst that will happen is that it will blow, probably not immediately but some time in the future even if there is no problem. Using the next higher common value like 1.75 A isn't recommended except for testing. The irony is that these strange values are often used in the primaries of switchmode power supplies where their function is to blow due to catastrophic failure, not a slight overload, and it really doesn't matter if they are slightly larger (but only slightly larger!). However, for reasons of liability, this is still not recommended. Don't do it!

2. **Voltage rating:** This is the maximum safe working voltage of the circuit (including any inductive spikes) which the device will safety interrupt. Thus, you may see fuses where the elements look like [|------|] versus [|==--==|]. Aside from the shape and size, the type of material used for the fuse element as well as what's surrounding it (e.g., air or sand) will affect voltage rating. It is safe to use a replacement with an equal or high voltage rating.

   And, it's quite likely that there will be no difference between 125 V and 250 V fuses except the labeling. It really doesn't cost more to make higher voltage fuses in the same package size of the type found in consumer electronic equipment so any labeling like this would be more of a regulatory issue.

   For high voltage, current limited equipment (up to 500 V or more, up to 10 times the fuse current rating), it may still be acceptable to use a 250 V fuse.

3. **AC versus DC:** Fuses rated for AC and DC may not be the same. For a given voltage, a shorter gap can be used to reliably interrupt an AC circuit since the voltage passes through zero 120 (100) times a second. For example, a fuse rated 32 VDC may look similar to one rated for 125 VAC.

4. **Type:** Normal, fast blow, slow blow, etc. It is safe to substitute a fuse or circuit breaker with a faster response characteristic but there may be consistent or occasional failure mostly during power-on. The opposite should be avoided as it risks damage to the equipment as semiconductors tend to die quite quickly.

5. **Mounting:** It is usually quite easy to obtain an identical replacement. However, as long as the other specifications are met, soldering a normal 1-1/4" (3AG) fuse across a 20 mm fuse is perfectly fine, for example. Sometimes, fuses are soldered directly into an appliance.

   However, any soldering of wires directly to a fuse should be done with care and it may weaken the fuse element or its connection if the fuse doesn't just fall apart. Thus, where soldered-in fuses are used, obtain replacements with wire leads that preattached or solder in a fuse holder.

Thermal protection devices - thermal fuses and thermal switches

These devices protect against excessive temperature due to either a fault in the appliance (locked motor overheating) or improper use (blow dryer air blocked). They are at least as important as normal fuses or circuit breakers for prevention of fire and damage due to overheating. Also see the document: Notes on the Troubleshooting and Repair of AC Adapters, Power Supplies, and Battery Packs.

There are three typical types:

1. **Thermal fuses:** This is similar to an electrical fuse but is designed to break the circuit at a specific temperature. These are often found in heating appliances like slow cookers or coffee percolators or buried under the outer covering of motor windings or transformers. Some also have an electrical fuse rating as well. Like electrical fuses, these are one-time only parts. A replacement that meets both the thermal and electrical rating (if any) is required.

   CAUTION: When replacing a thermal fuse, DO NOT SOLDER it if at all possible. If the device gets too hot, it may fail immediately or be weakened. Crimp or screw connections are preferred. It is normally possible to obtain "crimp rings" when you order - they may be included. Then, just cut off the old fuse but leave some wire, slip the old and new wires into a crimp ring (twist them for added mechanical stability) and compress the ring tightly with a pair of pliers. Note the direction: If the appliance uses a polarized plug, it is recommended that the isolated lead of the thermal fuse be attached to the Hot AC wiring and the bare metal body of the thermal fuse which is connected to one lead be attached to the wiring of the appliance. This is a minor point but it doesn't cost anything!

```
                       *                     *
      To AC Hot -------||--     ______     --||-------- To appliance wiring
                     --||------<______|------||--
                           New Thermal Fuse

  * Twisted and crimped connection for maximum mechanical strength.
```

   If you must solder, use a good heat sink (e.g., wet paper towels, little C-clamps) on the leads between the thermal fuse and the soldering iron, and work quickly!

2. **Thermal switches or thermal protectors (strip type):** These use a strip of bimetal similar to that used in a thermostat. Changes in temperature cause the strip to bend and control a set of contacts - usually to to break a circuit if the set temperature is exceeded. Commonly found in blow dryers and other heating appliances with a fixed selection of heat settings. They may also be found as backup protection in addition to adjustable thermostats.

3. **Thermal switches or thermal protectors (disk type):** These use a disk of bimetal rather than a strip as in most thermostats. The disk is formed slightly concave and pops to the opposite shape when a set temperature is exceeded. This activates a set of contacts to break (usually) a circuit if the rated temperature is exceeded. They may also be found as backup protection in addition to adjustable thermostats. A typical thermal switch is a small cylindrical device (i.e., 3/4" diameter) with a pair of terminals and a flange that is screwed to the surface whose temperature is to be monitored.

In some applications, device types (2) and (3) may be used as the primary temperature regulating controls where adjustment is not needed.

Comments on importance of thermal fuses and protectors

Like a normal fuse or circuit breaker, a thermal fuse or thermal protector provides a critical safety function. Therefore, it is extremely ill advised to just short it out if it fails. Some designs even make this option extra tempting by providing an easy way to bypass even one buried inside a power transformer - using an additional, normally unused terminal.

For testing, it is perfectly acceptable to temporarily short out the device to see if the equipment then operates normally without overheating. However, while these fuses do sometimes just fail on their own, most likely, there was another cause. If you know what it was - you were trying to charge a shorted battery pack, using your window fan to mix cement, or something was shorted externally, then the fuse served its protective function and the equipment is fine. IT SHOULD BE REPLACED WITH THE SAME TYPE or the entire transformer, motor, or whatever it was in should be replaced! This is especially critical for unattended devices. Otherwise, especially with unattended devices, you have a situation where if the overload occurred again or something else failed, the equipment could overheat to the point of causing a fire - and your insurance company may refuse to cover the claim if they find that a change was made to the circuit. And even for portable devices like blow dryers and portable power tools, aside from personal safety should the device malfunction, the thermal protector is there to prevent damage to the equipment itself - don't leave it out!

More on thermal fuses

(From: Paul Grohe (grohe@galaxy.nsc.com).)

The following is From Microtemps' literature (`95 EEM Vol.B p1388):

> "The active trigger mechanism of the thermal cutoff (TCO) is an electrically non-conductive pellet. Under normal operating temperatures, the solid pellet holds spring loaded contacts closed. When a pre-determined temperature is reached, the pellet melts, allowing the barrel spring to relax. The trip spring then slides the contact away from the lead and the circuit is opened. Once TCO opens a circuit, the circuit will remain open until the TCO is replaced....."

Be very careful in soldering these. If the leads are allowed to get too hot, it may "weaken" the TCO, causing it to fail prematurely. Use a pair of needle-nose pliers as heat sinks as you solder it.

I have replaced a few of these in halogen desk lamp transformers. The transformers showed no signs of overheat or overload. But once I got it apart, the TCO's leads had large solder blobs on them, which indicated that the ladies that assembled the transformers must have overheated the cutouts leads when they soldered them.

The NTE replacement package also comes with little crimp-rings, for high-temp environments where solder could melt or weaken (or to avoid the possibility of soldering causing damage as described above --- sam).

Controls 1 - adjustable thermostats and humidistats

Thermostats are use to regulate the temperature in heating or cooling type appliances. Common uses include heaters, air conditioners, refrigerators, freezers, hair dryers and blow dryers, toaster ovens and broilers, waffle irons, etc. These are distinguished from the thermal switches discussed above in that they usually allow a variable temperature setting.

Four types are typically found in appliances. The first three of these are totally mechanically controlled:

1. **Bimetal strip:** When two metals with different coefficients of thermal expansion are sandwiched together (possibly by explosive welding), the strip will tend to bend as the temperature changes. For example, if the temperature rises, it will curve towards the side with the metal of lower coefficient of expansion.

   In a thermostat, the bimetal strip operates a set of contacts which make or break a circuit depending on temperature. In some cases the strip's shape or an additional mechanism adds 'hysteresis' to the thermostat's characteristics (see the section: What is hysteresis?).

2. **Bimetal disk:** This is similar to (1) but the bimetal element is in the shape of a concave disk. These are not common in adjustable thermostats but are the usual element in an overtemperature switch (see the section: Thermal protection devices - thermal fuses and thermal switches).

3. **Fluid operated bellows:** These are not that common in small appliances but often found in refrigerators, air conditioners, baseboard heaters, and so forth. An expanding fluid (alcohol is common) operates a bellows which is coupled to a set of movable contacts. As with (1) and (2) above, hysteresis may be provided by a spring mechanism.

Other variations on these basic themes are possible but (1)-(3) cover the vast majority of common designs.

Testing of mechanical thermostats: Examine for visible damage to the contacts. Use a continuity checker or ohmmeter to confirm reliable operation as the knob or slider is moved from end to end if it will switch at room temperature. Gently press on the mechanism to get the contacts to switch if this is not possible. Use an oven on low or a refrigerator or freezer if needed to confirm proper switching based on temperature.

4. **Electronic thermostats:** These typically use a temperature variable resistance (thermistor) driving some kind of amplifier or logic circuit which then controls a conventional or solid state relay or thyristor.

Testing of electronic thermostats: This would require a schematic to understand exactly what they are intended to do. If a relay is used, then the output contacts could perhaps be identified and tested. However, substitution is probably the best approach is one of these is suspected of being defective.

Humidistats, as their name implies, are used to sense relative humidity in humidifiers and dehumidifiers. Their sensing material is something that looks kind of like cellophane or the stuff that is used for sausage casings. It contracts and expands based on the moisture content of the air around it. These are somewhat fragile so if rotating the control knob on a humidifier or dehumidifier does not result in the normal 'click', this material may have been damaged or broken.

Testing of mechanical humidistats: examine for visible damage to the contacts. Use a continuity checker or ohmmeter to confirm reliable operation as the knob or slider is moved from end to end. Gently press on the mechanism to get the contacts to switch if this is not possible. Gently exhale across the sensing strip to confirm that the switching point changes.

What is hysteresis?

An intuitive explanation of hysteresis is that it is a property of a system where the system wants to remain in the state that it is in - it has memory.

Examples of systems with hysteresis:

- Thermostats - without hysteresis your heater would be constantly switching on and off as the temperature changed. A working thermostat has a few degrees of hysteresis. As the temperature gradually increases, at some point the thermostat switches off. However, the temperature then needs to drop a few degrees for it to switch on again.

- Toggle switches - the click of a toggle switch provides hysteresis to assure that small vibrations, for example, will not accidentally flip the switch.

Examples of systems which ideally have little or no hysteresis:

- Audio amplifiers - input vs. output.

- Pendulums on frictionless bearings - force vs. position.

Hysteresis is usually added thermostats by the use of a spring mechanism which causes the mechanism to want to be in either the open or closed position but not in between. Depending on the appliance, there may be anywhere from 0 hysteresis (waffle iron) to 5-10 degrees F (space heater). Sometimes, the thermal mass of the heated device or room provides the hysteresis since any change to the temperature will not take place instantaneously since the heating element is separated from the thermostat by a mass of metal. Therefore, some overshoot - which in effect performs the same function as a hysteresis mechanism - will take place.

Controls 2 - rheostats and potentiometers

These controls are usually operated by a knob or a slide adjustment and consist of a stationary resistance element and a wiper that can be moved to determine where on the fixed element it contacts. In some cases, they are not actually user controls but are for internal adjustments. In other cases, they are operated by the mechanism automatically and provide a means of sensing position or controlling some aspect of the operation.

- Rheostats provide a resistance that can be varied. Usually, the range is from 0 ohms to some maximum value like 250 ohms. They are used to control things like speed and brightness just by varying the current directly, or via an electronic controller (see the section: Electronic controllers - simple delay or microprocessor based").

```
B o-------------+
                |
                V
A o--------/\/\/\/\/\-----
        250 ohm rheostat
```

  In the diagram above, the resistance changes smoothly from 0 to 250 ohms as the wiper moves from left to right.

  Very often, you will see the following wiring arrangement:

```
B o-------------+------+
                |      |
                V      |
A o--------/\/\/\/\/\--+
       250 ohm rheostat
```

  Electrically, this is identical. However, should the most common failure occur with the wiper breaking or becoming disconnected, the result will be maximum resistance rather than an open circuit. Depending on the circuit, this may be preferred - or essential for safety reasons.

  Testing: Disconnect at least one of the terminals from the rest of the circuit and then measure with an ohmmeter on the appropriate scale. The resistance should change smoothly and consistently with no dead spots or dips.

- Potentiometers are either operated by a knob or a slide adjustment and implement a variable resistance between two end terminals as shown below. This can be used to form a variable voltage divider. A potentiometer (or 'pot' for short) can be used like a rheostat by simply not connecting one end terminal. These are most often used with electronic controllers.

```
B o-------------+
                |
                V
A o--------/\/\/\/\/\--------o C
      1K ohm potentiometer
```

In the diagram above, the resistance between A and B varies smoothly from 0 to 1K ohms as the wiper moves from left to right. At the same time, the resistance between B and C varies smoothly from 1K to 0 ohms. For some applications, the change is non-linear - audio devices in particular so that the perceived effect is more uniform across the entire range.

Testing: Disconnect at least two of the terminals from the rest of the circuit and then measure with an ohmmeter on the appropriate scale. The resistance should change smoothly and consistently with no dead spots or dips. Try between each end and the wiper. Check the resistance across the end terminals as well - it should be close to the stamped rating (if known).

Rheostats and potentiometers come in all sizes from miniature circuit board mounted 'trimpots' to huge devices capable of handling high power loads. The resistance element may be made of fine wire ('wirewound') or a carbon composition material which is silkscreened or painted on.

Interlocks - prevent operation with case or door open

Most of these are simple switches mechanically activated by the case or door. Sometimes, optical or magnetic interlocks are used (rare on small appliances but common on things like printers). Line cords that are firmly attached to the case and disconnect automatically when the case is removed are another example of an interlock. Interlocks may be designed to prevent injury during normal operation (e.g.. food processor blades will not start when cover is removed) or during servicing (remove AC power to internal circuits with case removed).

1. **Interlock switches:** Various kinds of small switches may be positioned in such a way that they disconnect power when a door is opened or cover is removed. These may fail due to electrical problems like worn or dirty contacts or mechanical problems like a broken part used to activate the interlock.

   Testing: Use an ohmmeter or continuity checker on the switches. The reading should either be 0 ohms or infinite ohms. Anything in between or erratic behavior is indication of a bad switch or cord.

2. **Attached cordset:** Should the case be opened, the cord goes with the case and therefore no power is present inside the appliance. To get around this for servicing, a 'cheater cord' is needed or in many cases the original can be easily unfastened and used directly.

   Testing: Use an ohmmeter or continuity check to confirm that both wires of the cord are connected to both AC plug and appliance connector. Wiggle the cord where it connects to the appliance and at the plug end as well to see if there might be broken wires inside.

Light bulbs - incandescent and fluorescent

Small incandescent light bulbs are often used in appliances for interior lighting or spot illumination. The common 'appliance bulb' is simply a 'ruggedized' 40 W incandescent light bulb in a clear glass envelope. Other types are found in vacuum cleaners, microwave overs, makeup mirrors, and so forth.

Testing: visual inspection will often reveal a burnt out incandescent light bulb simply because the filament will be broken. If this is not obvious, use an ohmmeter - an infinite resistance means that the bulb is bad.

See the chapter: Incandescent Light Bulbs, Lamps, and Lighting Fixtures for more info.

Small fluorescent lamps are often found in makeup mirrors, plant lights, and battery powered lanterns.

Testing: The best test for a bad fluorescent lamp (tube) is to substitute a known good one. Unfortunately, there is no easy go-no go test for a these as with an incandescent lamp. Other parts of the fixture (like the ballast or starter) could also be bad. Testing with a multimeter between the pair of pins at each end should show low resistance if the lamp is good. However, depending on the type of ballast, a lamp with an open filament may still work just fine even though strictly speaking, it is defective. Again, try a replacement to be sure. **CAUTION:** A defective ballast or starter can cause a fluorescent lamp to go bad in short order - if it still doesn't work, don't just let it continue to try to start!

See the document: Fluorescent Lamps, Ballasts, and Fixtures for additional information.

Indicators - incandescent or neon light bulbs or LEDs

Whereas lighting fixtures using incandescent or fluorescent bulbs are designed to illuminate a room or small area, an indicator is simply there to let you know that an appliance is on or in a specific mode.

There are three common types of electrical indicator lights:

1. **Incandescent bulbs:** Just like their larger cousins, an incandescent indicator or pilot light has a filament that glows yellow or white hot when activated by a usually modest (1.5-28 V) source. Flashlight bulbs are very similar but usually have some mechanical method of keeping the filament positioned reasonably accurately so that the light can be focussed by a reflector or lens. Since the light spectrum of incandescent indicators is quite broad, filters can be used to obtain virtually any colored light. Incandescent indicator lamps do burn out just like 100 W bulbs if run near their rated voltage. However, driving these bulbs at reduced voltage can prolong their life almost indefinitely.

   Incandescent indicator lamps are often removable using a miniature screw, bayonet, or sliding type base. Some are soldered in via wire leads. Others look like cartridge fuses.

   Testing: Visual inspection will often reveal a burnt out incandescent light bulb simply because the filament will be broken. If this is not obvious, use an ohmmeter - an infinite resistance is means that the bulb is bad.

2. **Neon lamps:** These are very common as AC line power indicators because they are easy to operate directly from a high voltage requiring only a high value series resistor.

   They are nearly all the characteristic orange neon color although other colors are possible and there is a nice bright green variety with an internal phosphor coating that can actually provide some illumination as well. While neon bulbs do not often burn out in the same sense as incandescent lamps, they do darken with age and may eventually cease to light reliably so flickering of old Neon bulbs is quite common. This is almost always just due to the natural aging process of the indicator and does **not** mean the outlet or appliance itself is bad.

   Some Neon bulbs come in a miniature bayonet base. Most are soldered directly into the circuit via wire leads.

   Testing: Inspect for a blackened glass envelope. Connect to AC line (careful - dangerous voltage) through a series 100K resistor. If glow is weak or absent, Neon bulb is bad.

3. **Light Emitting Diodes (LEDs):** LEDs come in a variety of colors - red, yellow, and green are very common; blue is now available as are virtually all other colors including white. These run on low voltage (1.7-3 V) and relatively low currents (1-20 mA). Thus, they run cool and are easily controlled by low voltage logic circuits. LEDs have displaced incandescent lamps in virtually all electronic equipment indicators and many appliances. Their lifetime easily exceeds that of any appliance so replacement is rarely needed.

   LEDs are almost always soldered directly into the circuit board since they rarely need replacement.

   As an item of interest which has nothing to do with appliance repair, many automotive tail lights are now red LEDs, particularly the middle brake light. In fact, the red (stop) lights in many traffic signals are now LED clusters that screw directly into a normal 115 VAC socket. This is done because one of these will outlast 50 normal incandescent lamps and the cost of replacement far exceeds the cost of the lamp itself. How can you tell which type is used? Easy, move your eyes (or head) from side-to-side while looking at the red light; since the LED actually pulses 120 times per second (for 60 Hz power), you will see a series of spots - an incandescent lamp will appear continuous. Yellow and green will probably follow shortly but all I've seen so far are the red ones using LEDs.

Testing: Use a multimeter on the diode test scale. An LED will have a forward voltage drop of between 1.7 and 3 V. If 0 or open, the LED is bad. However, note: some DMMs may not produce enough voltage on the diode test scale so the following is recommended: Alternative: Use a 6 to 9 V DC supply in series with a 470 ohm resistor. LED should light if the supply's positive output is on the LED's anode. If in doubt, try both ways, If the LED does not light in either direction, it is bad.

4. **Electroluminescent (EL) panels (sometimes used in night lights):** These produce a cool soft light (usually bluish-greenish) consuming very little power (well they don't produce all that much light, either!). A thin layer of non-conducting light emitting material is sandwiched between a pair of electrodes, one of which is transparent or translucent. They can be virtually any size though a typical night light might be 2 x 2-1/2 inches or so. The device is basically a capacitor that emits light when an AC voltage (typically 115 VAC) is applied to its plates. There may be some additional components like a current limiting resistor in series and an MOV or other surge suppressor across the actual EL device (particularly on units designed to operate on 220/240 VAC.

   Testing: Check for bad connections and bad components with a multimeter. An open series resistor, shorted EL device, or faulty (partially shorted) MOV is possible. However, sometimes these failures won't show up except when normal voltage is applied. Measure on the AC volts range across the EL device - there should be a high AC reading, probably over 100 VAC.

Heating elements - NiChrome coils or ribbon, Calrod, Quartz

All heating elements perform the same function: convert electricity into heat. In this they have one other characteristic in common: they are all nearly 100% efficient. The only electrical energy which does not result in heat is the slight amount of light (usually red-orange) that is produced by a hot element.

There are 3 basic types of heating elements. Nearly every appliance on the face of the planet will use one of these:

1. **NiChrome coil or ribbon:** NiChrome is an alloy of Nickel and Chromium which has several nice properties for use in heating appliances - First, it has a modest resistance and is thus perfect for use in resistance heating elements. It is easily worked, is ductile, and is easily formed into coils of any shape and size. NiChrome has a relatively high melting point and will pretty much retain its original shape and most importantly, it does not oxidize or deteriorate in air at temperatures up through the orange-yellow heat range.

   NiChrome coils are used in many appliances including toasters, convection heaters, blow-dryers, waffle irons and clothes dryers.

   The main disadvantage for our purposes is that it is usually not possible to solder this material due to the heating nature of its application. Therefore, mechanical - crimp or screw must be used to join NiChrome wire or ribbon to another wire or terminal. The technique used in the original construction is may be spot welding which is quick and reliable but generally beyond our capabilities.

   Testing: Visual inspection should reveal any broken coil or ribbon. If inspection is difficult, use a multimeter on the low ohms scale. Check for both shorts to the metal chassis as well as an open element (infinite ohms).

2. **Calrod(tm) sealed element:** This encloses a fine coiled NiChrome wires in a ceramic filler-binder inside a tough

metal overcoat in the form of a shaped rod with thick wire leads or screw or plug-in terminals.

These are found in toaster oven/broilers, hot plates, coffee makers, crock pots and slow cookers, electric range surface elements, conventional and convection ovens and broilers.

Testing: When these fail, it is often spectacular as there is a good chance that the internal NiChrome element will short to the outer casing, short out, and melt. If there is no visible damage but the element does not work, a quick check with an ohmmeter should reveal an open element or one that is shorted to the outer casing.

3. **Quarts incandescent tube:** These are essentially tubular high power incandescent lamps, usually made with a quartz envelope and thus their name.

   These are found in various kinds of radiant heaters. By running a less than maximum power - more orange heat - the peak radiation is in the infra-red rather than visible range.

   Testing: Look for a broken filament. Test with an ohmmeter just like an incandescent light bulb.

Repair of broken heating elements

In appliances like waffle irons and toaster ovens, these are usually welded. This is necessary to withstand the high temperatures and it is cheap and reliable as well. Welding is not normally an option for the doit yourselfer. However, if you are somewhat suicidal, see the section: Improving sensitivity of garage door openers receivers for a more drastic approach.

I have used nuts and bolts, say 6-32, bolt, wire, washer, wire, washer, lockwasher, nut. Depending on how close to the actual really hot element it is, this may work. If you are connecting to the coiled element, leave a straight section near the joint - it won't get as hot.

The use of high temperature solder or brazing might also work.

The best approach is probably to use high temperature crimp connectors:

(The following from: sad@garcia.efn.org (Stephen Dunbar))

You can connect heating element wires with high-temperature solderless connectors that are crimped onto the wires. Be sure to get the special high-temp connectors; the ordinary kind will rapidly oxidize and fall apart at high temperatures. If you want to join two wires to each other, you'll need either a butt splice connector (joins the wires end-to-end) or a parallel splice connector (the wires go into the connector side-by-side). To fasten a wire to a screw terminal you can use a ring or spade connector (though as noted above, a screw, nut, and washer(s) should work fine --- sam). If your waffle iron has quick disconnect terminals you'll need the opposite gender disconnect (AkA Faston). These come in both .187" and .250" widths.

Your best bet for getting these connectors in small quantity is probably a local appliance parts outlet that caters to do-it-yourselfers. If you can't find what you need there, try Newark Electronics (branches all over the place). I have an old copy of their catalog which lists SPC Technology Voltrex Brand High Temperature Barrel Terminals in several styles: ring, spade, disconnect, and butt splice. The prices were around $10 to $12 per 100 (this catalog is a couple of years old) for wires in the 22-18 or 16-14AWG size ranges, almost twice that for the heftier wire gauges. (Be sure to determine the wire gauge of your heating elements so you can get the right size terminal.)

You can spend a *lot* of money on crimp tools, but for occasional light use you can probably get by with one of those $10 gadgets that crimp, strip & cut wires, and cut bolts--the sort of thing you'd find in your local home center or Radio Shack.

(From: Nigel Cook (diverse@tcp.co.uk).)

The thin stainless steel strip found spot welded to multicell NiCd batteries make good crimps for joining breaks in heater resistance wire. Form a small length of this strip around a needle or something similar to make a tight spiral with enough clearance to go over doubled-up heater wire. Abraid or file the cut ends of the broken wire. Crimp into place with a double lever action crimper. If there is an area of brittle heating element around the break then cut out and splice in a replacement section with two such crimps. Such a repair to my hot-air paint stripper (indispensable tool in my electronics tool-kit) has survived at least 50 hours.

(From: Dan Sternberg (steberg@erols.com).)

Another old trick for nichrome repair is to make a paste of Borax, twist the two broken end together, and energize the circuit. A form of bond welding takes place. I've have used this on electric clothes dryer heater elements with good luck.

Solenoids - small and large

Solenoids are actuators operated by electromagnets that are used to operate valves, slide or engage various parts, eject or prevent opening of a door, and other functions. While shapes and sizes may vary, all electrically operated solenoids use an electromagnet - AC or DC - to pull on a movable piece called an armature which generally moves back and forth but rotary motion is also possible.

Solenoids are usually two position devices - they are not used to provide intermediate amounts of force or travel like motors.

Sizes ranges from small 1/2" long units providing a fraction of an ounce of force and 1/8" travel to large 3" long units providing many pounds of force with travels of 2" or more.

Testing: Inspect for free movement. Use an ohmmeter to confirm that the coil is intact. There could be other problems like shorted turns in the coil but these would be less common than lack of lubrication or an open coil. Check voltage on operating solenoid to determine whether drive power is present.

Small electronic components - resistors, capacitors, diodes

A variety of small electronic components may be found in appliances though unlike true electronic equipment, these do not usually run the show.

- **Resistors** may be used in various ways to adjust the current flowing in part of a circuit. Many different types of resistors are possible - tiny carbon or metal film types looking like small cylindrical objects often with colored bands which indicate the value.

- **Power resistors** are larger cylindrical or rectangular shaped devices which are often ceramic coated. These may get quite hot during operation. Their resistance value and power rating are usually printed on the resistor.

- **Capacitors** come in a variety of shapes and sizes. Some may look like disks, jelly beans, cylinders, boxes, etc. Their value is often marked in uF, nF, or pF.

- **Diodes or rectifiers** are solid state devices that permit electric current to only flow in one direction (positive current in the direction of the arrow when marked this way). These are most often used in appliances to change AC to DC or to cut the power to a motor or heater (by allowing only half of the AC current to pass).

For more information on these types of components, see any good introductory electronics text.

Transformers - low voltage, high voltage

A transformer consists of a laminated iron or ferrite core and 2 or more insulated windings that are most often not connected to each other directly. If one set of windings is used as the input for AC power or an audio signal (the 'primary' winding), the voltage appearing on each of the other windings (the 'secondary' winding(s)) will be related by the ratio of the number of turns on each of the windings. However, you don't get something for nothing: The current is related by the inverse of this ratio so the power doesn't change (except due to unavoidable losses).

Transformers are used in nearly every type of electronic equipment both for power and signals, and throughout the electrical distribution network to optimize the voltage/current used on each leg of the journey from the power plant to the user.

The types we are interested in with respect to household appliances and power tools are most often use to convert the AC line voltage to some other value, lower or higher:

1. **Low voltage power transformers** are found in AC wall adapters and electronic equipment as part of their power supplies to generate 1 or more DC voltages to run the device, recharge its batteries, etc. Their outputs are typically between 2 and 48 VAC but almost any other value is possible.

2. **High voltage power transformers** are found in microwave ovens, old TVs and audio equipment based on vacuum tubes, oil burner ignitions, and some neon signs. Their output can go as high as 15,000 V or more.

3. **Flyback (or LOPT), inverter, and other more specialized transformers** are driven by a high frequency oscillator or chopper in various equipment like TVs and monitors (HV, LV, and other power supplies), PCs and some of their peripherals, electronic flash units. Note that these will NOT operate from the AC line directly and are therefore useless unless driven by a proper electronic circuit.

There are also a couple of other common types of AC line operated transformers used in servicing:

4. **Isolation transformers** are wound 1:1 so that the output voltage is the same as the input voltage. However, with no direct connection between windings, equipment can be tested with less risk of shock.

5. **Variable transformers (or "Variacs", which is one brand name)** allow the output voltage to be adjusted between 0 and full (or slightly above) line voltage which is useful for testing purposes where the behavior of a piece of equipment is being determined. Some very old light dimmers may use this technology as well (newer ones use solid state phase control. See the sections starting with: Dimmer switches and light dimmers.)

See the document: Troubleshooting and Repair of Consumer Electronic Equipment for more information on these types of transformers.

Motors - universal, induction, DC, timing

A large part of the functionality of modern appliances is based on the use of motors of one form or another. We devote an entire chapter to motors. The following is just an introduction.

Motors come in all shapes and sizes but most found in small appliances can be classified into 5 groups:

1. Universal motors.
2. Single-phase induction motors.
3. Shaded pole induction motors.

4. Small permanent magnet DC motors. Synchronous timing motors.

See the chapter: Motors 101 for more detailed information on the common types of motors found in small appliances.

Fans and Blowers - bladed or centrifugal

The entire purpose of a particular appliance may be to move air or this may simply be needed for cooling. Obviously, portable and window fans are an example of the former. However, many appliances have built in fans you may not even be aware of as part of the motor(s) or other rotating components.

There are two primary types of configurations:

1. **Bladed fans:** We are all familiar with the common desk or window fan. This uses a set of rotating blades - typically 3-5 to gather and direct air. In the specific case of an oscillating desk fan, a gear drive linked to the motor also permits the general direction of air movement to be controlled in a back-and-forth motion. I recently saw one where in addition to moving back and forth, the front grille can be set to rotate at an adjustable rate providing more variation in air flow.

   The direction of the air movement with respect to blade rotation is determined by the pitch - the tilt - of the blades. Although reversing air direction is possible by reversing the motor, one direction is usually more effective than the other due to the curve of the blades.

2. **Centrifugal blowers:** These use a structure that looks similar to a squirrel cage to suck air from the center and direct it out a plenum formed around the blower. While these may be found in all sizes, the most common household application is in the vacuum cleaner. Large versions of these blowers are used in central heating and airconditioning systems, window air conditioners, and oil burners.

   Direction of rotation of the blower motor does not change the direction of airflow. However, one direction will be more effective than the other (where the blower is rotating in the same direction as the way exit port on the air plenum points. Because of this, it is not possible for a vacuum cleaner to blow out the suction hose due to a reversed motor (which in itself is for all intents and purposes, impossible as well). This is usually caused by back flow due to a blockage.

Bearings and bushings

The shafts of rotating parts normally are mounted in such a way that friction is minimized - to the extent needed for the application. A bearing is any such joint with more specific terms used to describe the typical types found in small appliances - or lawnmower, automobile engines, or 100 MW turbines.

- **Plain bearings** consist of an outer sleeve called a bushing in which a polished shaft rotates. The bushing may be made of a metal like brass or bronze or a plastic material like Teflon(tm). The shaft is usually made of steel though other materials may be found depending on the particular needs. Where a metal bushing is used, there must be means provided for lubrication. This may take the form of oiling grooves or holes and an oil reservoir (usually a saturated wad of felt) or the bushing itself may be sintered. Metal particles are compressed at high temperature and pressure resulting in a very porous but strong material which retains the lubricating oil.

  Under normal conditions, a plain bearing wears only during start and stop cycles. While the shaft is rotating at any reasonable speed, there is no metal to metal contact and thus no wear. With a properly designed and maintained bearing of this type, a very thin oil film entirely supports the shaft - thus the importance of clean oil. Your automobile engine's crankshaft is entirely supported by these types of bearings.

Eventually, even 'lubricated for life' bearings of this type may need to be disassembled, cleaned, and lubricated. The plain bearings in small appliances must be lubricated using a proper light oil like electric motor or machine oil - not automotive engine oil and NEVER NEVER WD40.

NEVER, ever, use WD40 as a lubricant (unless specifically recommended by the manufacturer of the equipment, that is)! WD40 is not a good lubricant despite the claims on the label. Legend has it that the WD actually is an abbreviation for Water Displacer - which is one of the functions of WD40 when used to coat tools. WD40 is much too thin to do any good as a general lubricant and will quickly collect dirt and dry up. It is also quite flammable and a pretty good solvent - there is no telling what will be affected by this.

WD40 has its uses but lubrication unless specifically recommended by the manufacturer (of the equipment, that is) is not one of them. Results initially may be good with that instant gratification that comes from something returning to life. However, the lighter fractions of WD40 evaporate in a few days

For very small metal-in-plastic types, the following might be useful:

(From: Frank MacLachlan (fpm@bach.n2.net).)

> "I've had good luck with a spray lubricant called SuperLube. It contains a solvent which evaporates and leaves a Teflon film which doesn't migrate or retain dust. I spray some into a spray paint cap and then apply the solution with a toothpick, allowing the lubricant to wick into the bearing areas. Worked great for some balky Logitech mice I purchased at a local swap meet."

- **Frictionless bearings** are usually of the ball or roller variety. An inner ring called a race rotates supported by a series of balls or rollers inside an outer race. There is virtually no friction even at stand-still with these bearings. However, rolling metal to metal contact is maintained at all speeds so they are not quite as wear free as a properly maintained and constantly rotating plain bearing. However, for all practical purposes in small appliances, these will last a long time and are rarely a problem.

  Sometimes, reworking an appliance to use a ball bearing instead of a plain bearing is a worthwhile effort - I have done this with electric drills and shop vacs. They run smoother and quieter with ball bearings. Not surprisingly, higher-end models of these devices (which use ball bearings) share parts with the cheaper versions and finding standard ball bearings that would fit was not difficult.

Mechanical controllers - timing motors and cam switches

While these are not that common on small appliances, they may be present in washing machines, dryers, dishwashers. and refrigerator defrost timers. They in themselves may be considered small appliances - and often can be repaired or replaced easily.

Most of these are just small timing motors (synchronous motors running off of the AC line) which rotate one or more cams (disks with bumps) which activated one or more switches at appropriate times during the rotation cycle. Typical cycle times range from a minute or less to several hours (refrigerator defrost timer). Most like washing machine timers are in the 1 hour range. Sometimes, the motor is stopped during certain portions of the cycle awaiting completion of some other operation (i.e., fill).

These controllers therefore consist of several parts:

- **Timing motor:** A very small synchronous AC line operated motor with an integral gear train is most common. Sometimes, the rotor and geartrain are in a sealed, easily replaceable unit - a little metal case that clamps within the pole pieces of the AC field magnet. In other cases, it is a separate motor assembly or an integral part of the overall timer mechanism.

- **Escapement (not present on all types):** This is a device which converts the continuous rotation of the timing motor to a rapid movement for each incremental cam position. A common type is a movement every 45 seconds to the next position. This assures that the make or break action of the switches is rapid minimizing arcing.

- **Cam(s):** One or more cams made of fiber composite, plastic, or metal, are rotated on a common shaft. There will be one set of switch contacts for each circuit that needs to be controlled.

- **Switches:** These will either be exposed sets of contacts or enclosed 'microswitches' which are operated by the cams.

Testing: If the controller is not working at all, check for power to the motor. Listen for the sound of the motor parts rotating. Check for gummed up lubrication or broken parts.

If some of the circuits do not work, check the switches for dirty or worn contacts or broken parts.

Electronic controllers - simple delay or microprocessor based

These can range from a simple R-C (resistance-capacitance) circuit to provide the time delay in a toaster to sophisticated microprocessor based systems for programming of a coffee maker or microwave oven.

While generally quite reliable, bad solder connections are always a possibility as well as failed parts due to operation in an environment prone to temperature extremes.

Testing: Check for bad solder connections and connectors that need to be cleaned and reseated. Inspect for obviously broken or burned parts. Test components for proper value.

For digital clock/programmers or microprocessor based controllers, not much else can be done without a schematic - which not likely to be easily available.

Batteries - Alkaline, Lithium, Nickel-Cadmium, Lead-Acid

More and more small appliances and power tools are cutting their cords and going to battery power. Although there are a large number of battery types, the most common for power applications (as opposed to hearing aids, for example) are:

- **Alkaline:** Primary (non-rechargeable, for the most part), long shelf life, high energy density.

- **Lithium:** Primary and secondary (rechargeable) available though most appliance applications (which are just beginning to develop) are not rechargeable. Long shelf life, very high energy density. Still quite expensive.

- **Nickel Cadmium:** Most common rechargeable technology in cordless appliances and power tools. However, relatively fast self discharge and on about half the capacity of a similar sized Alkaline. Now being replaced for higher performance applications with Nickel-Metal-Hydride (NiMH). **CAUTION** NiMH batteries generally require a different type charger or else they will rapidly fail. Thus, you can't just pop a set of NiMH cells into your old Dustbuster!

- **Lead-Acid:** Secondary type similar to the battery in your automobile but packaged in a totally sealed container which is virtually indestructible and leakproof. Medium self discharge rate but will deteriorate if left discharged for an extended period of time.

See the document: Notes on the Troubleshooting and Repair of AC Adapters, Power Supplies, and Battery Packs, and Other Related Information for more details.

AC adapters and chargers - wall 'warts' with AC or DC outputs

These wall adapters are used to power many small electronic devices and appliances directly and/or to recharge their batteries. They usually plug directly into the wall socket and convert the 115 VAC (U.S.) to a lower voltage - 3 V to 24 V AC or DC typical. More sophisticated units may actually be a switching power supply with smart electronic control of battery charging and power management. The following are typical types:

- **AC output:** 3 to 24 VAC (or more) at 50 mA to 3 A. The only internal component is a power transformer which may include a thermal or ordinary fuse for protection.

- **DC output:** 3 to 24 VDC (or more, under load) at 50 mA to 1.5 A. In addition to the power transformer, there is a rectifier, filter capacitor, and possibly a three terminal IC regulator (not that common). Some type of protection will probably be built in as well.

- **Universal/switching power supply:** Typically 6 to 18 VDC at .5 to 3 A. These will usually operate off of any voltage input from 90 to 240 VAC (or DC) and provide a well regulator output. There will generally be an internal fuse as well as overvoltage and overcurrent protection.

In some cases, a single adapter will put out multiple voltages. See the document: Notes on the Troubleshooting and Repair of AC Adapters, Power Supplies, and Battery Packs, and Other Related Information for more details.

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AC Line and Battery Powered Household Appliances

Table lamps

This is the most popular type of lighting for reading or general illumination. The type described in this section takes normal 115 VAC light bulbs.

The common table lamp is just a light duty cordset, switch, and sockets for one or more incandescent light bulbs. In many cases, the switch and socket are combined into one assembly. In other designs, particularly where more than one bulb can be lit independently (for example, a large bulb up top and a night light in the base), a separate switch (rotary or push-push) selects the light bulb(s) to be turned on.

For the most common combined switch and socket, there are several varieties and these are all generally interchangeable. Therefore, if you want to take advantage of the added convenience of a 3-way bulb allowing low, medium, and high illumination, it is a simple matter to replace the simple on-off switch in your lamp with a 3-way switch (not to be confused with the 3-way switches used in house wiring to control a single light fixture from 2 places).

- Wire color coding: Brass screw is AC line Hot, Silver is Neutral.

Virtually the same switch/socket combo is used where there is a bulb in the top and the base. But instead of switching the extra contact inside a 3-way socket, that terminal goes to the bottom lamp holder.

- Wire color coding: Brass screw is AC line Hot, Silver is Neutral and is also connected to the outer shell of the bottom lampholder, Black goes to the centter of the bottom lampholder.

Push-push, pull chain, and rotary switches are common for simple on-off control. The 3-way switches are usually of the rotary variety with off-low-medium-high selected as the knob is rotated. The 3-way bulb has two filaments which can be switched on individually or in combination to provide the 3 levels of illumination.

Dimmer sockets can often be substituted for the normal kind as long as conventional incandescent bulbs (and not compact fluorescents) are to be used.

Touch and even sound activated switch-sockets are also available though my personal recommendation is to stay away from them.

Most common problems: burned out bulb, worn switch, bad plug or cord. Where the light flickers, particularly if jiggling or tapping on the switch has an effect, a bad switch is almost always the problem. Switch failure is more common when using high wattage bulbs but can occur just due to normal wear and tear.

Replacements for most common switches and sockets are readily available at large hardware stores, home centers, and electrical supply houses. It is best to take along the old switch so that an exact match (if desired) can be obtained. While the thread sizes for the screw on socket shells are quite standard, some older lamps may have an unusual size. For more complicated switches with multiple sockets, label or otherwise record the wiring. If color coded, cut the wires so that the colors are retained at both the lamp and switch ends.

Rebuilding a basic table lamp

As noted in the Introduction, virtually any table lamp can be restored to like-new electrical condition for a few dollars at most. The following is the detailed procedure for the majority of common table lamps found in the U.S.

This is assumed to be the type of lamp which has a combination socket and switch with a metal (brass-colored usually) outer shell. It is your decision as to whether a simple on-off switch or a 3-way type is to be used - they are usually interchangeable and a normal light bulb can be put into a 3-way socket (two clicks of the knob will be needed to switch a normal light bulb on or off, however). You can also put a 3-way bulb into a normal socket but you will, of course, only get one level of illumination (medium). For lamps with lighted bases, also see the section: Lamps with night-light bulbs in their base.

You will need: (1) a new socket/switch of the appropriate type and (2) a new cordset (if you want to replace this as well). A polarized type plug is desirable to minimize the possibility of shock when changing bulbs. A medium size straight blade screwdriver and wire strippers are the only required tools.

- First, unplug the lamp!!!

- Rremove and set aside any shade, frosted chimney, and other cosmetic attachments.

- Examining the metal shell, you will note that it is in two pieces. If you look carefully, there will probably be indications of where firmly pressing the top portion will allow it to be separated from the bottom part mounted on the lamp. These are usually near where the knob, button, or chain, enters the switch. Sometimes, a fine screwdriver blade will be useful to gently pry the two halves apart.

- With the top part removed, unscrew and disconnect two wires and remove the switch. If desired, loosen the set screw (if any) and unscrew the bottom portion of the shell. If you are simply replacing the switch, at this point you would just attach the new one and reassemble in reverse order. Screw on the bottom of the new switch enough so that it is either tight or until the threads are fully engaged but not pressing on or protruding above the cardboard insulating disk in the bottom half of the shell. If the entire assembly is still loose, it should be possible to tighten hardware on the bottom of the lamp to secure it against rotation. Note: it is important to do this to avoid eventual damage to the wires should the switch move around significantly during normal use.

- To replace the cordset, you may need to partially remove any felt pad that may be glued to the base of the lamp. Sometimes, it is possible to cut off the old plug, attach the new cord to the end of these wires, and pull it through. However, in most cases, there will be a knot or other strain relief in the original cord which will make this impossible (and you will want to replicate this in the replacement as well). Therefore, if needed, carefully peel back the felt pad only enough to gain access to the interior. In some cases, just cutting a small X in the center will allow sufficient access and this can be easily patched with a piece of cloth tape.

- Install the new cord in exactly the same way as the original with a knot for a strain relief if needed. If there was no strain relief to begin with, adding a knot is a good idea if there is space for one in the base. Snake the cord through to the top of the lamp.

- Strip the ends of the wires to a length of about 1/2 inch and twist the strands tightly together in a clockwise direction. If you are using a cordset with a polarized plug, identify the wire attached to the wide prong (with a continuity checker or ohmmeter if it is not clearly marked by a stripe on the insulation) and connect it to the silver colored screw. Connect the wire attached to the narrow prong to the brass colored screw. Always wrap in a clockwise direction. See the section: Attaching wires to screw terminals.

- Confirm that there are no loose wire strands and that the insulation is nearly flush with the screw to avoid possible shorts. Pop the shell top with its insulating cardboard sleeve over the switch and press firmly onto the base. There should be a very distinct click as it locks in place.

- If needed, adjust the strain relief at the base of the lamp so that pulling on the cord does not apply any tension to the wires attached to the switch. Tighten the nut in the base of the lamp holding the entire assembly in place if the socket is still loose and rotates easily. Don't overdo it - the supporting structure is often just a glass jar or something similar. Put a drop of Loctite, nail polish, Duco cement, or something similar - or a second nut - on the threads to prevent the nut from loosening. Use some household cement to reattach the felt pad you peeled back earlier.

Lamps with night-light bulbs in their base

These are the types of lamps where either the normal bulb on top or a smaller one in the base (or both) can be turned on using a turn-key or pull-chain.

This is a standard, if somewhat unusual socket. It is basically the same as a 3-way type but with the extra connection going to the bulb in the base of the lamp. In the old days when sockets were assembled with screws instead of rivets, it might have been possible to modify a new 3-way socket to provide the extra connection.

An electrical supply parts distributor or lamp store should have what you need or be able to order it for you.

Take note of the connections as you remove the old socket to avoid mistakes. When routing the wires to the bulb in the base, avoid allowing the hot bulb from contacting the insulation - the plastic stuff might melt (for a 7 W or less wattage bulb and high temperature insulation is probably not an issue, however).

What causes a lamp to flicker?

Many things can cause the light bulb in a table lamp to flicker:

- Loose bulb(s). :-)

- Squashed center contact in socket. With the plug pulled or power off, use a small flat blade screwdriver of similar tool to gently bend the center metal piece so it is raised from the base (at about a 20 or 30 degree angle).

Then, DON'T tighten the bulbs down all the way - just so they are a snug fit in the socket.

- Bad switch. These do wear out particularly if multiple high wattage bulbs are being used. If gently jiggling the switch results in flickering this is the most likely cause.

- Bad connections. These could be anywhere but the most likely locations (where only a single lamp is involved) would be either at the screw terminals on the switch or from a plug that isn't making secure contact in the outlet - check it.

- Voltage fluctuations. Occasional flickering when high wattage appliances kick in is not unusual especially if they are on the same branch circuit but could also be a symptom of other electrical problems like a loose Neutral connection - see the section: Bad Neutral connections and flickering lights or worse.

  If a dimmer control is present, keep in mind that these are somewhat more sensitive to slight voltage fluctuations especially when set at low levels. You may simply not have noticed any flickering with a normal on/off switch.

High intensity lamps

These include several types but they all use a transformer to reduce the 115 VAC to something lower like 12-24 V.

Tensor(tm) (and their clones) high intensity lamps have been around for over 30 years and are essentially unchanged today. They use a low voltage transformer producing 12-24 VAC along with a special high output light bulb that looks similar to an automotive tail light. However, it uses substantially more current for the same voltage and puts out a much more intense, whiter light. These are not halogen lamps though their spectral characteristics are similar since the filaments run hotter than normal incandescents - and have shorter lives.

Some will have multiple levels of illumination based on selecting taps on the transformer. Normal dimmers may not work (and should not be used) with these due to their transformer design - damage to the dimmer or lamp may result and this may be a fire hazard.

Problems with Tensor lamps tend to center around the socket and switch. These may fail due to overheating as a result of the high temperature and high current operation. Replacements are available but they may take some effort to locate. A replacement lamp may be cheaper. (I often find complete Tensor lamps in perfect operating condition at garage sales for around $2.

Halogen lamps and fixtures

Halogen lamps share many of the design characteristics of high intensity lamps in that they are designed for local high intensity lighting and use a transformer usually (though some may use solid state voltage conversion instead). While some halogen lamps come with dimmers, some of the advantages of the halogen cycle are lost if the bulbs are not run at full power. The worst case is where they are operated just below full power - too cool for the halogen cycle to take place but hot enough for substantial filament evaporation to occur.

Should the dimmer portion of such a fixture fail or become unreliable, it may a blessing in disguise since the lamp will either run at full intensity or can be easily rewired to do so by bypassing the electronics and just using the on/off switch!

WARNING: halogen bulbs run extremely hot and are a serious fire hazard and burn hazard if not properly enclosed. When changing a halogen bulb, wait ample time for the old one to cool or use an insulated non-flammable glove or pad to remove it. When installing the new bulb, make sure power is off, and do not touch it with your fingers - use a clean cloth or fresh paper towel. If you do accidentally touch it, clean with alcohol. Otherwise, finger oils may etch the quartz and result in early - possibly explosive failure - due to weakening of the quartz envelope.

Safety guidelines for use of halogen lamps

These guidelines were prompted by a number of fires including some fatalities that have been linked to improper use of halogen lamps - in particular the high power torchiere variety of floor lamps. However, the guidelines apply to many other types of halogen lamps including work-lights, desk lamps, slide and overhead projectors, and other lamps or fixtures where the bulb is not entirely enclosed and thermally insulated from the exterior.

(Source: The Associate Press except as noted).

Safety groups recommend the following precautions for owners of halogen torchere lamps with tubular bulbs:

- Place the lamps where they cannot be tipped over by children, pets, or strong drafts (away from open windows, for example).
- Never use halogen lamps in children's bedrooms or playrooms where combustible objects like stuffed toys may be accidentally placed on top of or next to them.
- Never use a replacement bulb of a higher wattage or of a different type than specified by the manufacturer. Avoid bulbs larger than 300 W.
- Never attempt to replace or discard a bulb that is too hot to touch.

  Do not touch the new bulb with your fingers as the oils and acids may make them more prone to exploding. Clean the bulb thoroughly with isopropyl alcohol after any accidental contact (--- sam).
- Never drape cloth over the lamp.
- Operate the lamps at less than maximum wattage on a dimmer whenever possible.

  Note that this may not result in maximum life but will be safer due to the lower temperature of the bulb (--- sam).
- Keep lamps away from elevated beds like bunk beds where the bedding may get too close to the bulb.
- Never use unprotected halogen lamps in locations like bathrooms where water may splash resulting in the bulb exploding (--- sam).
- Never operate lamps with their thermal or UV shields removed (--- sam).

Bad connections in halogen lamps

(From: Norbert Koot (norbert@ican.net).)

- Dimmable 120V household halogen lamps that make popping noises as they are turned on, and have light output that is not smooth. This appears to be common with the less expensive "torchiere" type floor lamps with straight tube bulbs as a result of poor or deteriorating contacts at the bulb ends.
- Replacement bulbs for the same lamps have recessed contacts, that may be recessed too far for the original contact to reach.

I have used the same technique to fix both these problems: with a medium power soldering iron, simply tin the contact. Then before it cools, hold a center punch in the molten solder to make a cup shape of sorts. This keeps the bulb secure in the spring-loaded lamp contacts.

Touch lamp problems

Personally, I think touch lamps are one of the dumber uses of technology to appear on this planet but that is just my opinion. :-)

These are susceptible to damage from voltage surges or just plain old random failures. In addition, the current surge that often results at the instant an incandescent bulb burns out (the bright flash) may blow the thyristor in the electronics module.

If the lamp is stuck on, the thyristor is probably shorted. The specific part can be replaced but to be sure it is bad, some testing will be needed and it is probably soldered in place. However, if you have repaired an ordinary lamp, you will be able to replace the entire module fairly easily.

If the lamp is stuck off, there could be a bad connection or bad bulb, or the electronics module is defective. Again, replacement is straightforward.

Erratic problems could be due to bad connections, dried up electrolytic capacitors (especially if the electronics module is near the hot bulb), or even external E/M interference (e.g., a dimmer or vacuum cleaner on the same circuit).

Some problems are of the following type:

> "I have 2 touch lamps in the bed room and they are both plugged in to the same receptacle. Every once in a while the lamps come on by themselves for no apparent reason. Even more strange is that every so often just one lamp turns on by itself."

(From: Tim Moore (tmoore@interserf.net).)

These use a MOSFET type circuit to switch the lamps on and off. The circuit is attached to the metal in the lamp base. When you touch it the impedance changes ever so minutely but enough to change the MOSFET from off to on and visa versa. My wife could never get our lamps to switch, she often had to blow on her hand first to get it moist so it would make better contact. Here is part of the problem. It takes a certain amount of signal from the lamp base to switch the circuit. Electronic parts all have acceptable ranges of operation and when put into identical circuits they sometimes perform differently. One circuit might need a good hard touch while the other might need only a slight touch. Power surges would often switch one of my lamps, although it didn't happen often. A strong radio signal could do it too. The bottom line is that these lamps are not rocket science and can't be counted on as 100% reliable. Sorry, that's the truth. You give up a little to get the convenience of just having to touch them. I ended up removing mine - an electrical storm wiped one out and wiped the other out a few years later.

Touch lamps and RF interference

While many people swear by touch lamps, nearly as many swear at them since in addition to frequent failures (bulb burn-outs killing the triac, for example), they can also be tempermental, cycling through their brightness settings and/or turning on or off due to static electricity, power line transients causing RFI, and stray pickup from the local ham rig.

(Portions from: John Evans - N0HJ (jaevans@codenet.net).)

Here is a fix my buddy, Ed, a fellow ham radio operator, has come up with to solve this problem.

As usual it took 8 months and 10 minutes to fix.

Two parts: 1/4 watt, 1k Ohm resistor and 2.5 mH 1/2 watt size molded coil. Connect in-line with the touch wire.

I send 2 or more watts from my rig. My son works the CB.

You'll find it on when you get home.

So the darn thing is an oscillator which changes frequency when you touch it. The circuit does the rest. By adding the resistor/inductor pair, its sensitivity is reduced and the problem disappears.

One more thing: (Most important!), you won't hear interference FROM the oscillator in the lamp anymore on your radio.

And don't open up the module inside the lamp base, you are wasting your time there, and adding more work to glue the module back together.

Just Choke off the sense wire with the resistor and 2.5 mH choke. You'll be fine.

Incandescent fixtures

A fixture is normally permanently mounted to a wall or ceiling. However, aside from not usually having a plug - being directly wired - they are similar to table lamps in what is inside.

There will be one or more sockets for light bulbs - often all wired in parallel so that all the bulbs come on at the same time. For wall fixtures, there may be a switch on the fixture though most often the switch is mounted on the wall elsewhere.

Unlike table lamps where most of the heat rises from the bulb away from the socket, mounting the sockets horizontally or inverted (base up) can result in substantial heating and eventual deterioration of the socket and wiring. Common problems relate to this type of problem - bad connections or brittle wire insulation. Replacement parts are generally available at home centers and electrical supply houses. Just make sure to kill power before working on any fixture wired into your house's electrical system!

Removing the base of a broken light bulb

Turn off power and double check! Wear safety goggles to protect against flying bits of glass.

Then use a pair of needlenose pliers or any other tool that will grip what is left of the base to twist it free. A piece of a raw potato may even work!

Locating burnt out bulbs in series circuits

Christmas and other decorative lights are constructed as series strings of low voltage light bulbs as shown below:

```
                          Bulbs
    Male o------O----O----O----O----O----O----O----O---+
    Plug                                               |
         o---------------------------------------------+
```

Or the following which permits several strings to be connected end-to-end:

```
          +----------------------------------------------+
          |             Bulbs                            |
    Male o--+---O----O----O----O----O----O----O----O---+  +--o Female
    Plug                                               |       Socket
         o---------------------------------------------+-----o
```

Many variations on these are possible including multiple interleaved series strings. One of the bulbs in each circuit may be a flasher. All newer light sets must include a fuse as well.

In a series connected circuit, if one bulb burns out, all lights go out. The newer types include a device in each bulb which is supposed to mechanically short out that bulb if it burns out. However, these don't always work or you may have a set that doesn't have this feature.

The following assumes a single series circuit - large light sets (e.g., perhaps 50 or more) will have multiple series strings so you will have to identify the particular circuit that is bad. If more than one bulb is burnt out, this may further complicate matters.

To locate a burnt out bulb in a series string, you can use the binary search approach: pull a bulb in the middle of the string. Test the bulb and between the power cord end and the middle for low resistance. If these are ok, you know the bad bulb is in the other half. Then divide the 'bad' portion in half and test one half of it and so forth. For example, using this technique, you will need to make at most 6 sets of measurements to locate a bad bulb in a 50 light set.

Sears, K-Mart, Radio Shack, among others sell inexpensive testers (e.g., Lite-Tester Plus, about $4). These detect the electric field generated by the (now floating) wire on the Hot side of the gap of the burnt out filament. These will also locate open wires and blown fuses in the same manner.

I have also heard of bulb sets in which the individual bulbs are gas filled in such a way that if the filament breaks, current flows across the gap through the gas resulting in a faint glow in the burnt out bulb. I don't know if these things still exist.

WARNING: Do not be tempted to bypass a bad bulb with a wire. This will reduce the total resistance and increase the current to the remaining lamps shortening their life. Replace a few bulbs and the entire string will pop. This is a serious safety hazard especially on older light sets that may not have internal fuses. Also, some fuses look like lamps - replace only with an identical fuse - not with a lamp!

Comments on Christmas tree bulb/string repair

Original type of problem: No light but fuses are good and no obvious damage.

(From: Ken Bouchard (bouchard@ime.net).)

My advice, is trash them and go out and buy new ones. After all, you can get them typically around 5-10 bucks a set.

Then you have the old set to raid bulbs from, for the ones that blow out.

Quality control is not an issue when they build xmas lights. One slight tug of a wire, can break it, and the entire set goes dead.

First I assume you wiggled all the bulbs, often just a loose bulb causes this. In the smaller type bulb sets the string is wired in sections, so one bulb goes out, and every 4th or 5th one is dead.

The little bulbs were also designed, that if the filament breaks in the bulb a piece of foil inside it shorts out that bulb so that the remaining lights keep on working. This works up to a point, until more than 4-5 bulbs blow out at once, then the remaining ones get too much voltage and blow out too.

Often the cheesy sockets get water in them and corrode, and/or the wires on the bulb get twisted or broken.

They also use a cheap method of crimping the wiring together in these lights. Most times you can find the broken wire, by inspecting, seeing where it goes into the socket it pulls out easily.

Well avoid doing this when the set is live (heh...) unless you like the idea of getting zapped.

Shortening a Christmas light string

For strings using large 115 V bulbs, this is easy as all the bulbs are in parallel like the outlets in your house. Cut off the unwanted bulbs and insulate the wire ends.

However, for the common type of tiny bulbs that are in series, you cannot really do this easily. Removing and bypassing 1 or 2 bulbs in a 50 light string won't have much effect on the remaining bulbs but cutting it in half will double the voltage on each bulb - you will get a very bright string of lights for a very short time.

The only way to shorten a string by more than a few percent of lights and have it survive is for the current to be limited by a bulb or resistor or to run it off of reduced voltage. A light dimmer might work except for the fact that they typically require a minimum load of 60 to 100 W - your light string is a small fraction of this.

However, for the special case of 1/2 (give or take) the original number of bulbs, there is a simple solution: A rectifier diode (1A, 200 V PRV min.) in series with the string will cut the effective voltage approximately in half. Typical part numbers are 1N4003 though 1N4007. Even Radio Shack will carry them.

Whatever you do, make sure your connections are secure (with wire nuts or properly soldered) and well insulated. For fire safety, the built-in fuse (usually at the plug-end) must be retained.

Controlling a fixture or outlet from multiple locations

Although the specific case of controlling a fixture or outlet from exactly two locations is a special case of switches at more than 2 locations, each is described separately since the former is much more common.

Should you care, these implement the multiple input XOR (exclusive OR) logic function for controlling electrical devices.

Note: See the section: Dimmer switches and light dimmers if you would like to have control of brightness of a lamp or fixture from multiple locations.

The descriptions below are for using traditional mechanical switches at more than one location. There are also electronic solutions, some even are wireless, where a control module is placed between the load (e.g., lamp or fixture) and the power line and the 'switches' or user controls are mounted remotely. The X10 system is a more general way of doing this providing fully programmable timed (automatic) switching and dimming (where appropriate) from one or more locations.

- For exactly two locations (say at the bottom and top of basement stairs), you will need a pair of what are known as 3-way switches.

  These are actually SPDT (Single Pole Double Throw) switches which look like ordinary wall switches but have 3 screws instead of 2. Two of these screws will be the same color (usually brass) while the third will be different (darker copper or brown). They may be marked as well.

Note that a socket for a 3-way bulb for a lamp is not related to this - only the name is similar.

Typical wiring for controlling a fixture or outlet from exactly two locations is as follows:

```
            Location 1         Location 2
             3-way SW     A     3-way SW          +---------+
                /o----------------o\              | Fixture |
    Hot o-----/                     \o-----------|   or    |--------o Neutral
                 o----------------o        Center | Outlet  | Shell
                          B               (brass) +---------+ (silver)

                                             /o---o                    o---o
  A 3-way switch connects either up  o---/         or down  o---o\          .
                                              o---o                  \o---o
```

As usual, the brass screw on the fixture or outlet should be connected to the Hot side of the wiring and the silver screw to the Neutral side.

Another common variation is shown below:

```
                                          Location 1          Location 2
                                           3-way SW    Rd :     3-way SW
                                    : Bk      /o-------------------o\
        Hot o--------------------------------/          Wh :          \o---+
                                    :          o-------------------o      |
                    +---------+     :                     :               |
                    | Fixture |     : Wh   Splice      Bk :               |
    Neutral o-------|   or    |---------------X---------------------------+
                    | Outlet  |     :     (Wirenut)       :
                    +---------+   14-2                  14-3
```

Details may differ for your particular installation (like to which sides the Hot and Neutral are connected and/or particular wire colors used).

You may also see something along the lines of the following which works but may not be allowed by NEC Code for obvious safety reasons (the load can be electrically live even if off and someone wiring it this way may be tempted to pull the Hots and Neutrals from separate circuits) but has that ever stopped anyone from doing something stupid?):

```
                                 +---------+
         Hot o------------o\     | Fixture |     /o------------o Hot
                             \---|   or    |---/
     Neutral o------------o      | Outlet  |      o------------o Neutral
                                 +---------+
```

(And, if you accidentally get the Hots from opposite phases - watch out!)

- For more than two locations (say at 3 doors to your dining room), you will need a combination of 3-way switches and 4-way switches. Two of the 3-way type will be needed at the ends of the circuit (below) with 1 or more 4-way type in between. Thus for 'n' switch locations, n-2 of the 4-way switches will be needed.

4-way switches have 4 terminals arranged as two pairs. In one position pair 1 is connected to pair 2 straight through. In the other position, the connections are interchanged.

Typical wiring for controlling a fixture or outlet from 3 or more locations is as follows:

```
        Location 1     Location 2     Location 3
         3-way SW   A   4-way SW   A   3-way SW        +---------+
            /o------------o\ /o-----------o\           | Fixture |
  Hot o---/                 /               \o---------|   or    |---o Neutral
             o------------o/ \o-----------o    Center  | Outlet  | Shell
                    B              B           (brass) +---------+ (silver)

                                              o---o                o\ /o
  A 4-way switch connects either straight           or exchange    /    .
                                              o---o                o/ \o
```

This can be extended to an arbitrary number of positions.

As usual, the brass screw on the fixture or outlet should be connected to the Hot side of the wiring and the silver screw to the Neutral side.

Note that a 4-way switch can be constructed from a DPDT (Double Pole Double Throw) type (e.g., toggle switch) as follows:

```
                    +--------------+
                    |              |
      A(in) o---------------+      |
                    |       |      |
                    +----o  o/ o-------+------o A(out)
                             :     |   |
                    +----o  o/ o---+----------o B(out)
                    |       |  DPDT    |
      B(in) o---------------+  toggle  |
                    |          switch  |
                    +------------------+
```

For low voltage (non-house wiring) or panel mount applications, this may be easier than using actual 4-way switches (which are probably not available in small sizes).

The 3-way switches (at least the basic white, ivory, or brown toggle type) can be found nearly anyplace that sells common electrical devices including hardware stores and home centers. You may have to look a little harder for 4-way switches as well as styles or colors to match your decor as these are not as widely available. However, a decent electrical supply house should have all of these.

The wires marked A and B (sometimes called 'travelers') may be in a single (Romex) cable and should be on the screws that are both the same color.

If you do use Romex with a black and white wire, put black tape on the insulation at the ends of the white wire (or paint the ends black) to indicate that this is a Hot wire and not a Neutral. This is required by Code but allows the use of this type of wire.

These diagrams represent one wiring arrangement. Sometimes, there are other slight variations. For example, you might find the switches in the Neutral instead of Hot portion of the wiring - however, this is not recommended.

UK translation for 3-way and 4-way wiring

For 2 locations, you would think that a pair of 2-way switches rather than 3-way switches would be needed! Makes sense, huh? Actually, the number of screw terminals on the switch correlates with the 3-way or 4-way designation. (I don't know anyone who refers to 2-way switches in the US.)

Perhaps they got it right in the UK :-).

(From: Dion L Heap (Dion@homesix.globalnet.co.uk).)

I had to translate the American into the English. If anyone UK is reading this then for what we (UK) call 2 way lighting is the normal stairs light with 2 switches controlling it, (one up & one down). Both these switches are "2 way switches", to add another switch you would be creating 3 way lighting, for this you use both the existing 2 way switches and in-between the L1 & L2 you use an "intermediate switch" I asked at my supplier for a 4 way switch & they thought I was talking Japanese. A phone call to MK technical support revealed that the UK equivalent is the aforementioned intermediate switch. this has 4 points, the L1 & L2s from the 2 existing 2 way switches are taken through the intermediate.

Identifying unmarked wiring or improperly functioning 3-way switch

(Also see the section: Controlling a fixture or outlet from multiple locations.)

So you forgot to label the wires before you removed the old switch, huh? :-).

Or, you moved the wires from the old switches to the new switches but guess what? The new switches may not have the corresponding screws in the same locations and your symptoms are that one switch has to be up for the other switch to do anything - and that is if you are lucky!

You have several options:

- Hire an electrician (depending on his/her competence, this may or may not actually be helpful!).
- If you can go back to the old hookup and/or examine the switches you removed to identify the original connections, do so! Then, transfer the wires to the proper color screws without regard to actual location on the switch.
- It may be obvious from the way the box is wired as to which are the A/B pair.
- Use a tester to figure out which wire is which (see below).
- Interchange the different colored screw wire with one of the others. If this doesn't fix it, swap the different colored screw wire with the other one. As long as you have only touched the wires on the old switch, you cannot damage anything by doing this.
    - For a single switch, this will require at most 2 swaps.
    - If you messed with both switches, this will require at most 6 swaps (2 in box 1, 3 possibilities for each of

these in box 2).

I won't even consider the case of more than 2 switches!

Of course, kill power before touching or changing anything!

Or a slight variation on the theme:

(From: Greg Fretwell (JRFC31A@prodigy.com).)

"Pull out one of the switches (the first one you "fixed" to create this problem) mark all 3 wires. Rotate them all one terminal to the right. Try it. If no luck shift one more time. One of those should work."

Here is one way to identify the proper wires more quickly than trial and error but requires testing the live wiring:

1. Identify the Hot wire. With all 3 wires in each box disconnected and their ends exposed, use a tester between each one and the a earth ground (the box if metal and properly grounded). With power on, only one of the 6 wires will be live.

Now, turn off the power and confirm that it is off by retesting the hot wire you identified above.

2. Connect the lone screw (the different or darker colored one) on one switch to this Hot wire. Connect the same-color screws on the switch to the other two wires. This should take care of one box.

3. With any luck, you should be able to connect the wires in the other box exactly the same way color wise.

(From: CodeElectric@Worldnet.att.net).

Check both boxes. There will be a single Hot - that goes on the common of the 3-way switch. Put the other two wires on the other two screws.

Now, at the other switch, you will find one hot. Put that on a screw, not the common. Switch the other switch, and you'll find another hot. That is the other traveler. You've got one wire left,,, that's the other common.

In more detail:

- First, shut off the power to the circuit. Then remove the wires from the switches. Ignore the colors of the wires... there's too many combinations to use so the colors won't mean anything.

- Look closely at the switches. You will find one screw different from the other two. It may be black, while the other 2 are gold, or may have the word 'common' printed near it. This is, (duh!) the 'common' terminal. The other two are 'traveler' terminals. Having identified the commons and travelers, make sure your family knows you're working with live wires, and let them know not to touch!!!!

- Turn the power back on, and out of the six wires that came off of the two switches, ONE of them will have power. Once you find that one, turn the power back off, and hook that one wire to the common terminal of a switch. Hook the other two wires in that box to the traveler terminals. It doesn't matter which one goes where. Put the switch into the box, and place the cover back on. You're done with than switch.

- Now turn the power back on, and check the remaining three wires. One will be hot. Flip the first switch, and another will be hot. These are your traveler wires. Turn the power back off, and hook those two wires to the two traveler terminals on the second switch. Again, it makes no difference which goes where. The final wire goes to the common terminal. Button everything up, and you should be done.

- Turn the power back on, and you should be up and running.

Dimmer switches and light dimmers

In the old days, a dimmer was a large high wattage rheostat put in series with the light bulb. (Some were probably also Variacs but these would have been more expensive.) Rheostats were both inefficient and producers of a lot of heat. Modern dimmers use a device called a triac (a type of thyristor) which is a solid state switch to control illumination by turning the light bulb on for only a part of each AC half-cycle (100 or 120 times a second depending on where you live) as determined by the adjustment knob or slider. This is called solid state phase control. Once switched on, it remains on for the remainder of the half-cycle:

- For low intensity, the current is switched on late in the half-cycle.

- For medium intensity, the current is switched on around the middle of the half-cycle.

- For high intensity, the current is switched on early in the half-cycle.

- For full intensity, the triac may be bypassed entirely. There will probably be a detectable click position with the control set to full brightness if this is present.

There is also a nice simple description of the principle of operation (with a little diagram) of a modern dimmer at How A Dimmer Switch Works.

Dimmers are available to replace standard wall switches and even for use in place of the light bulb socket/switch in most table lamps. However, nearly all of these are designed only for normal incandescent light bulbs - not fluorescents, compact fluorescents, or high intensity or halogen lamps (or any other type of lamp with a transformer).

(There are special dimmers for use with fluorescent lamps but these must be specifically matched to the lamp type and wattage and their dimming range is usually not very wide. See: the fluorescent lamp information at http://www.misty.com/~don/light.html for a discussion of dimming techniques and details on several relatively simple approaches that may work for your needs.)

Installation is generally very straightforward as there are only two wires and polarity does not matter. They simply replace the existing switch.

To assure long life, it is best to select a dimmer with a higher power rating than your maximum load. For example, if you are using four 100 W bulbs, a 600 W dimmer should be the minimum choice and one rated at 1000 W would be better. This is particularly true if halogen bulbs are used since these may be harder on dimmers than normal types. Further derating should be applied where multiple dimmers are installed in the same outlet box resulting in greater combined heating. Higher wattage dimmer switches will have better heat sinking as well which should result in the active components - the thyristors - running cooler. Dimmers are under the most stress and generate the most heat when operating at about 50% output.

Dimmers may fail due to power surges, excess load, momentary fault (short) at the instant of light bulb failure, or just plain old age. A failed dimmer will generally be stuck at full brightness since the thyristor will have shorted out. The mechanical on-off switch which is part of the dimmer will probably still work.

- A power surge may result in a failed dimmer just like any other solid state device.

- Make sure you are nor overloading the circuit controlled by the dimmer. Most common types are rated for 600 W maximum with heavy duty types up to 1,200 W or more. My advice is to not load them to more than 60 to 75% of their rating.

- When light bulbs burn out, there can be an instantaneous spike of high current due to the failure mechanism. This may blow a fuse or trip a circuit breaker - but it may also blow out a dimmer control.

- Dimmers are not always of the highest quality design or construction and parts may run hot - ever touch the wall plate of a dimmer running at 50% power? Long term reliability may not be that great.

You can't test a dimmer switch with a multimeter except to determine if it is totally shorted: With the control set mid-range, the resistance between the two terminals or wires should be high or infinite regardless of the switch position (if separate from the setting of the control). If it is under 10 ohms, the triac is shorted and at best you have a fancy on/off switch.

To more fully test it, you can make up a simple circuit with a wall plug and cord, and the dimmer in series with a 60-100 W light bulb (less wattage may not be enough to provide enough load and the dimming range may be restricted). Make sure everything is well insulatded!

For a 3-way type dimmer, test/connect between the common (different color wire ors crew) and each of the travelers (same color wires or screws) for all switch positions.

It is not generally worth worrying about repair of a dimmer as they are so inexpensive. However, before replacement confirm that there is no actual problem with the wiring (like a short circuit in the fixture) and that you are not overloading the dimmer.

Typical dimmer schematics

These are the type of common light dimmers (e.g., replacements for standard wall switches) widely available at hardware stores and home centers.

While designed for incandescent or heating loads only, these will generally work to some extent with universal motors as well as fluorescent lamps down to about 30 to 50 percent brightness. Long term reliability is unknown for these non-supported applications.

CAUTION: Note that a dimmer should not be wired to control an outlet since it would be possible to plug a device into the outlet which might be incompatible with the dimmer resulting in a safety or fire hazard.

Simplest dimmer schematic

The first schematic is of a normal (2-way) inexpensive dimmer - in fact this contains just about the minimal number of components to work at all!

S1 is part of the control assembly which includes R1.

The rheostat, R1, varies the amount of resistance in the RC trigger circuit. The enables the firing angle of the triac to be adjusted throughout nearly the entire length of each half cycle of the power line AC waveform. When fired early in the cycle, the light is bright; when fired late in the cycle, the light is dimmed. Due to some unavoidable (at least for these cheap dimmers) interaction between the load and the line, there is some hysteresis with respect to the dimmest setting: It will be necessary to turn up the control a little beyond the point where it turns fully off to get the light to come back on again.

```
Black o--------------------------------+--------+
                                       |        |
                                    |  |        |
                                 R1 \  |        |
                              185 K /<-+        |
                                    \  v CW     |
                                    |         __|__ TH1
                                    |         _\/\_ Q2008LT
                                    +---|>|    / |   600 V
                                    |   |<|--'   |
                                 C1 _|_  Diac    |
                              .1 uF ---  (part of |
             S1                      |    TH1)   |
Black o------/ ----------------------+-----------+
```

The parts that fail most often are the triac, TH1, or the combination switch/control (S1/R1).

3-way dimmer schematics

There are at least two varieties of inexpensive 3-way style dimmer switches which differ mainly in the switch configuration, not the dimmer circuitry. You will probably have no reliable way of telling them apart without testing or disassembly.

None of the simple 3-way dimmer controls permit totally independent dimming from multiple locations. With some, a dimmer can be installed at only one switch location. Fully electronic approaches (e.g., 'X10') using master programmers and addressable slave modules can be used to control the intensity of light fixtures or switch appliances on or off from anywhere in the house. See the section: True (electronic) 3-way (or more) dimmers.

However, for one simple, if inelegant, approach to independent dimming, see the section: Independent dimming from two locations - kludge #3251.

Simple 3-way dimmer schematic 1

The schematic below is of one that is essentially a normal 3-way switch with the dimmer in series with the common wire. Only one of these should be installed in a 3-way circuit. The other switch should be a normal 3-way type. Otherwise, the setting of the dimmer at one location will always affect the behavior of the other one (only when the remote dimmer is at its highest setting - full on - will the local dimmer have a full range and vice-versa).

Note that the primary difference between this 3-way dimmer schematic and the normal dimmer schematic shown above is the addition of an SPDT switch - which is exactly what is in a regular 3-way wall switch. However, this dimmer also includes a choke (L1) and capacitor (C2) to suppress Radio Frequency Interference (RFI). Operation is otherwise identical to that of the simpler circuit.

This type of 3-way dimmer can be used at only one end of a multiple switch circuit. All the other switches should be conventional 3-way or 4-way types. Thus, control of brightness is possible only from one location. See the section: True (electronic) 3-way (or more) dimmers for reasons for this restriction and for more flexible approaches.

```
Red 1 o--------o
                \
```

```
                 S1   o----+------------+-----------+
                           |            |           |
   Red 2 o--------o        |         R1 \  ^ CW     |
                           |      220 K /<-+        |
                           |            \  |        |
                           |            |  |        |
                           |            +--+        |
                           |            |           |
                           |         R2 /           |
                       C2 _|_      47 K \           |
                  .047 uF ---           /         __|__ TH1
                           |            |         _\/\_ SC141B
                           |            +---|>|   / |   200 V
                           |            |   |<|--'  |
                           |        C1 _|_   D1     |
                           |   .062 uF ---  Diac    |
                           |            |           |
                           |   ::::::   |           |
   Black o-----------------+---^^^^^^---+-----------+
                                 L1
                         40 T #18, 2 layers
                       1/4" x 1" ferrite core
```

The parts that fail most often are the triac, TH1, or the combination switch/control (S1/R1).

Simple 3-way dimmer schematic 2

The schematic below is of a 3-way dimmer with a slightly more complex switching arrangement such that when the local dimmer is set to full on or full off, it is bypassed. (If you ignore the intermediate dimming range of the control, it behaves just like a normal 3-way switch.) With this scheme, it is possible to have dimmers at both locations without the dimmer circuitry ever being in series and resulting in peculiar behavior.

Whether this is really useful or not is another story. The wiring would be as follows:

```
              Location 1             Location 2
             3-way Dimmer      A    3-way Dimmer     +---------+
                  /o----------------------o\         |  Lamp   |
    Hot o------o/    Silver 1     Silver 2   \o------|   or    |-----o Neutral
           Brass   o----------------------o   Brass  | Fixture |
                     Silver 2  B  Silver 1           +---------+
```

(If dimming interacts, interchange the A and B wires to the silver screws at one dimmer).

This one uses a toggle style potentiometer where the up and down positions operate the switches. Therefore, it has 3 states: Brass to Silver 1 (fully up), dim between Brass and Silver 1 (intermediate positions), and Brass to Silver 2 (fully down).

```
                        Br  /o---o            Br   o---o          Br/\/o---o
  3-way dimmer is up o---o/   S1   or down o---o\  S1    or Dim o---o  S1
                             o---o                \o---o               o---o
                              S2                   S2                  S2
```

However, it is still not possible to have totally independent control - local behavior differs based on the setting of the remote dimmer (details left as an exercise for the reader).

Like the previous circuit, this dimmer also includes a choke (L1) and capacitor (C3) to suppress Radio Frequency Interference (RFI). It is just a coincidence (or a matter of cost) that the 3-way dimmers have RFI filters and the 2-way type shown above does not.

```
  Silver 1 o---+----------------+--------------------+-----------+
               |                |                    |           |
               |                |                 R1 \  ^ Up     |
               |                |              150 K /<-+        |
               |                |                    \  |        |
               |                |                    |  |        |
               |                |          +---------+--+        |
               |                |          |         |           |
               |            C3 _|_         |      R2 /           |
               |               ---         |    22 K \           |
               |                |          |         /         __|__ TH1
               |                |      C2 _|_        |         _\/\_
               |                | .047 uF ---        +---|>|   / |   200 V
           Up \                 |          |         |   |<|--'  |
               |                |          |     C1 _|_   D1     |
               |                |          |.047 uF ---  Diac    |
               |                |   ::::   |         |           |
               |  Dim  o--------+---^^^^---+---------+-----------+
               |     /               L1
     Brass o---+---o               12T #18
                           1/4" x 1/2" ferrite core
                 Down  o
                       |
  Silver 2 o-----------+
```

The parts that fail most often are the triac, TH1, or the combination switch/control (S1/S2/R1).

True (electronic) 3-way (or more) dimmers

The objective is to be able to control a single fixture from multiple locations with the capability of dimming as well as just power on/off.

The simple type of 3-way dimmers are just a normal dimmer with a 3-way instead of normal switch. This allows dimming control from only one location. The other switches in the circuit must be conventional 3-way or 4-way type.

Connecting conventional dimmers in series - which is what such a hookup would require - will not really work properly. Only if one of the dimmers is set for full brightness, will the other provide full range control. Anywhere in between will result in strange behavior. The other dimmer may have a very limited range or it may even result in oscillations - periodic or chaotic variations in brightness. The safety and reliability of such an arrangement is also questionable.

True 3 way dimmers do exist but use a more sophisticated implementation than just a normal dimmer and 3-way switch since this will not work with electronic control of lamp brightness. One approach is to have encoder knobs (similar to those in a PC mouse) or up/down buttons at each location which send pulses and direction info back to a central controller. All actions are then relative to the current brightness. A low cost microcontroller or custom IC could easily interface to a number, say up to 8 (a nice round number) - of control positions. The manufacturing costs of such a system are quite low but due to its specialty nature, expect that your cost will be substantially higher than for an equivalent non-dimmable installation.

If control of intensity at only one of the locations is acceptable, a regular dimmer can be put in series with the common of one of the normal 3-way switches. However, your brightness will be set by that dimmer alone. See the section: Typical dimmer schematics.

An alternative is to use X-10 technology to implement this sort of capability. This would likely be more expensive than a dedicated multi-way switch control but is more flexible as well. X-10 transmits control information over the AC lines to select and adjust multiple addressable devices like lamps and appliances.

However, for the adventurous, see the section: Independent dimming from two locations - kludge #3251.

Independent dimming from two locations - kludge #3251

Here is a scheme which will permit dimming with independent control from two locations. Each location will have a normal switch and a dimmer knob. The toggle essentially selects local or remote but like normal 3-way switches, the actual position depends on the corresponding setting of the other switch:

```
                 Location 1       Location 2
           +--------+  4-way SW    3-way SW
Hot o--+---| Dimmer |----o\ /o--------o\            +---------+
       |   +--------+      /            \o----------| Fixture |------o Neutral
       |              +--o/ \o--------o      Center +---------+ Shell
       |              |                      (brass)           (silver)
       |              |            +--------+
       |              +------------| Dimmer |--+
       |                           +--------+  |
       +---------------------------------------+
```

As usual, the brass screw on the fixture or outlet should be connected to the Hot side of the wiring and the silver screw to the Neutral side.

The dimmers can be any normal knob or slide type with an off position.

Note that as drawn, you need 4 wires between switch/dimmer locations. 4-way switches are basically interchange devices - the connections are either an X as shown or straight across. While not as common as 3-way switches, they are available in your favorite decorator colors.

If using Romex type cable in between the two locations, make sure to tape or paint the ends of the white wires black to indicate that they may be Hot as required by Code.

And, yes, such a scheme will meet Code if constructed using proper wiring techniques.

No, I will not extend this to more than 2 locations!

Also see the section: Controlling a fixture or outlet from multiple locations.

CAUTION: However, note that a dimmer should not be wired to control an outlet since it would be possible to plug a device into the outlet which might be incompatible with the dimmer resulting in a safety or fire hazard.

Humming or buzzing lamps or fixtures on dimmers

Unlike the normal AC power, the output of a cheap dimmer is a chopped waveform with sharp edges every 120th of a second for 60 Hz power (or every 100th of a second for 50 Hz power). This can result in annoying audible vibration of the filaments of the light bulbs.

The severity of the problem is due to a variety of causes with the two most likely being related to the bulb's filament construction/supports and what, if any filtering, is provided by the dimmer itself - some are just worse than others and cost may not be a reliable indication of which-is-which.

There is nothing really wrong with your installation - incorrect wiring would result in it not working at all, blowing a fuse or tripping a breaker, or or not working in certain positions of switches in a 3-way or 4-way (multiple switch locations) setup. If it bothers you try a different brand of bulbs or a different brand of dimmer.

How do touch dimmers work?

(From: Neil).

Touch dimmers work in a couple of different ways, depending on the IC used. Simple ones, such as those in the cheap 'touch lamps' that you find for sale on market stalls, etc. normally have three or four preset brightness levels and an OFF setting, which are operated sequentially: touch once for full brightness, again to dim slightly, again to dim a bit more, etc, until the OFF setting is reached. The next touch will then bring the lamp to full brightness.

The better (and more expensive) units, such as the touch dimmer switches that are sold as direct replacements for conventional light switches, are similar, but have many more steps. A single touch will usually bring the lamp to full brightness, while keeping your finger in contact with the touch plate will slowly dim the lamp. You just remove your finger when the lamp is at the required brightness level.

Both kinds of touch dimmer have three basic parts;

1. A touch sensor - this normally works by picking up mains hum from the touch plate, and rectifying it in a high-gain amplifier.
2. A ramp generator - normally in the form of a digital counter with DAC output.
3. A mains power control element - Generally a thyristor or triac. In some designs, this is encapsulated within the IC, while in others it is a discrete component.

Most touch dimmers can be operated by standard push-button switches as well as a touch plate, and many can be adapted for remote control.

There are a number of specially designed IC's available for touch dimmers, notably the HT7704B ,a four-step device for touch lamps as described above, and the SLB0586A, which is the other kind, with facilities for remote control.

(From: Jack Schidt (jack@wintel.net).)

Body detection usually follows one of three forms:

- 60 Hz (50 Hz) detection from the touch. High impedance timer or op-amp receives 60 Hz emitted from power lines. Body is antenna, contacting button. rectification / pulse shaping drives relay.
- Resistive (DC sensing) detection from the touch. Simple enough, two closely placed touch points, simple op amp or transistor circuit pulses relay.
- AC removal (capacitance) detection from the touch. An insulated contact is AC driven through a high impedance. If a finger (or a body) comes close, that signal is attenuated, and detection is 'missing pulse' type, generating an output to toggle relay.

Light dimmers and interference with radio or TV

Due to the sharp edges on the power supplied by a cheap light dimmer, Radio Frequency Interference (RFI) may be conducted back down the wiring directly to other appliances and/or radiated through space as well. Effects will include noise bars in the picture on some TV channels and/or a buzz in the audio across portions of the AM radio band.

(Zero crossing switching, a technique used with electrical heaters and heating appliances to minimize RFI cannot be used for lighting as it would result in way too much flicker or a very limited number of brightness levels.)

Better light dimmers will include a bypass capacitor (e.g., .01 uF, 1kV) and a series inductor to suppress RFI but these components were often left off in basic models. The FCC has tightened up on their regulations around 1992 so replacing older dimmer switches with newer ones may be the easiest solution.

I can't really recommend a particular model that it better in this regard. However, the package may list 'low RFI' as a feature so checking out Home Depot or wherever won't hurt.

Installing in-line power line filters may work but other options like replacing all your house wiring with metal conduit, or only listening to FM radio are probably not realistic!

BTW, I have used dimmers and AM radios to trace wiring inside the wall! :)

Dimmer wall plate hot to touch

This is probably normal if the dimmer is controlling a load which is close to (or beyond) its maximum rating. For most inexpensive dimmers, this is 600 W. Others are commonly rated up to 1,200 W. Keep in mind that the switching device (the triac) is dissipating a wattage proportional to the load. With a full 600 W load, it may be as much as 6 to 10 W (depending on the setting of the control knob), which is not a trivial amount of power - and the face plate is used as a heat sink. The larger ones have to dissipate even more power.

My recommendation would be to get a dimmer rated for 30 to 50 percent more power than you are using. It will still get warm but will have a better (probably finned) heat sink and will be running way below it maximum rating and should be more reliable. In general, any device should be derated to boost longevity!

Can I use a dimmer to control transformer operated low voltage lighting?

(Portions from: Charles Sullivan (chrs@dartmouth.edu).)

It is very tempting to try using a common light dimmer to control devices using power transformers. Will this work?

It will usually work fine, but it can lead to a fire hazard and is not recommended. Most major dimmer manufacturers have special dimmers designed for this application, that prevent the hazard inherent in using a standard dimmer. It is worth your while to use one of those.

The problem results from the inductive nature of the impedance the transformer presents to the dimmer. The load is most inductive when the transformer is lightly loaded. Even if you set up your system with a fully loaded transformer, it can become lightly loaded when bulbs burn out. If there is any small asymmetry in the firing angle of the triac on the two half cycles, there will a be small DC voltage across the transformer winding. This is no big deal - you'll get a bit of DC current, and the core will run with some DC flux, and may saturate a bit, but neither will cause significant heating or a real hazard. However, the point at which the triac turns *off* will also then be different on the two half cycles. Because ordinary dimmer circuits time the triac turn on from the turn off point, not from the line voltage zero crossing, the asymmetry in turn-off times leads to a even greater turn-on time asymmetry. If the load is sufficiently inductive, this process can "run away" until the dimmer is acting as a diode, applying nearly full line voltage across the transformer winding. Ordinarily, this would result in enough current to trip a circuit breaker or a fuse, but smaller transformers can have enough DC resistance to keep the current low enough that the breaker does not trip. When I've experimented with this, the transformer winding soon started to smoke. I didn't continue the experiments to see what would happen next, but there have been reports of fires starting this way. A suitably rated small fuse installed in series with the transformer would probably work but I wouldn't want to depend on it.

Dimmers designed for this application can use several methods to get around the problem. Some use a DC detection circuit and shut off if DC is detected. Others use a three-wire connection scheme, such that the line- neutral voltage is available to the dimmer, and can be used for the timing reference, so that the triac is always fired at the same time relative to the line-voltage zero crossing, not relative to when the triac turns off. Thus, although there may still be a small amount of DC present due to asymmetry in the firing circuit, the system can never run away to the point of applying a much high DC voltage. (In good dimmers designed for this application, the asymmetry will also be small to begin with.)

References for further information:

- Lutron Electronics application note #19, Guide to Dimming Low Voltage Lighting, http://www.lutron.com/applicationnotes/362219.pdf

- "Low Voltage Dimming System," Jenkin Hua, Conference Record of the 1999 IEEE Industry Application Conference, p.1700.

Flashlights and lanterns

Battery operated flashlights (torches for those on the other side of the Lake) and lanterns are among the simplest of appliances. We probably all have a box or drawer full of dead flashlights.

The most common problem after dead batteries is very often damage due to leaky batteries. Even supposedly leak-proof batteries can leak. Batteries also tend to be prone to leaking if they are weak or dead. Therefore, it is always a good idea to remove batteries from any device if it is not to be used for a while. How to assure the batteries will be with the flashlight? Put them in separate plastic bags closed and fastened with a twist tie.

Test the batteries with a multimeter - fresh Alkalines should measure 1.5 V. Any cell that measures less than about 1.2 V or so should be replaced as they will let you down in the end. On a battery tester, they should read well into the green region.

Check the bulb with a multimeter on the ohms scale - a bad bulb will test open. Bulbs may fail from use just like any other incandescent lamp or from a mechanical shock - particularly when lit and hot. Replacement bulbs must be exactly matched to the number and type of batteries (cells). A type number is usually stamped on the bulb itself. There are special halogen flashlight bulbs as well - I do not really know how much benefit they provide.

The switches on cheap flashlights are, well, cheaply made and prone to unreliable operation or total failure. Sometimes, bending the moving metal strip a bit so it makes better contact will help.

Clean the various contacts with fine sandpaper or a nail file.

If a flashlight has been damaged as a result of battery leakage, repair may be virtually impossible.

High quality flashlights are another matter. Maglights(tm) and similar units with machined casings and proper switches should last a long time but the same comments apply to batteries - store them separately to avoid the possibility of damage from leakage. Keep a spare bulb with each of these - the specialty bulbs may be harder to find than those for common garbage - sorry - flashlights.

Rechargeable flashlights include a NiCd or lead-acid battery (one or more cells in series) and the recharging circuitry either as part of the unit itself or as a plug-in wall adapter or charging stand. See the sections: "Battery chargers" and "Typical rechargeable flashlight schematics" for more information.

Typical rechargeable flashlight schematics

Here are circuit diagrams from several inexpensive rechargeable flashlights. These all use very 'low-tech' chargers so battery life may not be as long as possible and energy is used at all times when plugged into an AC outlet.

First Alert Series 50 rechargeable flashlight schematic

This one is typical of combined all-in-one units using a lead-acid battery that extends a pair of prongs to directly plug into the wall socket for charging.

It is a really simple, basic charger. However, after first tracing out the circuit, I figured only the engineers at First Alert knew what all the diodes were for - or maybe not :-). But after some reflection and rearrangement of diodes, it all makes much more sense: C1 limits the current from the AC line to the bridge rectifier formed by D1 to D4. The diode string, D5 to D8 (in conjunction with D9) form a poor-man's zener to limit voltage across BT1 to just over 2 V.

The Series 50 uses a sealed lead-acid battery that looks like a multi-cell pack but probably is just a funny shaped single cell since its terminal voltage is only 2 V.

Another model from First Alert, the Series 15 uses a very similar charging circuit with a Gates Cyclon sealed lead-acid single cell battery, 2 V, 2.5 A-h, about the size of a normal Alkaline D-cell.

WARNING: Like many of these inexpensive rechargeable devices with built-in charging circuitry, there is NO line isolation. Therefore, all current carrying parts of the circuit must be insulated from the user - don't go opening up the case while it is plugged in!

```
                                             2V LB1  Light
                                           1.2A +--+ Bulb    S1
                                       +--------|/\|----------o/ o----+
            _ F1   R3         D3       |        +--+                  |
   AC o----- _----/\/\---+----|>|--+---|----------------------+       |
          Thermal  15    |    D2   |   |                 4A-h |       |
           Fuse          | +--|>|--+   |         BT1 - |+ 2V  |       |
                         | |  D4       +--------------||------|-------+
                         +----|<|--+   |               |      |       |
```

```
                           |  D1   |   |  D8   D7   D6   D5   |  D9   |
          +--------+-------+--|<|--+---+--|<|--|<|--|<|--|<|--+--|>|--+
          |        |                                                  |
          |        /                                                  |
         _|_ C1    \ R1                                               |
         --- 2.2uf / 100K                                             |
          |  250V  \                                                  |
          |        |               R2          L1  LED                |
   AC o---+--------+--------------/\/\-----------|<|------------------+
                                 39K 1W       Charging
```

Black & Decker Spotlighter Type 2 rechargeable flashlight

This uses a 3 cell (3.6 V) NiCd pack (about 1 A-h). The charging circuit is about as simple as it gets!

```
                                                                 S1
         11.2 VRMS                                        +---------------o/ o----+
  AC o-----+ T1       R1      LED1         D1     |  +| | | -          |
            )|| +----/\/\-----|>|---->>----|>|----+---||||||---+         |
            )||(      33    Charging     1N4002        | | |    |  KPR139  |
            )||(      2W                            BT1          |    LB1   |
            )||(                                    3.6V, 1 A-h |    +--+  |
            )|| +-------------------->>------------------------+----|/\|--+
  AC o-----+                                             Light Bulb +--+


        |<------- Charger ----------->|<--------- Flashlight ----------->|
```

I could not open the transformer without dynamite but I made measurements of open circuit voltage and short circuit current to determine the value of R1. I assume that R1 is actually at least in part the effective series resistance of the transformer itself.

Similar circuits are found in all sorts of inexpensive rechargeable devices. These have no brains so they trickle charge continuously. Aside from wasting energy, this may not be good for the longevity of some types of batteries (but that is another can of worms).

Brand Unknown (Made in China) rechargeable flashlight schematic

This is another flashlight that uses NiCd batteries. The charger is very simple - a series capacitor to limit current followed by a bridge rectifier.

There is an added wrinkle which provides a blinking light option in addition to the usual steady beam. This will also activate automatically should there be a power failure while the unit is charging if the switch is in the 'blink' position.

With S1 in the blink position, a simple transistor oscillator pulses the light with the blink rate of about 1 Hz determined by C2 and R5. Current through R6 keeps the light off if the unit is plugged into a live outlet. (Q1 and Q2 are equivalent to ECG159 and ECG123AP respectively.)

```
        R1          D1                 R3   LED1
AC o---/\/\----+----|>|-------+---+---/\/\--|>|--+    D1-D5: 1N4002
        33    ~|    D2        |+  |   150         |
       1/2W    +----|<|----+  |   |      R4      |  D5
                    D3     |  |   +------/\/\----+--|>|--+
          C1   +----|>|----|--+   |    33, 1/2W          |   LB1 2.4V
        1.6uF ~|    D4     |      |   | |                |   +--+ .5A
AC o--+---||---+----|<|----+--+---|--||||--------------+-+---|/\|----+
      |  250V  |              |-  | - | |+             |     +--+    |
      +--/\/\--+              |   |   BT1     + C2 -   |      R5     |
          R2                  |   |  2.4V   +---|(----|-----/\/\----+
         330K                 |   |          |  22uF   |     10K     |
                              |   |    R6    |       |/ E            |
                              |   +---/\/\---+-+-----| Q1            |
                              |      15K     |     |\ C  +---------+
                              |                /  C327 |   |         |
                              |             R7 \   PNP |   |   1702N |
                              |           100K /       |   |   NPN |/ C
                              |                \      +---|-------| Q2
                              |      On        |           |       |\ E
                              |   S1 o---------|-----------+         |
                              +----o->o Off    |                     |
                                     o---------+---------------------+
                                Blink/Power Fail
```

Solar Powered Walk Light

This was found in a Malibu(tm) LZ1 Solar light set made by Intermatic. It uses a solar cell, approximately 4 square inches in area, to charge a pair of AA NiCd cells during the day which powers a superbright yellow LED at night. I estimate the actual light output to be 2 or 3 mW at around 595 nanometers wavelength (something like stoplight yellow). Actually, it is kind of cool in more ways than one! :) If only the cheap plastic enclosure was actually waterproof....

```
   +------+---|>|---+------------+----------+
   |      |   D1    |            |          |
   |      | 1N4004  |            /          |
   |      |         |            \ R3     __|__
  +| SC1  |       +_|_ BT1       / 2.2K   _\_/_ LED
+--+--+   |         _  2xAA NiCd \          |
|Solar|   |        ___ 550mA-hr  |        |/ C
|Cell |   |       - _            +---+----| Q2 SS8050
+--+--+   |         |    R2      |   |    |\ E (ECG216)
  -|      |         |   20K    |/ C  /      |
   |      +---------|---/\/\---| Q1  \ R1   |
   |                |   SS9013 |\ E  / 100K |
   |                | (ECG123A)  |   |      |
   +----------------+------------+---+------+
```

When there is enough voltage from the solar cell, Q1 is turned on and Q2 (the LED driver) is turned off. As far as I can tell, there is nothing to actually limit current to the LED except for the combination of battery, transistors, LED, and wiring resistance. Both transistors could probably be replaced with 2N3904s. So, if you were duplicating this thing, I'd recommend adding something to control the current to the LED or at least checking it first!

Actual failure of this complex device would most likely be due to worn out NiCd cells or corrosion to due exposure to the weather.

Operational problems like weak output or inadequate lighting time could be due to insufficient Sunlight (the thing is installed under a bush!) or extended cloudy conditions. Of course, these don't produce a huge amount of light in any case!

Makeup mirrors

There are a simple movable mirror with incandescent or fluorescent lighting built in.

Replacing incandescent light bulbs can usually be done without disassembly. The bulbs may be of the specialty variety and expensive, however.

When a unit using fluorescent bulbs will no longer come on, the most likely cause is a bad bulb. However, replacement may involve disassembly to fain access. Where two bulbs are used, either one or both might be bad. Sometimes it will be obvious which is bad - one or both ends might be blackened. If this is not the case, replacement or substitution is the only sure test. These **will** be expensive $7-10 is not uncommon for an 8 inch fluorescent bulb!

Other possible problems: plug, cord, switch, light bulb sockets.

Chandeliers

A chandelier is simply an incandescent light fixture with multiple sockets. No matter how fancy and expensive, the wiring is usually very simple - all the sockets are connected in parallel to a cord which passes through the chain to a ceiling mounted electrical box.

If none of the lights come on, check for a blown fuse or circuit breaker, bad wall switch or dimmer, a bad connection in the ceiling box or elsewhere in the house wiring, or a bad connection where the cord is joined to the individual socket wires.

Where only one bulb does not light - and it is not a burned out bulb - a bad socket, loose wire connection at the socket, or bad connection at the point where the wires are joined (Wire Nuts(tm) or crimps) is likely.

Overhead (and other basic slide) projectors

(The type discussed here are overhead transparency projectors, opaque projectors, and the basic power and lighting circuits of slide projectors. Problems with the slide advance mechanism of those with automatic slide changers (e.g., Kodak Carousel) are usually mechanical in nature assuming the main motor is running. See the document: Audio Equipment and Other Miscellaneous Stufffor more information on these.)

A basic projector consists of a really bright lamp - usually halogen but some fancy ones use a High Intensity Discharge (HID) lamp (see the document: Gas Discharge Lamps, Ballasts, and Fixtures), a cooling fan, electrical and thermal protection devices, and possibly an interlock switch to prevent operation with the cover removed. The main switch may include reduced brightness settings which adds some resistance or a diode in series with the lamp.

(Repair of those with HID lamps unless it is a simple bad connection or failure in the protection devices is well beyond the scope of this document unless replacing the lamp is all that is needed. WARNING: The types of power supplies used for these may have capacitors that can retain a dangerous charge for a long time even after the plug is pulled.)

A reflector and condensing lens concentrates the light more or less uniformly onto the material to be projected {transparency or whatever) and a projection lens relays and enlarges that to the screen. Note that the large Fresnel lens (which should also be cleaned) that usually serves as the transparency platform of an overhead projector is not the primary condenser but serves a similar function directing most of the light which passes through the transparency to the projection lens. There may also be one or more pieces of heat absorbing glass between the lamp and condenser. While you're in there, a careful cleaning of the optics could be useful! After making sure the unit is unplugged, use a cloth moistened with isopropyl alcohol to clean all accessible optical surfaces. Rubbing (70%) or medicinal (91%) alcohol is fine as long as it doesn't contain any additives. Be gentle - optical glass is not that hard! WARNING: Avoid contact with the glass envelope of the lamp itself. If you do touch it by accident, use a fresh cloth or paper towel and alcohol to remove all traces of skin oils since this contamination can lead to failure at the elevated temperatures at which these run.

Like all incandescent lamps, those in projectors burn out - and since they are run at higher than normal wattage to get the most and whitest light, they usually are only rated for a small number of hours (e.g., 100). When burnout occurs, other components may be blown as well.

Since everything runs hot, deteriorated connections, contacts, sockets, etc., are quite common. Any major damage will require repair or replacement of the offending components. The fan may be on a thermostat which can also fail. If the fan doesn't start (usually immediately or after a minute or so at most), overheating WILL occur. Check the thermostat (bypass it to test) and the fan for dry bearings, bad connections, or a bad motor.

If replacing the bulb doesn't help, check the fuses and thermal protectors for opens. Check the outlet as the burnout may have blown the fuse or tripped the circuit breaker for that branch circuit.

If the new bulb runs excessively bright, TURN IT OFF IMMEDIATELY! Some of these projectors use 82 V bulbs (it will say on the bulb and/or its package), and a series diode (or diodes) may be used to reduce power to the bulb to run it at an effective voltage of 82 VRMS. (The RMS value of half wave rectified 115 VAC is close to 82 V). When the old bulb blew (or even if it didn't), these diodes can fail - often shorted. The new bulb won't last long on the full line voltage. The replacement diodes need to have a PIV rating of at least 200 V (for 115 VAC power) and a current rating adequate to handle the operating current and the initial surge (which can be 10X of that). Depending on the bulb's wattage, a 25 A or higher diode may be needed. An proper replacement will be available from the projector manufacturer but will be more expensive than one purchased from an electronics distributor.

Portable fans and blowers

These consist of a cordset, switch, and AC motor. Oscillating fans add a gearbox to automatically swivel the fan to direct air in more than one direction. Most are of the bladed variety though some small types might use a squirrel cage type centrifugal blower.

There are two kinds of problems: totally dead or stuck/sluggish.

A totally dead fan can be the result of several possible causes:

- Bad cord or plug - these get abused. Test or substitute.
- Bad power switch - bypass it and see if the fan starts working or test with a continuity checker or multimeter. Sometimes, just jiggling it will confirm this by causing the fan to go on and off.
- Open thermal fuse in motor - overheating due to tight bearings or a motor problem may have blown this. Inspect around motor windings for buried thermal fuse and test with continuity checker or multimeter. Replacement are available. For testing, this can be bypassed with care to see if the motor comes alive.
- Burned out motor - test across motor with a multimeter on the low ohms scale. The resistance should be a few

Ohms. If over 1K, there is a break in the motor winding or an open thermal fuse. If there is no fuse or the fuse is good, then the motor may be bad. Carefully inspect for fine broken wires near the terminals as these can be repaired. Otherwise, a new motor will be needed. If the motor smells bad, no further investigation may be necessary!

- Bad wiring - check for broken wires and bad connections.

As always, your continuity checker or multimeter on the low ohms scale is your best friend and can be used to trace the wiring from the wall plug through all components of the appliance.

Sluggish operation can be due to gummed up lubrication in the motor or any gears associated with an automatic oscillating mechanism. Disassemble, thoroughly clean, and then lubricate the motor bearings with electric motor oil. Use light grease for the gearbox but this is rarely a problem.

A noisy fan may be due to dry motor or other bearings or loose hardware or sheetmetal. Disassemble, clean, and lubricate the motor or gearbox as above. Inspect for loose covers or other vibrating parts - tighten screws and/or wedge bits of wood or plastic into strategic locations to quiet them down.

Damaged fan blades will result in excessive vibration and noise. These may be easily replaceable. They will be attached to the motor shaft with either a large plastic 'nut' or a setscrew. However, locating a suitable set of blades may be difficult as many cheap fans are not made by well known companies.

Computer power supply (and other) fans

Virtually all of these use brushless DC motors with stationary coils and a rotating multipole magnet which is part of the blade assembly. Most common problems are gummed up lubrication or worn bearings - especially for the cheap sleeve bearing variety found in most PCs. Occasionally, an electronic failure will result in a dead spot or other problem.

Ball bearing fans rarely fail for mechanical reasons but if the bearings become hard to turn or seize up, replacement will usually be needed. (Yes, I have disassembled ball bearings to clean and relube THEM but this used only as a last resort.)

WARNING: For power supply fans, be aware that high voltages exist inside the power supply case for some time (perhaps hours) after the unit is unplugged. Take care around the BIG capacitors. If in doubt about your abilities, leave it to a professional or replace the entire power supply!

The only type of repair that makes sense is cleaning and lubrication. Else, just replace the fan or power supply. It isn't worth troubleshooting electronic problems in a fan!

If you want to try to clean and lubricate the bearings, the blade assembly needs to be removed from the shaft. There should be a little clip or split washer holding it on. This is located under a sticker or plastic plug on the center of the rotating blade hub. Once this fastener has been removed, the blades will slide off (don't lose the various tiny spacers and washers!)

Thoroughly clean the shaft and inside the bushings and then add just a couple drops of light oil. Also, add a few drops of oil to any felt washers that may be present as an oil reservoir.

Reassemble in reverse order making sure the tiny washers and spacer go back in the proper positions.

How long this lasts is a crap shoot. It could be minutes or years.

Replacement fans are readily available - even Radio Shack may have one that is suitable. Nearly all run on 12 VDC but some small CPU fans may use 5 VDC. While current ratings may vary, this is rarely an issue as the power supply has excess capacity. Air flow rates may also vary depending on model but are usually adequate for use in PCs.

Piezo fans

These may be used for localized cooling of electronic components or some other very low air flow application. I cannot imagine a use around the house. They use a pair of piezo electric bars that vibrate thin vanes to move a few dozen air molecules per second. Drive is from the power line via a transformer or dropping resistor.

Advantages include virtually infinite life, very low power consumption, to nearly total silence when operating. However, they aren't going to cool very much :-).

(If you care, something that is said to be piezo electric changes shape (e.g., bends or compresses/expands) when a voltage is applied (and vice-versa). Many materials exhibit the piezo electric effect include crystals like quartz, various ceramics and plastics, and even some organic compounds. The most common example of a piezo electric device in modern technology is the beeper in a common digital watch, pocket alarm clock, or pager - in which case an electrical signal at a most annoying frequency causes the change in thickness of a ceramic disk and results in the audible tone.)

The piezo fan I have is just a pair of thin plastic flaps or vanes, each about 1/2" x 3", separated by perhaps 1" and slightly diverging. A pair of piezo elements at one end vibrate the vanes when driven through a dropping resistor from the 60 Hz AC line. Interestingly, the resonance is actually at 50 Hz but I do not think this unit was designed for European power. A plastic housing helps to guide the air flow - what of it there is. The result is a just detectable breeze so I wouldn't recommend using one of these to cool your Pentium II!

Except for mechanical damage, there isn't much to go wrong as long as the piezo elements themselves are getting power. However, a buildup of dirt on the vanes could change the resonant frequency to the point of greatly reducing effectiveness (to the extent that there is any to begin with!).

Don't worry, you may never see one of these things in several lifetimes :-).

Speed control of DC fans

The small fans used in computers and peripherals usually run on 5, 12 (most common) or 24 VDC. Most of the time, their speed and air flow are fine for the application. However, is it possible to vary it should the need arise?

Usually, the answer is a qualified 'yes'. Except for some that are internally regulated or thermostatically controlled, the speed is affected by input voltage. It is likely that the fan will run on anywhere from .5 to 1.25 times the nominal input voltage though starting when it is near the low end of this range may need some assistance.

A universal DC wall adapter, adjustable voltage regulator, or (variable) series power resistor can provide this control. For example:

```
                  25, 2 W        + +--------+ -
 +12 VDC o-----+---/\/\---+--------| DC FAN |----o Gnd
               |   +      |        +--------+
               +----|(----+      12 VDC, .25 A
                 10,000 uF
                   25 V
```

The 25 ohms power resistor should reduce the speed of this fan by about 25 to 30 percent. The capacitor provides full voltage for a fraction of a second to assure reliable starting.

Speed control of small AC fans

The following comments should also apply to many other types of appliances using small AC motors.

These small shaded pole fans will work just fine on a Variac. Any speed you want, no overheating, etc. I had done this with all sorts of little computer cooling fans as well as larger ones (remember those old DEC PDP-11 rack fans?).

A true rheostat (variable power resistor) will also work. However, significant power will be dissipated in the rheostat which must be sized so that the maximum power density of any portion of its element does not exceed its power handling capability - this can end up resulting in a massive device even for a small fan. For example, to vary a 120 VAC fan rated at 24 VA from between 1/2 to full power would require a 600 ohm, 25W rheostat; down to 1/4 power would require an 1,800 ohm 75 W rheostat!

Small triac based speed controls like those used for ceiling fans may also work. Even light dimmers will *probably* work for medium size fans or banks of fans though I cannot guarantee the reliability or safety of these. The problem is that small induction motors represent a highly inductive loads for the light dimmer circuitry which is designed for a resistive load. I have achieved a full range of speeds but over only about 1/4 to 1/2 of the rotation of the control knob. There is some buzz or hum due to the chopped waveform.

However, from my experiments, light dimmers may have problems driving a single small fan. If the load is too small, the result may be a peak in speed (but still way less than normal) at an intermediate position and the speed actually much lower when on full, or reduced speed even on full. In this case, adding a resistive load in parallel with the motor - a light bulb for example - may improve its range. It adds a sort of quaint look as well! :-)

If you do opt for a solid state speed control, make sure you include a fuse in the circuit. A partial failure of the triac can put DC through the motor which would result in a melt-down, lots of smoke, or worse. (This isn't a problem with a light bulb load since its resistance is the same for AC and DC; a motor's DC resistance is quite low.)

The reason these simple approaches will work for these AC motors is that they are high slip to begin with and will therefore have a high range of speed vs. input voltage. The only concern is overheating at some range of lower speeds due to reduced air flow. However, since these fans are normally protected even against stall conditions, I wouldn't expect overheating to be a problem - but confirm this before putting such fans into continuous service.

If all you need to do is provide a fixed, reduced speed for a bank of similar AC fans, try rewiring them as two sets of parallel connected fans in series. The result will be 1/2 the normal line voltage on each fan motor which may provide exactly the speed you want! The extension to more than 2 sets of fans is left as an exercise for the student :-).

Ceiling fans

While the original slow rotating ceiling mounted fan predates the widespread use of airconditioning, there is a lot to be said for the efficiency, effectiveness, and silence of this technology - not to mention the ambiance.

A ceiling fan is just an induction motor driving a set of blades. Multiple taps on the motor windings in conjuac dansnction with a selector switch provides speed control for most inexpensive fans. Better units include a solid state motor speed control.

The light often included with the fan unit is usually just an incandescent fixture with 1-5 bulbs and a switch. This may be a simple on-off type, a selector to turn on various combinations of bulbs, or a dimmer with continuous or discrete control of illumination.

WARNING: Always check mechanical integrity of fan mounting when installing or servicing a ceiling fan. Original design and construction is not always as fail-safe as one might assume. Double check for loose nuts or other hardware, adequate number of threads holding fan to mounting, etc. These have fallen without warning. Only mount in ceiling boxes firmly anchored to joists - not just hanging from the ceiling drywall! Check that the fan is tight periodically. The constant vibration when running, slight as it is, can gradually loosen the mounting hardware. Furthermore, if pull chain type switches are used for the fan or light, constant tugging can also tend to loosen the entire fan.

Failures of ceiling fans can be divided into electrical and mechanical:

Electrical:

- **No power:** Use a circuit tester to determine if power is reaching the fan. Check the fuse or circuit breaker, wall switch if any, and wire connections in ceiling box.

- **Bad switch in fan:** with power off, check with a continuity tester. If wiring is obvious, bypass the switch and see if the fan comes alive. Jiggle the switch with power on to see if it is intermittent. For multispeed fans, exact replacements may be required. For single speed fans, switches should be readily available at hardware stores, home centers, or electrical supply houses.

- **Bad or reduced value motor start/run capacitor:** This might result in slower than normal speed or lack of power, a fan that might only start if given some help, or one that will not run at all.

  For an existing installation that suddenly stopped working, a bad cap is a likely possibility. An induction motor that will not start but will run once started by hand usually indicates a loss of power to the starting (phase) winding which could be an open or reduced value capacitor.

  This is probably a capacitor-run type of motor where the capacitor provides additional torque while running as well. Therefore, even starting it by hand with the blades attached might not work. With the blades removed, it would probably continue to run. Of course, this isn't terribly useful!

- **Bad motor:** If all speeds are dead, this would imply a bad connection or burned winding common to all speeds. There might be an open thermal fuse - examine in and around the motor windings. A charred smelly motor may not require further testing. A partially shorted motor may blow a fuse or trip a circuit breaker as well or result in a loud hum and no or slow operation as well.

Schematics for some typical ceiling fans can be found at Gary Tait's Ceiling Fan Wiring Diagrams Page. **Mechanical:**

- **Noise and/or vibration:** Check that fan blades are tight and that any balance weights have not fallen off. Check for worn or dry bearings. Check for sheetmetal parts that is loose or vibrating against other parts. Tighten screws and/or wedge bits of plastic or wood into strategic spots to quiet it down. However, this may be a symptom of an unbalanced fan, loose fan blade, or electrical problems as well. Check that no part of the rotating blade assembly is scraping due to a loose or dislodged mounting.

- **Sluggish operation:** Blades should turn perfectly freely with power off. If this is not the case, the bearings are gummed up or otherwise defective. Something may be loose and contacting the casing. (This would probably make a scraping noise as well, however).

Lubricating ceiling fans

(From: Chris Chubb (cchubb@ida.org).)

I use synthetic transmission lube, 80-130 (manual gearbox, not automatic transmission fluid which is very thin --- sam). I imagine that any similar lubricant, synthetic or not, would work as well, but the synthetic flows down in better and works well.

Do not use WD-40, 3-in-1 oil or any other lightweight oil. Motor oil is good as well, but it does not stick to the bearings as well. DO NOT use automatic transmission fluid - extremely thin.

Grease would be perfect, white lithium, divine! But, getting the grease down into the bearings would be very difficult.

Just about three or four drops should be all it takes. Getting it on the lower bearings of the ceiling fan will be tough. I have an oil can that I pump a drop to the tip of, then hold it against the bearings until they wick the oil inside. This is very slow. It takes about 15 minutes per fan to oil, clean the top of the blades, oil a little around the hanging ball, pull the globe off and clean the globe inside, and make sure everything is OK.

Variable speed ceiling fan on normal circuit

It is usually not possible to use a normal light dimmer to control the fan as this uses an AC induction motor. A dimmer can only be used on the built in light if a separate wire is available to power it.

Doing this will likely result in a nasty hum or buzz at anything other than full brightness (speed) or off. This is both annoying and probably not good for the fan motor as well. A dimmer works by reducing the power to the light by controlling when the voltage is applied on each cycle of the AC. If it is turned on half way through the cycle half the power is provided, for example. However, with cheap lamp dimmers, this results in sharp edges on the waveform rather as peak voltage is applied suddenly rather than with the nice smooth sinusoid. It is these sharp edges causing the coils or other parts of the fan to vibrate at 120 Hz that you are hearing.

Special speed controls designed for ceiling fans are available - check your local home center or ceiling fan supplier.

Here is another alternative:

(From: Rick & Andrea Lang (rglang@radix.net).)

Here's a potential solution if you don't mind spending a little more for a ceiling fan (If you already have one in that location, perhaps you can put it in another room). Ceiling fans with remote control are now available. They only require power to the ceiling fan (2 wire) and a remote control. With the remote you can dim the lights, slow the fan or both. You can then use the existing new wall switch as a power ON/OFF switch also. If you choose this route, be careful of interference with garage door openers. Usually, the remotes have at least 4 frequency selections to help avoid interference with other remote systems. I put one in that three of the four frequencies opened the garage door. I lucked out on the 4th one!

Throbbing noise from ceiling fan

This could be due to a mechanical problem - bad bearings or blades out of balance - or an electrical problem with the speed control.

(From: David Buxton (David.Buxton@tek.com).)

A quickie test. Get the fan turning at a speed that demonstrates the throbbing noise. Come up with a way to instantly remove power to the fan. If the noise continues for a little bit until the fan has slowed down enough, then you know the noise is in the mechanical dynamics, perhaps blades out of balance. If the noise quits instantly with power removal, then you need a better speed control better designed for fan motor control.

Ceiling fan motor speed control and capacitor replacement

(From: Kevin Astir (kferguson@aquilagroup.com).)

Ceiling fans are normally multipole, capacitor-run types. They normally run fairly close to stalled, the blades being big enough that the motor never gets anywhere near synchronous speed.

Speed control in three speed types is by switching the value of the cap in series with the quadrature windings. The caps normally have two sections of 3 and 6 uF, with a common connection between the two sections allowing connections of 3, 6, or 9 (3 in parallel with 6) uF total.

I have seen some caps of slightly different value, but they should be close, just translate my 3 and 6 to what you actually have in what follows.

The higher the capacitance the higher the stall torque, so the faster the fan runs against the non-linear (square-law) torque vs. speed characteristic of the blades. (remember I said it is always pretty much stalled)

If you miswired the cap, then you may be getting 3 or 6 and 2 (3 in *series* with 6 uF which would result in low speeds. This *is* the case if any 2 out of 3 speeds seem to be the same. The replacement caps are usually marked with what terminal is which, but originals often are not. I don't know if there is a standard color code, but manufacturers are under no obligation to adhere to it even if there was. If you are totally lost, there are only 6 possible ways to connect the capacitor. 2 of these will give you all 3 speeds (but one in wrong order). So if you keep good notes (essential here) then you could try all possibilities in 20 minutes or so...yes, you're probably working with hands over head, what you wanted easy too?

OK, here is how to get it in 3 tries max:

Identify the "common" capacitor lead (connects to both 3, and 6 uF sections, hopefully your replacement is marked). It is currently connected to the wrong place, so swap it with one of the other cap wires. If you now have three speeds in the correct order, then your done. If you have three speeds in the wrong order, then leave common wire alone, but swap other two. (correct order is: off-hi-med-lo usually)

If you *didn't* have three different speeds following the first wire swap, then swap that common wire with the one wire you haven't moved yet. Now you should have three speeds, now correct the order as described, if needed.

If you currently have three speeds, but all are too slow, then it is likely that your fan needed a higher value capacitor. another explanation might be that the old cap was getting leaky when it warmed up after start, and letting the fan have extra current, thus giving extra speed.

In my experience, the three speed types should run from just slow enough to follow with the eye, to fast, fairly noisy, and making a fair amount of wobble on the mounting.

Continuously variable speed types put a fixed 9 or 10 uF cap in series with the quadrature winding, and regulate voltage to both windings via lamp-dimmer style triac circuit.

Mike's notes on ceiling fan installation

(From: morris@cogent.net (Mike Morris).)

Depending on what wiring you have and what new wiring needs to be installed, I would install 14/3 cables for all ceiling lights. That way, you will be able to control ceiling fan and light from two separate switches.

Each time a new light has to be installed in our house, I make sure a 14/3 wire is installed. For three-way switches, I make it two 14/3 wires, even if I don't install a ceiling fan now. A 14/3 wire is not that much more expensive, and 10 years down the road, it might be useful.

The local high-end lights-and-fans shops have a handout that recommends that wherever a ceiling fan is to go have the following wiring:

1. Neutral.
2. Ground (if local code requires it, good idea anyway).
3. Switched hot for the lights.
4. Switched hot for the fan.
5. An extra wire - some brands need 2 hots for the fan, and if your brand doesn't need it, an extra conductor doesn't hurt.

Why two switched hots?

- It allows to run the lights and fan separately.

- You should not use a lamp dimmer as a motor speed control. While it may work to some extent, the motor will likely hum and long term reliability and safety are questionable.

Note that this does not preclude using a fan with built-in controls - unused wire is just that. And pulling in 5 conductors during construction or remodeling costs just a little more that pulling in 2 or 3.

The handout sheet also point out that adding a extra brace to the ceiling during any remodeling or new construction sized for a 100 pound dead weight is a good idea - it can be as simple as a couple of feet of 2x6" lumber and a couple of sheet metal fasteners. A wobbling fan can cause fatigue in a light duty metal brace rapidly. The extra cost is minimal, and it can prevent a fan from landing in the middle of the bed!

Ceiling fan construction

The following describes a basic capacitor run split phase induction motor, though the arrangement of pole pieces and coils is unusual compared to the typical squirrel cage variety.

(From: George Eccles (geccles@ibm.net).)

I just took ceiling fan motor apart. The (center) stator has 16 coils, in 2 concentric groups of 8, arranged around the circumference of a flat disk. The groups are offset from each other by (maybe) 20 or 30 degrees. Based on resistance readings, I think one group is all wired in series. (I think) the other group is arranged in different combinations, based on the speed setting. For highest speed, I think all are in series, though I don't know what the phasing is. For the lower speeds, 1 or 2 coil pairs have their phasing reversed.

The rotor (aka the housing) has no visible windings, and no permanent magnets. AFAIK, it's just a thin ring (maybe 1/2" thick vertically, 3/4" radially) of laminated (maybe 10 or 12) strips of ferrous metal, embedded in a slightly larger aluminum casing. The laminations are not insulated from each other. Along the innner cicumference, the laminations are interrupted with weird pattern of what might be just interlocking to the aluminum casing.

Air cleaners

Simple air cleaners are just a motor driven fan and a foam or other filter material. HEPA (High Efficiency Particulate Air) types use higher quality filters and/or additional filters and sealed plenums to trap particles down to a specified size (.3 micron). A clogged (neglected) filter in any air cleaner is probably the most likely problem to affect these simple devices.

Failure of the fan to operate can be a result of any of the causes listed above in the section: Portable fans and blowers.

Electronic air cleaners include a high voltage low current power supply and oppositely charged grids in the air flow. A failure of the solid state high voltage generator can result in the unit blowing air but not removing dust and particulate matter as it should. A typical unit might have 7.5 to 10 kV at 100 uA maximum (short circuit current, probably less at full voltage). Actual current used is negligible under normal conditions. This voltage is significant but the current would be just barely detectable, if at all.

The power supplies for smaller table top devices like the AirEase(tm) Personal Space Ionization Air Cleaner from Ion Systems, Inc. would probably generate similar voltages (possibly slightly lower) but at much lower current - perhaps only, 5 to 10 uA.

The modules are usually quite simple: a transistor or other type of switching circuit driving a step-up transformer and possibly a diode-capacitor voltage multiplier. See the sections: "Electronic air cleaner high voltage module schematic" and "Auto air purifier schematic" for an example of a typical circuit.

Where there is no high voltage from such a device, check the following:

- Make sure power is actually getting to the high voltage portion of the unit. Test the wall socket and/or AC adapter or other power supply for proper voltage with a multimeter.

- Excessive dirt/dust/muck/moisture or physical damage or a misplaced paper clip may be shorting it out or resulting in arcing or corona (a strong aroma of ozone would be an indication of this). With such a small available current (only uA) it doesn't take much for contamination to be a problem. Thoroughly clean and dry the unit and check for shorts (with a multimeter between the HV electrodes and case) and then test it again. Your problems may be gone!

- If this doesn't help and the unit is not fully potted (in which case, replacement is the only option), check for shorted or open components, especially the power semiconductors.

On the topic of high voltage power supplies/transformers:

(From: Marvin Moss (mmoss@mindspring.com).)

These transformers have a very large air gap in the core and are designed to be able to operate for an extended period of time when the output is short circuited. If you get a piece of dirt or aluminum foil or something conductive in the filter, it has to bear the short until you clean the filter. I found several sources of surplus high voltage power supplies in the range of 5,000 volts at 2 mA. or so for $14.95 and bought several of them. I did in fact replace one of my two supplies in my A/Cs with this unit and it has been working perfectly for about 10 years now. The voltage is not critical but too high a voltage will create excessive ozone. Too low a voltage will not filter well. I think that 3,500 to 6,000 volts is the range but I can give you more info if you want it.

Electronic air cleaner high voltage module schematic

At least I assume this cute little circuit board is for an electronic air cleaner or something similar (dust precipitator, positive/negative ion generator, etc.)! I received the unit (no markings) by mistake in the mail. However, I did check to make sure it wasn't a bomb before applying power. :-)

This module produces both positive and negative outputs when connected to 115 VAC, 60 Hz line voltage. Each is about 5 kV at up to around 5 uA.

The AC line powered driver and HV multiplier are shown in the two diagrams, below:

```
                   D1                                            T1  o
  H o--------------|>|----+---+--------------------+               +-----o A
                 1N4007   |   |        Sidac     __|__ SCR1     ::(
                          |   |   R3  D2 100 V   _\_/_ T106B2   ::(
  AC                  C1  |   +--/\/\---|>|      / |   200 V    ::(
 Line      Power  .15 uF _|_     1.5K   |<|--+--'  |   4 A    o ::( 350 ohms
          IL1 LED   250V ---                _|_    |  +-------+ ::(
        +--|<|---+        |              C2 ---    |  |        )::(
        |   R1   |   R2   |        .0047 uF  |     |  | .1 ohm )::(
  N o---+--/\/\--+--/\/\--+                  +-----+--+        )::(
           470      3.9K  |                                +--+    +--+--o B
           1 W      2 W   |                                |    R4    |
                          +--------------------------------+---/\/\---+
                                                               2.2M
```

The AC input is rectified by D1 and as it builds up past the threshold of the sidac (D2, 100 V), SCR1 is triggered dumping a small energy storage capacitor (C1) through the primary of the HV transformer, T1. This generates a HV pulse in the secondary. In about .5 ms, the current drops low enough such that the SCR turns off. As long as the instantaneous input voltage remains above about 100 V, this sequence of events repeats producing a burst of 5 or 6 discharges per cycle of the 60 Hz AC input separated by approximately 13 ms of dead time.

The LED (IL1) is a power-on indicator. :-)

The transformer was totally potted so I could not easily determine anything about its construction other than its winding resistances and turns ratio (about 1:100).

```
                                            A o
                                     C3       |
                              +------||-------+
          R5     R6      D3   |   D4     D5   |  D6     R7       R8
  HV- o--/\/\---/\/\--+--|>|--+--|>|--+--|>|--+--|>|---/\/\--+--/\/\--o HV+
         10M    10M   |      C4       |                20K  |  10M
                      +------||-------+                      |
       D3-D6: 10 kV, 5 mA            _|_                    _|_
       C3,C4: 200 pF, 10 kV          --- C5                 --- C6
       C5,C6: 200 pF, 5 kV            |                      |
                                 B o--+----------------------+
```

The secondary side consists of a voltage tripler for the negative output (HV-) and a simple rectifier for the positive output (HV+). This asymmetry is due to the nature of the unidirectional drive to the transformer primary.

From my measurements, this circuit produces a total of around 10 kV between HV+ and HV-, at up to 5 uA. The output voltages are roughly equal plus and minus when referenced to point B.

I assume the module would also operate on DC (say, 110 to 150 V) with the discharges repeating continuously at about 2 kHz. Output current capability would be about 5 times greater but at the same maximum (no load) voltage. (However, with DC, if the SCR ever got stuck in an 'on' state, it would be stuck there since there would be no AC zero crossings to force it off. This wouldn't be good!)

This module is probably for a device similar to the AirEase(tm) Personal Space Ionization Air Cleaner from Ion Systems, Inc. This unit has the positive output of its HV module connected to a 3/16" diameter electrode on the side of the case. This is in contact with a piece of foam (a cylinder about 2" in diameter by 5" high) which surrounds the entire unit. While it appears that this foam should be conductive, I could not detect any evidence of this with a multimeter. The negative output is connected to a 1-1/4" conductive foam disk on the top of the unit. Unfortunately, the HV module in the AirEase was totally potted so I could not determine anything about its internal circuitry.

Auto air purifier schematic

Well, maybe. :-) This thing is about the size of a short hot-dog and plugs into the cigarette lighter socket. It produces a bit of ozone and who knows what else. Whether there is any effect on air quality (beneficial or otherwise) or any other effects is questionable but it does contain a nice little high voltage circuit.

```
                                                                   DL1 +-+ |
                                                   o  T1 +-------+-----|o|
  +12 o---+--------+----------+---------------------+ ::(        |     +-+ |
          |        |          |                D 30T )::(        | DL2 +-+
          |        |        -_|_ 4.7uF           #30 )::(        +-----|o| |
          |        |         --- 50V         +------+ ::( 3000T  |     +-+
          |       _|_ C2    + |              |        ::( #44    | DL3 +-+ |
          |       --- 470pF   +--------------|------+ ::(        +-----|o|
          |        |          |              | F 30T )::(        |     +-+ |
        +_|_ C1    |          |       D1     |   #36 )::(        | DL4 +-+
         --- 33uF  +----------|---+---|<|----|------+ ::(        +-----|o| |
        - |  16V   |          |   | 1N4002   |     o     +--+          +-+
          |        /          /   |        |/ C           o |              |
          |     R1 \       R2 \   +--------|Q1  TIP41       +--------------+
          |     1K /     4.7K /            |\ E             |            Grid
          |        \          \              |              |
          |        |          |              |              |
  GND o---+--------+----------+--------------+--------------+
```

T1 is constructed on a 1/4" diameter ferrite core. The D (Drive) and F (Feedback) windings are wound bifilar style (interleaved) directly on the core. The O (Output) winding is wound on a nylon sleeve which slips over the core and is split into 10 sections with an equal number of turns (100 each) with insulation in between them.

DL1 to DL4 look like neon light bulbs with a single electrode. They glow like neon light bulbs when the circuit is powered and seem to capacitively couple the HV pulses to the grounded grid in such a way to generate ozone. I don't know if they are filled with special gas or are just weird neon light bulbs.

Bug zappers

You know the type - a purplish light with an occasional (or constant) Zap! Zap! Zap! If you listen real closely, you may be able to hear the screams of the unfortunate insects as well :-).

The high-tech versions consist of a high voltage low current power supply and fluorescent (usually) lamp selected to attract undesirable flying creatures. (Boring low-tech devices may just use a fan to direct the insects to a tray of water from which they are too stupid to be able to excape!)

However, these devices are not selective and will obliterate friendly and useful bugs as well as unwanted pests.

Here is a typical circuit:

```
         S1        R1         C1            C2            C1-C4: .5 uF, 400 V
  H o----o/ o--+--/\/\--------||---+--------||---------+  D1-D5: 1N4007
               |  25K        D1    |   D2        D3    |   D4
               |          +---|>|---+---|>|---+---|>|---+---|>|---+
              +-+         |        C3        |        C4        |
 AC Line      |o| FL1     +---+----||----+----+---+----)|----+----+--o +
              +-+ Lamp    |   |    R3    |        |    R4    |       500 to
               |          |   +---/\/\---+        +---/\/\---+       600 V
               |   R2     |       10M                  10M           to grid
  N o----------+--/\/\---+-------------------------------------------o -
                  25K
```

This is just a line powered voltage quadrupler. R1 and R2 provide current limiting when the strike occurs (and should someone come in contact with the grid). The lamp, FL1, includes the fluorescent bulb, ballast, and starter (if required). Devices designed for jumbo size bugs (or small rodents) may use slightly larger capacitors!

(From: Jan Panteltje (pante@pi.net).)

I have one, bought it very cheap: they are only $10 here :)

It comes with a 25 W blue lamp inside, with wires around it. The lamp did not last long, so I replaced that with a 7 W electronic fluorescent type, that now just keeps going and going and going. The bugs do not care, they just go for the light. Then they hit the wires.

Here, we have 230 V, in the lamp is a voltage doubler, with 2, 220 nF capacitors, 2 silicon diodes, and a 10 K Ohm series resistor in the mains. The whole thing cannot be touched by humans from outside. The voltage between the wires is something like 620 V. If an insect shorts the wires, the 10K limits the current until it is destroyed (the insect that is). The insect actually explodes, the 600 V cap discharges into it.

(From: (Abe Shultx) abe_shultz@hotmail.com).)

I grabbed a bug zapper from someone's garbage and opened it up. Instead of a voltage multiplier, there was a transformer. It had a capacitor across the output, and threw an approximately 3/4 inch loud blue arc. I don't know the cap values, because it was potted. :-(

Electric fences

Yes, I know, this isn't a common small appliance but....

(From: John Harvey (johnharvey@bigpond.com).)

Most DIY fence energizers use an automotive ignition coil and kits (generally minus coil) are available in Australia and probably elsewhere.

Commercial units operate on the capacitor discharge principle and are fired at a 1.2 second interval. Voltage O/P needs to be around 5 to 8 kV (which will drop under load). The energy O/P (pulse duration) is determined by the capacitor and 10 to 20 uF is about right for a small unit (up to 2km or so). They must use a pulse grade capacitor (which has a high dV/dt) to be reliable.

Appliance and light timers

There are two basic types: mechanical and electronic.

- Mechanical timers are simply a synchronous timing motor and gear reducer controlling a two prong (usually polarized) outlet.

  The most common problems relate to failure of the timing motor or gear train. With time, the oil and grease used inside the timing motor may gum up. Eventually, it gets so stiff that the motor stops - or more likely - doesn't start up after a power failure or the unit has been unplugged for a while.

  The cheap plastic gears may also break, chip, or loose teeth.

  Sometimes, disassembly, cleaning, and lubrication, will get the motor going - possibly for a long time. However, replacement parts are rarely worth the cost compared to a complete new timer.

- Fully electronic timers use digital clock-type circuitry to control a triac or other solid state switching device.

  These may fail in the same way as other electronic controls such as dimmers. Most likely problems are that they are either stuck off or stuck on. Aside from testing for bad connections or shorted or open components (with power OFF or disconnected!), repair is probably economical. Assuming it can be opened non-destructively at all, check the triac and other parts in its vicinity. The rest of the circuitry is probably in a proprietary chip - but these don't fail much.

  Also see the section: Warnings about using compact fluorescent lamps on electronic timers.

Warnings about using compact fluorescent lamps on electronic timers

You may have seen these warnings in the instructions or on the package of electronic (not mechanical) timers and/or compact fluorescents.

There are two issues:

1. Providing the trickle current to operate the clock circuitry in the timer.

   Where a solid state timer is used to replace a normal switch, there is usually no connection to the Neutral so it must derive all its operating power from current through the load (though at a very low current level).

   The type of circuitry in a compact fluorescent with an electronic ballast (or other equipment with a switching power supply like a TV, some VCRs, computer, etc.) may result in this current being too low or erratic. The result will be that the timer doesn't work properly but damage isn't that likely (but no guarantees).

   If it is installed with 3 wires (Hot, Neutral, Load), then this should not be a problem.

   In addition, interference (e.g., spikes) from the CF ballast may feed back into the electronic timer and this may either confuse or actually result in failure.

2. Damage to either or both of the devices dues to incompatibility.

The solid state switching device - usually a triac - in the timer unit may be blown by voltage spikes or current surges when the power goes on or off into an inductive or capacitive load like an electronic ballast (or normal magnetic ballast, for that matter.

In short, read and follow label directions! Although a given combination may actually work reliably for years even if it is not supposed to but you should be able to find a pair for which this shouldn't be a problem.

Wall thermostats

These can be divided into several classes depending on:

- Normal or setback (electronic or electromechanical).
- 24 VAC or self powered (thermopile or thermocouple) valve control.
- Heating, airconditioning, or combination.

It is not possible to cover all variations as that would require a complete text in itself. However, here is a summary of possible problems and solutions.

Conventional thermostats usually use a bimetal strip or coil with a set of exposed contacts or a mercury switch. In general, these are quite reliable since the load (a relay) is small and wear due to electrical arcing is negligible. On those with exposed contacts, dirt or a sliver of something can prevent a proper connection so this is one thing to check if operation is erratic. The following description assumes a single use system - heating or cooling - using 24 VAC control which is not properly controlling the furnace or air conditioner.

1. Locate the switched terminals on the thermostat. Jumper across them to see if the furnace or air conditioner switches on. If it does, the problem is in the thermostat. If nothing happens, there may be a problem in the load or its control circuits. Cycle the temperature dial back and forth a few times to see if the contacts ever activate. You should be able to see the contacts open and close (exposed or mercury) as well.

   (**CAUTION:** on an air conditioner, rapid cycling is bad and may result in tripped breakers or overload protectors so ideally, this should be done with the compressor breaker off).

2. Check for 24 VAC (most cases) across the switched circuit. If this is not present, locate the control transformer and determine if it is working - it is powered and its output is live - you may have the main power switch off or it may be on a circuit with a blown fuse or tripped breaker. I have seen cases where the heating system was on the same circuit as a sump pump and when this seized up, the fuse blew rendering the heating system inoperative. Needless to say, this is not a recommended wiring practice. The transformer may be bad if there is no output but it is powered. Remove its output connections just to make sure there is no short circuit and measure on the transformer again.

3. If 24 VAC is present and jumpering across the terminals does nothing, the heater valve or relay or air conditioner relay may be bad or there is a problem elsewhere in the system.

4. Where jumpering the terminals turns on the system, the thermostat contacts may be malfunctioning due to dirt, corrosion, wear, or a bad connection. For a setback unit, the setback mechanism may be defective. Test and/or replace any batteries and double check the programming as well. On those with motor driven timers operating off of AC, this power may be missing.

5. Where jumpering the terminals does not activate the system, check the load. For a simple heating system, this will be a relay or valve. Try to listen for the click of the relay or valve. If there is none, its coil may be open though in this case there will be no voltage across the thermostat contacts but the 24 V transformer will be live. If you can locate the relay or valve itself, check its coil with an ohmmeter.

6. If the previous tests are ok, there may be bad connections in the wiring.

Some additional considerations:

> **Type of control:**Most systems use a 24 VAC circuit for control. However, some use low voltage self powered circuits that require special compatible (sometimes called thermopile or thermocouple) thermostats with low resistance contacts and no electronics directly in series with the control wires. Erratic or improper control may result from using the wrong type.
>
> **Setback thermostats:** These may be controlled electromechanically by a timer mechanism which alters the position of the contacts or selects an alternate set. Newer models are fully electronic and anything beyond obvious bad connections or wiring, or dead batteries is probably not easily repaired. However, eliminate external problems first - some of these may need an additional unswitched 24 VAC or 115 VAC to function and this might be missing.
>
> **Heat anticipators:** In order to reduce the temperature swings of the heated space, there is usually a small heating element built into the thermostat which provides some more immediate feedback to the sensor than would be possible simply waiting for the furnace to heat the air or radiators. If this coil is defective or its setting is misadjusted, then erratic or much wider than normal temperature swings are possible. There will usually be instructions for properly setting the heat anticipator with the thermostat or furnace.

Units that control both heating and airconditioning are more complex and will have additional switches and contacts but operate in a similar manner and are subject to similar ailments.

Testing a thermostat

Where a heating appliance doesn't come on or go off as it should, a bad thermostat is possible.

- Failure to run could also be due to any number of other causes: bad wiring; defective motor/compressor or heating element, open thermal fuse, protector, or case interlock; and of course, no power! Easiest test is to jumper across the contacts of the thermostat (do this with the plug pulled!) and then plug in the appliance to see if it will run. CAUTION: This assumes a single set of contacts as with a space heater.

- Failure to cycle where the heating/cooling is operating correctly is very likely thermostat related. However, it just may be set too high or on 'continuous run', or the interior of the appliance may just need a proper cleaning (or defrosting) - the cold or heat may not be reaching the thermostat!

Most thermostats in refrigerators and freezers, air conditioners, heating systems, hot plates, fryers, and the like, are simple on/off switches activated by the bending of a bimetal strip (due to the differing expansion coefficients of the two types of metal) or by the expansion of a liquid filled bulb or capillary (often in cooling appliances).

- For motor driven appliances like air conditioners, there should be a distinct 'click' as the contacts open and close around the set-point. This snap action minimizes arcing at the contacts. And, there should be some 'hysteresous - the knob should have to be turned back somewhat past where it switched on for it to turn off and vice-versa.

- For heating appliances like waffle irons and toaster-ovens, there may be no click or very much hysteresous but it should be possible (see below) to determine that the contacts open and close reliably.

- If something seems broken or loose inside, the thermostat is probably bad.

Basic tests can be done with a container of hot, cold, or freezing water (depending on the application) and a multimeter (to check for the closing and opening of the contacts if it isn't visually or audibly obvious.

Fully open mechanisms (no enclosed switches) can be totally dunked in the water as long as they are dried thoroughly afterwards. This should be avoided where the bimetal activates an enclosed 'microswitch' since it is difficult to be sure of removing all the trapped water.

To test an air conditioner thermostat, for example, turn the knob to the highest (coldest) setting. The contacts should be closed. Then, cool the bimetal strip off with cold tap water. The contacts should open. The range can be determined with a thermometer and various combinations of hot and cold water.

- If resistance measurements are erratic - there should be no readings between 0 and infinity - but the contacts appear to be closing and opening properly (if visible or distinct click is heard), contact cleaner may help, at least temporarily. For enclosed switches, it may be possible to spray in through an existing opening or drill a tiny hole in the plastic case for this purpose.

- Where the contacts (if visible) are seriously pitted or burned, a temporary repair may be possible using a fine file or sandpaper but replacement will be needed. However, these drastic measures should be used as a last resort only - replacement will be needed.

Replacing a thermostat

The following applies to refrigerators and freezers, air conditioners, electric space heaters, as well as other small appliances.

Removing the thermostat (unplug AC line first!) and cleaning the contacts using contact cleaner NOT sandpaper or a file (except as a laser resor) - may help temporarily. Replacement is easy if the cold control is self contained using a bimetal strip. If it uses a liquid filled bulb, the tube may snake around inside the cabinet and may be more challenging. Still no big deal. An appliance part distributor or your appliance manufacturer should have a replacement.

Note that an exact replacement may not be needed as long as its electrical ratings (amps or HP) is at least as high, it is intended for the same application (e.g., freezer or space heater), the sensing element is similar, and it can be made to fit! This could come in handy if trying to repair a 30 year old air conditioner!

Electric space heaters

All types have one thing in common - they are nearly 100% efficient which means that just about every watt of power utilized is turned into heat. The remainder is used for any built in fans or the wasted light produced by glowing elements or quart lamps.

However, this does not mean that these are the most economical heating devices. Heat pumps based on refrigeration technology can be much less costly to run since they can have coefficients of performance - the ratio of heat output to energy input - of 3 or more to 1. Thus, they are in effect, 300% or more efficient. Note that this does not violate any conservation of energy principles as these simply move heat from one place to another - the outdoors is being cooled off at the same time.

Space heaters come in 3 common varieties:

- Radiant - heating element with polished reflector.
- Convection - heating element and small fan to circulate heated air.
- Oil filled radiator - heating element heats oil and metal fins.

Problems with space heaters are nearly always related to bad heating elements, problems with the thermostat, interlock switches, or fan (if any), or bad connections. Blown fuses or tripped circuit breakers are very common with these appliances as they are heavy loads - often the maximum that can safely be plugged into a 15 A outlet - and thus overloads are practically assured if **anything** else is used on the same circuit. Since we rarely keep track of exactly what outlets are on any given circuit, accidentally using other devices at the same time are likely since the same circuit may feed outlets in more than one room - and sometimes some pretty unlikely places.

Radiant space heaters

These use a coiled NiChrome, Calrod(tm), or quartz lamp heating element. There is no fan. A polished reflector directs the infra red heat energy out into the room. Radiant space heaters are good for spot heating of people or things. They do not heat the air except by convection from the heated surfaces.

Of course, first check that the outlet is live.

As with other heating appliances, the most likely problems are with burned out heating elements; defective on/off switches, thermostats, or safety interlock or tip-over switches, bad cord or plug, or bad wiring connections. Your continuity checker or ohmmeter will quickly be able to identify which of these are the problem.

Warning: do not be tempted to bypass any interlock or tip-over switches should they prove defective. They serve a very important fire and personal safety function. Never, ever cover the heater in any way as a serious fire hazard will result.

Convection space heaters

A small fan blows air over or through a heating element. This may be a NiChrome coil, Calrod(tm) element, or ceramic thermistor. This type is probably the most popular since it can quickly heat a small area. The ceramic variety are considered safer than the others (of this type) since they are supposed to operate at a lower surface temperature.

In addition to the problems covered in the section above: "Radiant space heaters", the fan can also become sluggish or seize up due to gummed up lubrication (as well as other fan-motor problems). Since it is running in a high temperature environment, disassembly, cleaning, and lubrication may be needed periodically despite what the manufacturer may say about permanently lubricated parts.

Oil filled electric radiators

These are also considered convection heaters but they do not have any fan.

The typical unit consists of a pair of heating elements providing 600, 900, or 1500 Watts depending on which are switched on. A simple bimetal adjustable thermostat is used for temperature control. The heating elements are fully submerged and sealed inside an oil filled metal finned replica of an old style radiator. The whole affair is mounted on wheels as it is quite heavy.

Depending on design, there may be one or two thermostats (oil and air) in addition to thermal and electrical protection devices.

Common problems with these have been the pair of power switches which tend to fail resulting in no or erratic operation. Note: if your heater is a Delongi, there has been a free (well $5 S&H) upgrade to replace the failure prone power switches and air temperature thermostat on some common models.

The heating elements are replaceable (as a set). Since they are immersed in the oil, you MUST have the radiator on its end with the terminals straight up while changing them or else there will be a mess. Replacement will be worth the cost and effort only if you require the high settings as it is unlikely for both elements to fail. If testing reveals an open element, you will just not have the heat ranges that use it. If an element shorts to the case, it must be disconnected to prevent a shock hazard though the other one can still be safely used. Parts should be available.

So, what about the Pelonus Disk furnace?

(From: Kirk Kerekes (kkereke@iamerica.net).)

It is a portable electric heater, using high-power thermisters as the heating elements. This technology was originally developed by TDK a few decades ago. The premise is that the power thermisters will automatically control the heating element temperature (the thermister), so that if the air flow is blocked, the heater won't cook. The manufacturers make efficiency claims, but these seem to be bogus. (All space heaters are nearly 100% efficient. See the section: Electric space heaters --- Sam.)

I have a bathroom version of this device, and it works.

Electric pencil sharpeners

AC powered pencil sharpeners consist of a small shaded pole induction motor, pencil sense switch, and some gears and cutter wheels. Aside from pencil shavings crudding up the works - which can be cleaned - the most common failure is of the cheap plastic gears. These can be easily be replaced if you can get them - the original manufacturer is likely the only source. The switch contacts may become dirty or level/bar may become misaligned or worn. Some clever repositioning or the addition of a shim may help in these cases.

Battery operated pencil sharpeners use a small DC motor for power. These tend to be whimpier than their AC counterparts but all other comments apply. Always try a fresh set of batteries first.

Blenders

A blender really is just a high speed motor mounted inside a base. Units with 324 speeds accomplish (this more or less useless marketing gimmick) through a combination of diodes, resistors, and multiple windings on the motor. Without addressing the ultimate utility of thousands of speeds, problems with these units are more likely to be in the motor itself - open or shorted windings, or bad bearings. However, the selector switches and electrical parts can fail as well.

The motors are typically of the series wound universal type. These have carbon brushes which are prone to wear. However, given the relatively short total usage of a blender, this is not usually a problem.

Disconnecting (and labeling!) connections one at a time may permit the source of a problem to be localized. Diodes can be tested with a multimeter (they should read open in one and only one direction) and resistors checked as well. Shorts in a motor with multiple taps on its windings may be difficult to identify or locate. Shorted windings can result in overheating, incorrect speeds, or even a blender that runs with the power switch supposedly in the off position as the wiring is sometimes sort of strange!

Bad bearings will result in any number of mechanical problems including excessive or spine tingling noise, vibration, a seized rotor or very sluggish rotation. Sometimes, disassembly, cleaning, and oiling will be effective but since these rotate at high speed, don't count on it. Unfortunately, cheap bronze bushings are often used instead of ball bearings. However, substituting a set from another similar unit might work since it is usually the bronze bushing and not the motor shaft that fails.

The most sophisticated units will have a variable speed control - similar to a light dimmer. If this goes bad - the blender always runs at full speed - then the active element (triac) has probably blown. Replacement is possible and the part types should be readily available.

Drip coffee makers

A drip coffee maker consists of several components:

1. **A heating element:** Combined or separate Calrod(tm, usually) types for operating the drip pump and then keeping the coffee warm.

2. **Thermal protector:** To prevent excess temperatures.

3. **Some kind of water interlock:** Prevents dripping when separate reservoir is used.

4. **Timer or controller:** The simplest are mechanical while programmable units with clocks and electronic timers are also available.

Many problems are be mechanical - clogged water passages or interlock. Extended use with hard/high mineral content water can also result in reduced heating effectiveness and/or increased heating times. It may be possible to flush the unit a couple of times with viniger.

If there is no heating, check the element and thermal protector with an ohmmeter. If the element is open, it is probably time for a new coffee maker. The thermal protectors can be replaced but the underlying cause may be a defective, shorted overheating element so it may not be worth the trouble. Timers can develop bad contacts and bad connections are possible on electronic controller circuit board wiring.

Drip coffee maker repair

(From: Niels Henriksen (ap294@FreeNet.Carleton.CA).)

I wish I had thought of this sooner rather than throwing out the first coffee maker and I had planned to throw this one out. For some reason I thought I would just look inside to see what was up.

Where I live the water is hard (well) and there is constant scaling and buildup of calcium. We heard that all you have to do is to run a mixture of vinegar through the coffee maker to rejuvenate.

A friend and the 2 of ours all started to leak very badly when the vinegar/water mixture when through. I though that the internal plumbing had corroded through the metal parts and the vinegar dissolved the calcium that was protecting the holes and therefore unrepairable. Who knows where these ideas come from.

Now for the technical solution.

The element that is used to boil the water and uses the bubbles to bring hot water to top of coffee maker is the same element that is used to keep the pot warm.

There is a metal tube attached to the metal warming element and this unit has a heating element embedded. There are 2 rubber hoses attached. One brings cold water to heater and the other brings boiling water to top. The cold water tube has a check valve that prevents the bubbling water from going to cold water reservoir.

When vinegar is added the calcium scales start to dissolve and in 3 of 3 so far, this blocked the metal tube. The water starts to boil and since the cold water inlet has a check valve the water pressure can only buildup to where the rubber tube is blown off the metal pipe. No damage to parts.

To fix:

1. Take bottom off to gain access to heater area.

2. Remove rubber tubes which are connected with spring clamps.

3. Run rubber tubes through your fingers to loosen scale buildup and flush out

4. Push a thin copper wire or other bendable wire through heating tube. This is to unblock and loosen some scale.

5. Pour straight vinegar into metal tube to dissolve calcium and use wire to loosen.

6. Repeat several times till clean.

7. Re-attach all parts and use.

The solution is to start a regular process of using vinegar BEFORE the calcium has buildup to the point where when loosened it will block the tube.

Coffee percolators

While largely replaced by the drip coffee maker, these are still available, particularly in large sizes. The components are similar to those in a drip coffee maker - element, thermal protector, possibly a thermostat as well. The element and bottom of the water/coffee container are likely one piece to provide the best thermal conduction for the 'pump' in the middle. Even if the element is removable, it may not be worth the cost of replacement except for a large expensive unit.

Electric kettles

These consist of a heating element, thermal protector, and possibly a thermostat and/or timer. See comments for coffee makers.

Electric (motor driven) clocks

While line operated clocks have mostly been superseded by electronic (LED or LCD) clocks on nearly every kitchen appliance, many of these are still in operation on older clock radios and ranges.

AC operated clocks depend on the AC line frequency (60 Hz or 50 Hz depending on where you live) for time keeping. The accuracy of a line operated clock is better than almost any quartz clock since the long term precision of the power line frequency is a very carefully controlled parameter and ultimately based on an atomic clock time standard.

Therefore, most problems are related to a clock motor that does not run or will not start up following a power outage. Once running, these rarely fail.

The most common problems are either gummed up oil or grease inside the motor and gear train, broken gears, or broken parts of the clock mechanism itself. See the sections on "Synchronous timing motors" for repair info.

Battery operated quartz clocks usually operate on a 1.5 V Alkaline cell (do not replace with NiCds as they do not have a long absolute life between charges even if the current drain is small as it is with a clock).

First, test the battery. Use a multimeter - usually anything greater than 1 V or so will power the clock though if it is closer to 1 V than 1.5 V, the battery is near the end of its life. The clock may run slow or fast or erratically on a low battery.

With a good battery, failure to run properly is usually mechanical - one of the hands is hitting against the glass front or something like that. Don't forget to check any on/off switch - these are not expected but are often present presumably to permit you to start the clock at precisely the right time. I had one case where the fine wire to the solenoid that operates the once per second clock mechanism broke and had to be resoldered but this is exceedingly rare.

If the clock consistently runs slow or fast with a known good battery, there is usually a trimmer capacitor that can be adjusted with a fine jeweler's straight blade screwdriver. Without test equipment the best you can do is trial and error - mark its original position and turn it just a hair in one direction. Wait a day or week and see if further adjustment is needed (right, like you also won the lottery!) and fine tune it.

If the hands should fall off (what a thought!), they can usually be pressed back in place. Then, the only trick is to line up the alarm hand with the others so that the alarm will go off at the correct time. This can usually be done easily by turning the hour hand counterclockwise using the setting knob in the rear until it is not possible to turn it further. At this point, it is lined up with the alarm hand. Install all hands at the 12:00 position and you should be more or less all set.

Rotisseries

The mechanism consists of a shaded pole induction motor and gear train. Clean and lubricate the gears. See the section: Shaded pole induction motors for motor problems.

Electric can openers and knife sharpeners

There consist of a shaded pole induction motor, gear train. and power switch. Likely problems relate to broken gear teeth, dirty or worn power switch, dull cutting wheel, and broken parts. Lubrication may be needed if operation is sluggish. Parts that come in contact with the cans and lids collect a lot of food grime and should be cleaned frequently.

Electric carving knives

A small motor operates a pair of reciprocating mounts for the blades.

AC powered carving knives include a momentary power switch, small motor (probably universal type), and some gearing. Congealed food goo as well as normal lubrication problems are common. The power switch is often cheaply made and prone to failure as well. The cord may be abused (hopefully not cut or damaged by careless use of the knife!) and result in an intermittent connection at one end or the other. For motor problems, see the appropriate sections on universal motors.

For battery powered knives, bad NiCds cells are a very likely possibility due to the occasional use of this type of appliance.

See the section: Small permanent magnet DC motors and the document: AC Adapters, Power Supplies, and Battery Packs for information on repair.

Electric scissors

Similar to electric carving knives except for the linkage to the blades. All other comments apply.

Portable and stationary food mixers

These consist of a universal motor which usually features a continuously variable speed control or a selection of 3 to 5 speeds, a gearbox to transfer power to the counter-rotating beaters, and a power switch (which may be part of the speed control).

Sluggish operation may be due to cookie dough embedded in the gearing. Fine particles of flour often find their way into the gears - clean and lubricate. There may be a specific relationship that needs to be maintained between the two main beater gears - don't mess it up if you need to disassemble and remove these gears or else the beaters may not lock in without hitting one-another.

The speed control may be a (1) selector switch, (2) mechanical control on the motor itself (a governor/spring/switch arrangement), or (3) totally electronic. Parts may be replaceable although, for portables at least, a new mixer may make more sense.

For sluggish operation (non-mechanical), sparking, burnt smells, etc., see the section: Problems with universal motors.

Food processors

A powerful universal motor is coupled to interchangeable cutters of various types. In most respects, food processors are similar to any other universal motor driven appliance with one exception: There will be a safety interlock switch to prevent operation unless the cover is on properly and secured. This switch may go bad or its mechanical position adjustment may shift over time resulting in difficulty in engaging power - or a totally dead unit.

As usual, cord and plug problems, bad bearings, burnt motor windings, and broken parts are all possibilities.

Steam and dry irons

Most modern irons (does anyone really use these anymore?) can be used dry or with steam.

An iron consists of a sole plate with an integrated set of heating coils.

Steam irons will have a series of holes drilled in this plate along with a steam chamber where a small amount of water is boiled to create steam. A steam iron can be used dry by simply not filling its reservoir with water. Those with a spray or 'shot of steam' feature provide a bypass to allow hot water or steam to be applied directly to the article being ironed.

Over time, especially with hard water, mineral buildups will occur in the various passages. If these become thick enough, problems may develop. In addition, mineral particles can flake off and be deposited on the clothes.

A thermostat with a heat adjustment usually at the top front of the handle regulates the heating element. This is usually a simple bimetal type but access to the mechanism is often difficult.

Where an iron refuses to heat, check the cord, test the heating element for continuity with your ohmmeter, and verify that the thermostat is closed.

An iron that heats but where the steam or spray features are missing, weak, or erratic, probably has clogged passages. There are products available to clear these.

Newer irons have electronic timeout controllers to shut the iron off automatically if not used for certain amount of time as a safety feature. Failure of these is not likely and beyond the scope of this manual in any case.

When reassembling an iron, take particular care to avoid pinched or shorted wires as the case is metal and there is water involved - thus a potential shock hazard.

Toasters

In addition to a fine heating element, there is a controller to determine the length of time that the bread (or whatever) is heated. A solenoid or bimetal trip mechanism is used to pop the bread up (but hopefully not totally out) of the toaster then it is 'done' and turn off the heating element at the same time.

Since most of these are so inexpensive, anything more serious than a broken wire or plug is probably not worth repairing. The heating element may develop a broken spot - particularly if something like a fork is carelessly used to fish out an English muffin, for example. (At least unplug it if you try this stunt - the parts may be electrically live, your fork is metal, you are touching it!). They may just go bad on their own as well.

Being a high current appliance, the switch contacts take a beating and may deteriorate or melt down. The constant heat may weaken various springs in either the switch contact or pop-up mechanism as well. Sometimes, some careful 'adjustment' will help.

Controllers may be thermal, timer based, or totally electronic. Except for obvious problems like a bent bimetal element, repair is probably not worth it other then as a challenge.

Automatic toaster will not drop bread

If it really is old, then your problem is almost certainly mechanical - a spring sprung or gummed up burnt raisin bread. You will have to do a little investigative research meaning: take the thing apart! Try to determine what the bread does to cause the support to drop down. It is possible that putting the bread in is supposed to trip a microswitch which activates a solenoid, and the switch or solenoid is now defective - bad contacts or broken wires, bad coil in the solenoid, or grime.

The following applies directly to several Sunbeam models (and no doubt to many others as well).

(From: John Riley (jriley@calweb.com).)

I will assume that the toaster is either a model ATW or possibly an older model 20 or the like.

When you drop the bread in the toaster it trips a lever that is attached to the bread rack. This lever pushes in on the contacts inside of the thermostat (color control switch) which actually turns the toaster on. In "most cases" adjusting the screw on the bottom of the toaster will do the trick. The proper adjustment is to adjust the carriage tension so that the bread rack in the side where it marked for a single slice of bread comes just to the uppermost limit of its travel. Any more is overkill.

If you have adjusted it as mentioned above and it still won't go down, there is one more thing you can try. Take the toaster a sort of BUMP it down onto the table rather firmly. Sometimes a piece of crumb will get in between the thermostat contacts. A couple of good "bumps" on the table will usually dislodge the particle.

If all of the above doesn't work, and you know the cord isn't bad, them you may very well have a thermostat that has gone south. They are still available for replacement on most models. Suggest you check with your local SUNBEAM AUTHORIZED SERVICE for price and availability.

Toaster oven (broilers)

I really liked the old original style GE toaster oven. It was very versatile and convenient for baking and toasting. The newer types seem to have lost some of these qualities. The pop open door and oven tray have apparently not been retained in any modern models that I am aware of.

Modern toaster oven (broilers) use Calrod style elements - usually two above and two below the food rack. Depending on mode, either just the top (top brown/broil), just the bottom (oven), or both sets (toast) will be energized. Each pair may be wired in series meaning that a failure of one will result in both of the pair being dead. Very old units may use a coiled

NiChrome element inside a quartz tube.

Thermostats are usually of the bimetal strip variety with an adjustment knob. A cam or two on the shaft may also control main power and select the broil function in the extreme clockwise position.

There may be a mode switch (bake-off-broil) which may develop bad contacts or may fuse into one position if it overheats. These are often standard types and easily replaceable. Just label where each wire goes on the switch before removing it to take to an appliance repair parts store.

Newer models may use an electronic timer for the toast function at least. I assume it is not much more than something like an IC timer (555) operating the trip solenoid. However, I have not had to deal with a broken one as yet.

Testing is relatively straightforward. Check the heating elements, thermostat, mode switch,, cord, and plug. While replacements for heating elements and thermostats are often available, removing the old one and wiring the new one may not be straightforward - rivets may be used for fastening and welds for the wire connections. You will have to drill the rivets with an electric drill and replace them with nuts, bolts, and lockwashers. Crimp splices or nuts and bolts can be used for the wiring. Take extra care in reassembly to avoid any bare wires touching the metal cabinet or other parts as well as insulation being cut by sharp sheetmetal parts. The high temperature fiberglas or asbestos insulation is not very robust. In the end, it may not be worth it with full featured toaster oven/broilers going for $20-30 on sale.

Some more details and comments are provided in the section: Troubleshooting a toaster oven.

Troubleshooting a toaster oven

You might expect that there would be a way of obtaining a schematic. Forget it, there is no such thing. :(However, these aren't designed by rocket scientist so it should be possible to draw one out if you really need it.

Before doing this, there are basic things to check:

1. Toaster ovens usually operate in three modes:

   - Oven (both top and bottom should be on)
   - Toast (same)
   - Top brown (only top elements)

   The broiler option is similar to top brown.

   Thinking about which elements need to be powered for which mode, and whether the thermostat is involved (not for toasting), will help to narrow down the area of attack.

   If a heating element is found to be bad either by inspection or the ohmmeter check, it can be replaced though this may only make sense from a cost perspective if you have one that can be salvaged from another appliance. If the length and resistance are similar, it should work. Attaching the cut wires may be a challenge unless you are into welding. However, a mechanical connection with a screw and nut will work though for how long is anyone's guess. Also see below. Solder can't be used.

2. A typical toaster oven has 2 sets of elements - either a pair of the Calrod(tm) type, top and bottom, with each pair usually wired in series or, a coil or pair of Nichrome coils, top and bottom.

   Visually inspect the heating elements. Failure of a Calrod(tm) type often results in an external wart of blemish where the internal coil shorted and melted the cladding. Nichrome (wire) elements fail by breaking somewhere along their length.

And/or measure the resistance of each of the elements. Typical values are 10 to 12 ohms for a single Calrod type or 20 to 25 ohms for a complete Nichrome coil. (Your measurements will vary depending on the actual wattage of the oven. These values are typical in the U.S.A. for operation on 115 VAC.)

3. If the elements are good, both top and bottom, another likely place for failure are the contacts of the mode switch(es) and thermostat. Check each of these sets of contacts and make sure they are moving appropriately and decisively - I have seen the springs lose some of their springiness over time resulting in some not working. Sometimes they can be bent back into service.

4. Broken/deteriorated wiring is very common since everything gets very hot during use. All connections in a toaster oven are likely welded but you can replace them with either a nut and bolt or high temperature crimp. Soldering will also work if the location of the failure isn't too close to the elements.

5. The thermostat on some of these units senses via a riveted attachment to the oven wall. If these rivets loosen with age, the oven may run hotter than normal. Drilling them out and using nuts and bolts or pop-rivets may work in this case.

6. On newer units that have electronic controls, parts can fail but the most likely problems are probably due to cold solder joints on the little wiring board that sits in a hot area so check for these before trying to locate a datasheet for an obscure chip.

(From: Terry (tsanford@nf.sympatico.ca).)

Get a 'wire-nut' connector. Not one of the usual ones with a wire spiral inside it; but one of the ones that has a brass insert with a screw to secure the wires. See 'Note' re set screw. Throw away the plastic outer shell. Put end of the element heating wire and the end of a short piece of heat resistant wire into the wire nut brass insert and tighten the screw; real tight cos it's going to get somewhat hot! Dress the wire and/or suspend what is now your brass connector so that it is clear of everything or use some woven 'glass' heat resistant tubing to cover the connection. Repeat at other end as necessary. Probably last for quite a while. Note: Look for one that has a set-screw that can be tightened with a hexagonal 'Allen' wrench rather than a straight edge screwdriver. With these it would seem you can get the screw and therefore contact with the wires much tighter! Another connection that might work, but have not used for this is to clip the screw terminals off the end of a duff oven element and use those as screw terminals to secure a connection to the toaster heating element wire? Those oven element terminals do get hot in normal use anyway!

Circuit diagram of typical toaster oven/broiler

Here is a schematic of a typical 'dumb'toaster oven/broiler - one without a P5-1000 chip if you can believe such a thing exists. :) Most of the complexity of these simple devices is actually in the sheet metal of the toast release mechanism! Like the more elaborate unit described in the section: Circuit diagram of Toastmaster toaster oven/broiler with electronic controls, there is a knob for control of the oven/broiler functions and another for toast Light/Dark. A separate lever engages the toast function which terminates when the toast is done. You will note that other than that unit having an IC for toast timing, the basic circuits are almost the same.

Apparently, the only real difference between a "toaster oven" and a "toaster oven/broiler" is that the latter has a means of disabling the bottom heating element while in oven (non-timed) mode - and, of course, the price!

- The heating elements are either Calrod(tm) type or Nichrome wire coils, possibly enclosed in quartz tubes.
- A single knob selects OFF (full CCW, S1A open), oven temperature S1B opens at selected temperature), and

BROIL (full CW, S1C open). Some models may have a separate both/top only switch.

- The Toast Timer can be a mechanical timer and/or a bimetal or other toast temperature sensor. Individual details will vary but when the toast is ready, they will both release the Toast Lever and open S2 as well as possibly signaling with a bell. The Light/Dark control may vary time or the temperature at which toast is considered 'done'.

This diagram is not based on any particular model.

```
                  +- - - - - - + - - - - - - - + All part of Oven Control
                  :            :               :
                 S1A      S1B _:_              :        R1          R2
  AC H o--+------/ -----------o o------+---+---:-----/\/\/\/\----/\/\/\/\---+
          |  Oven Power    Thermostat  |   |   :          Top Element       |
          |                            |   |   :                            |
          |         S2 ___ Toast On    |   |  S1C       R3          R4      |
          +------------o:o-------------+   +---/ ----/\/\/\/\----/\/\/\/\---+
                        :              |     Broil      Bottom Element      |
           +-------+    :           R5 /   Top Brown                        |
       +-->| Timer |--+ :  Toast   47K \   (Full CW)   R1-R4: 8-12 ohms     |
       |   +-------+   )|| Release     /                                    |
   Light/Dark          )|| Solenoid    |   +--+ IL1 Power                   |
   Temp. Sensor       +                +---|oo|---+ Indicator               |
                      |                NE2 +--+   |                         |
  AC N o--------------+---------------------------+-------------------------+
```

Circuit diagram of Toastmaster toaster oven/broiler with electronic controls

Well, for toast, at least! :)

Aside from the CMOS IC based toast timer, this is a fairly basic design:

- Toastmaster Toaster Oven/Broiler Schematic

The toast function and oven/broiler are controlled separately. A single Power/Temperature/Broil knob controls the oven/broiler. This is entirely electro-mechanical with a conventional bimetal thermostat. Toast darkness is based only on time using CD4541B timer chip to release a manually activated Toast lever. Older 'dumber' toasters often were more sophisticated in their operation using a combination of time and temperature. Not this one.

Its conventional counterpart would be identical except using a mechanical and/or toast temperature sensor in place of the IC timer. Despite what you might think, the most likely failures are NOT in the 'high-tech' electronics but the usual burnt out heating element(s), bad cord or plug, broken wires, and tired switches.

Convection oven noise

Unlike a regular (non-microwave) oven, convection ovens are not totally silent. There is a small fan used to circulate the hot air (thus the name: convection oven). Depending on the oven's design and age, these fans may be anywhere from nearly silent to objectionably noisy.

If you notice an increase in motor noise (whining or squealing, grinding, knocking) then the motor and fan should be inspected and parts replaced if necessary. Sudden failure is unlikely but if it were to happen - seized bearings, for example -

an overtemperature thermal protector should shut down the heating element or entire oven. Some of these may not be self resetting (thermal fuse).

Hot plates, waffle irons, broilers, deep friers, rice and slow cookers, woks

These are all just a single or dual heating element, thermal protector (not all will have one), and an adjustable (usually) thermostat. As usual, check the cord and plug first, and then each of the other parts with an ohmmeter.

Where a NiChrome coil type heating element is used, a break will be obvious. If it is very near one end, then removing the short section and connecting the remainder directly to the terminal will probably be fine. See the section: Repair of broken heating elements.

For appliances like waffle irons, burger makers, and similar types with two hinged parts, a broken wire in or at the hinge is very common.

Note that since these operate at high temperatures, special fiberglass (it used to be asbestos) insulated wiring is used. Replace with similar types. Take extra care in reassembly to avoid shorted wires and minimize the handling and movement of the asbestos or fiberglas insulated high temperature wiring.

Popcorn poppers (oil type)

An Oil popper is basically an electric frying pan with a built-in stirrer and cover. The internal parts are accessed from the bottom: Heating coil, thermostat and thermal protector, and small gear-motor similar to that used in a clock or timer. Take care to note the orientation of the motor when removing and to not damage any seals (you don't want oil seeping down under!).

As always, check for bad connections if the popper is dead or operation is erratic.

Problems with heating can arise in the heating element, thermostat, and thermal protector.

If the stirrer doesn't turn, a gummed up motor or stirrer shaft (since these are only used occasionally) may be the problem. See the chapter: Motors 101.

Popcorn poppers (air type)

Air poppers combine a heating element and blower to heat corn kernels without the need for any unhealthy oil. Of course, you probably then drown the popcorn in butter and salt, huh? Admit it! :-).

As always, check for bad connections if the popper is dead or operation is erratic.

Problems with heating can arise in the heating element, thermostat, and thermal protector.

The motor is probably a small PM DC type and there will then be a set of diodes or a bridge rectifier to turn the AC into DC. Check these and for bad bearings, gummed up lubrication, or other mechanical problems if the motor does not work or is sluggish. See the chapter: Motors 101.

Electrical heating tape

This is the stuff used to keep your pipes from freezing when it is -25 degrees F in the Sun. :-) They come in various lengths and plug into a normal 115 VAC outlet. There may or may not be a thermostat (you may serve that purpose!).

Obviously, if you can disassemble the unit to the point of access to the connections to the heating element, a simple continuity check of each component (heating element, thermostat/switch, fuse if any, line cord, etc.) will identify whether there is a bad part. Similarly, if there is no switch, thermostat, or any other accessible parts - the entire thing is a sealed glob with a line cord - if there is no continuity, it is bad.

However, for the more general case, there are two ways to test a heat tape if whether it is alive or not isn't obvious by feel and you can't get inside. If you cannot get to the connection to the actual heating element, then the tests need to be performed with any power switch or thermostat in the 'on' position. However, it may not be possible to get a thermostat to go on if you are inside a nice heated house. It may need to be bypassed or the tests run where it is cold!

1. Check for continuity at the plug. If you have an 'on' indicator that is a neon bulb (or no indicator), it won't affect this reading. However, if it is an incandescent bulb, go to (2).

2. Test for heating action. What a concept? :) Put the sensing end of a thermometer against the heat tape and wrap the whole thing in an insulating material like fiberglass or even bubble wrap or styrofoam peanuts. Let the temperature stabilize and record it. Then turn the heat tape on or off depending on what state it was in. If it is working you should see a perhaps small, but noticeable change in temperature.

The actual resistance element in the heating tape really cannot be repaired safely so replacement is the only option if you find a problem there. The only possible repair would be to a cord that got cut or damaged resulting in a break in the wire or a faulty thermostat.

Automatic bread machines

These are actually kind of clever and according to Consumer Reports, may actually make quite decent bread. In a nutshell (whether there are nuts in your bread or not), you dump in the raw ingredients, close the lid, and the bread machine does the rest, signaling when done. Unfortunately, sometimes things go wrong and you are left with a half-baked or half-beaten mess to clean up.

The basic components of a bread machine are:

- The bread/dough chamber. This is likely made of stainless steel and about the size and shape of the finished loaf. It is surrounded by a heating element and has a stirrer/beater/kneader sticking up from the bottom.

  Common problems: Blown thermal fuse (screwed to outside of chamber in series with everything, open heating element, leaking stirrer seal, bad or stuck release solenoid.

- Stirrer motor and belt drive.

  Common problems: Bad belt or one that has popped loose, bad motor or motor in need of lubrication.

- Controller with electronic touchpad and LCD display.

  Common problems: Blown triacs, contamination in touchpad due to overzealous cleaning, faulty microprocessor, surge or lightning damage.

It should be straightforward to locate bad parts not related to the actual microprocessor - test the heating element(s) and motor for continuity and shorts. Tset the triacs (if any) for shorts as well (the resistance between any pair of pins should be more than a few ohms). However, it may be hard to be sure that something else wasn't the cause if a bad part is found. For example, a blown thermal fuse (a very common failure) may be an isolated event (these things can just grow tired of life) but could also mean that the electronic thermostat sensor isn't working or a triac or relay is stuck in the 'on' position.

Like any other electronic device, a power surge or lightning strike can wipe out the controller rendering the bread machine dead as, well, a loaf of bread. Unless there are obviously blown parts AND you get very lucky, the only solution with any likelihood of success is a total brain transplant (controller board replacement) - which is probably more expensive than a new bread machine.

Sewing machines

Moth mechanical and electrical problems are possible. (Note: we are not going to deal with fancy computerized equipment as this is probably better left to a professional except for the more obvious problems like a bad cord or plug.)

I have a 1903 Singer foot-pumped sewing machine which we have since electrified and still runs fine. A couple of drops of sewing machine or electric motor oil every so often is all that is needed. They were really built well back then.

Although the appearance of the internal mechanism may appear intimidating at first, there really is not that much to it - a large pulley drives a shaft that (probably) runs the length of the machine. A few gears and cams operate the above (needle and thread) and below (feet and bobbin) deck mechanisms. Under normal conditions, these should be pretty robust. (Getting the adjustments right may be another story - refer to your users manual). Sometimes if neglected, the oil may seriously gum up and require the sparing use of a degreaser to loosen it up and remove before relubing.

If the motor spins but does not turn the main large pulley, the belt is likely loose or worn. The motor will generally be mounted on a bracket which will permit adjustment of the belt tension. The belt should be tight but some deflection should still occur if you press it gently in the middle.

If the motor hums but nothing turns, confirm that the belt is not too tight and/or that the main mechanisms isn't seized or overly stiff - if so, it will need to be cleaned and lubrication (possibly requiring partial disassembly).

The electric motor is normally a small universal type on a variable speed foot pedal (see the section: Wiring a sewing machine speed control).

If the motor does not work at all, bypass the foot pedal control to confirm that it is a motor problem (it is often possibly to just plug the motor directly into the AC outlet). Confirm that its shaft spins freely. All normal motor problems apply - bad wiring, worn brushes, open or shorted windings, dirty commutator. See the section: Problems with universal motors.

Wiring a sewing machine speed control

This assumes a basic sewing machine (nothing computer controlled) with a normal universal series wound motor (115 VAC).

The common foot pedals are simply wirewound rheostats (variable resistors) which have an 'off' position when the pedal is released. They are simply wired in series with the universal motor of the sewing machine (but not the light) and can be left plugged in all the time (though my general recommendation as with other appliances is to unplug when not in use.

While not as effective as a thyristor type speed controller, these simple foot pedals are perfectly adequate for a sewing machine. There are also fancier speed controls and using a standard light dimmer might work in some cases. However, there are two problems that may prevent this: the sewing machine motor is a very light load and it is a motor, which is not the same as a light bulb - it has inductance. The dimmer may not work, may get stuck at full speed, or may burn out.

Shavers

A variety of types of drive mechanisms are used in electric shavers:

1. **Vibrator (AC only):** These (used by Remington among others) consist of a moving armature in proximity to the pole pieces of an AC electromagnet. The mass and spring are designed so that at the power line frequency, the armature vibrates quite strongly and is linked to a set of blades that move back and forth beneath the grille.

   If dead, check for continuity of the plug, cord, switch, and coil. IF sluggish, clean thoroughly - hair dust is not a good lubricant. Sliding parts probably do not require lubrication but a drop of light oil should be used on any rotating bearing points.

   Note that since a resonance is involved, these types of shavers may not work well or at all on foreign power - 50 Hz instead of 60 Hz or vice versa - even if the voltage is compatible.

2. **Universal motor (AC or DC):** Very small versions of the common universal motors found in other appliances. A gear train and linkage convert the rotary motion to reciprocating motion for shavers with straight blades or to multiple rotary motion for rotary blade shavers. These may suffer from all of the afflictions of universal motors; bad cords, wires, and switches; and gummed up, clogged, or worn mechanical parts. Also see the sections on the appropriate type of motor. Take care when probing or disassembling these motors - the wire is very fine any may be easily damaged - I ruined an armature of a motor of this type by poking where I should not have when it was running - ripped all the fine wires from the commutator right off.

3. **DC PM motor:** Often used in rechargeable shavers running of 2 or 3 NiCd cells. These may suffer from battery problems as well as motor and mechanical problems. One common type is the Norelco (and clone) rotary shaver. See the chapters on Batteries and AC Adapters as well as the sections on "Small permanent magnet DC motors".

   A shaver that runs sluggishly may have a dead NiCd cell - put it on charge for the recommended time and then test each cell - you should measure at least 1.2 V. If a NiCd cell reads 0, it is shorted and should be replaced (though the usual recommendation is to replace all cells at the same time to avoid problems in the future).

   Note that in terms of rechargeable battery life, shavers are just about optimal as the battery is used until it is nearly drained and then immediately put on charge. The theoretical 500 to 1000 cycle NiCd life is usually achieved in shaver applications.

Comments on Norelco shaver maintenance and repair

The following applies to newer models that have more computing power in their battery chargers than 5 month old PCs, not those with just a bridge rectifier for electronics. :)

(Merged comments from: Jerry Greenberg (jerryg50@hotmail.com) and Paul Grohe (grohe@galaxy.nsc.com).)

I used to service some of the Philips models of shavers. These are the same as the Norelco. When the batteries are dead the shaver will not run. The shaver has a sophisticated uPC (for what it does) that manages its operation. When it sees the batteries as dead, it will inhibit the shaver from being able to run. If the batteries are shorted, nothing will even light up at all.

The little "power supply" does not have enough "juice" to run the motor. The motor runs off the cells. If the cells are *dead* (shorted), nothing will work.

You can "test" the power supply by either listening carefully, or, holding it up to an AM (MW) radio tuned off to the end (no station) while plugging the razor in.

If the charger is okay, but the cells are shorted or weak, you will hear a quick "ping" followed by a stretched-out, "constipated" squeal. This is the little switching power supply quitting under the "dead weight" of the cells.

A "good" razor will have a nice, steady squeal (or "hiss" on the radio).

Once the shaver is opened, if you are mechanically skilled, it is worth the effort to disassemble the top head assembly where the motor goes in to, and do a thorough cleaning. You can lubricate the gears and shafts with a very light silicon lubricant. The motor is held in position with two spring clips. Care must be taken to not break the plastic pieces.

Everything snaps together. Opening the case is usually the toughest part.

And take it apart over a paper towel. Powdered hair will fall out all over the place as you take it apart. Keep a dust-buster or vacuum near by to suck up any escaping "dust". The stuff is worse than wallboard dust!

If you do any soldering, do it in a well ventilated place. Burning hair is not a pleasant smell! I would take the shaver completely apart (like a watch) and clean all the pieces, including the circuit board and display. Everything would be dried off, mechanical parts lubricated, new batteries installed, new blades, and then the complete re-assembly would be done. Once used to this type of work, a complete overhaul takes less than about 30 to 40 minutes. Most of the time, it only needed new batteries and blades. The shaver would be good for another few years. This especially pays for the more expensive models.

I'm on my third set of cells after 12 years. Last month I installed new 1200 mA/H NiMh cells.

Also: While you have the motor removed - it is a good idea to "clean" the motor brushes by connecting it to an adjustable power supply and slightly over-voltaging it to make it run faster than normal (with no load). Run it full-out for about 5 minutes (or until it runs smoothly). Run it in both directions, too. This will eliminate any "chugging", stalling or rough starts you may be experiencing with older units.

As for original parts, Norelco will supply them if the shaver model is less than about 5 to 7 years old. Usually the replacement parts are not expensive in relation to replacing the shaver. As for replacement parts, they would only supply the complete circuit boards, batteries, and any mechanical parts if they are defective.

Mine is as good as new now!

Electric toothbrushes

These are basically similar to any other small battery operated appliance or tool such as a screwdriver or drill. The permanent magnet motor runs off of rechargeable NiCd batteries and cause the bristles or whatever to oscillate, rotate, or vibrate. Interchangeable 'brush' units allow each member of the family to have their own. Coupling to the internal battery is often via a 'contactless' mechanism using a pair of coils to transfer AC inductively. Inside the hand unit, this is rectified to charge the NiCd (usually) battery. See the section: Inductively coupled charging circuit for an example of one such design.

Problems can occur in the following areas:

- **Motor, battery pack, connections, on/off switch:** As with any other similar device.
- **Power train:** Gummed up lubrication, broken, or other mechanical problems.
- **Charging station or circuitry:** The fault may be with the base unit or circuitry associated with the battery pack. See the section: Braun electric toothbrush repair, below. Since these must operate in a less than ideal environment (humid or actual waterlogged!), contamination and corrosion is quite possible if the case is not totally sealed. Some

of the switches may be of the magnetic reed type so that there don't need to be any actual breaks in the exterior plastic housing. Even so, the motor shaft probably passes through a bushing in the housing and this will leak eventually.

Of course, getting inside may prove quite a challenge and in general one must consider the hand unit to be a throw-away item since it is generally glued together - permanently. While it is possible to use a hacksaw to carefully cut around the case, the resulting repair once the thing is put back together will be decidedly of the 'Jerry-rigged' type and sealing will be difficult and long term reliability and safety would be questionable.

(From: Jeff & Sandy Hutchinson (sandy2@flatoday.infi.net).)

It's darned near impossible to replace the batteries on the Interplak toothbrush without destroying the recharging circuit. The base of the hand unit has a little pickup coil in it, and when you unscrew the cap to get at the batteries, you break the connections to the pickup coil. Best to do an exchange with the factory.

(From: Bill Finch (alioth@ix.netcom.com).)

I've done this twice. Use a tubing (or pipe) cutter at the seam. Rotate and tighten the cutter slowly until the thing falls apart. Fish out the guts and resolder a new battery in place. Slip everything back into the lower tube. Glue the top back on with PVC pipe sealant. It helps to make a simple jig to hold the top steady while the PVC cement sets. Try not to get excess cement on the external plastic or you wife will complain. A good trick here is to mask with drafting tape or whatever.

If this fails just buy a new toothbrush.

(From: Chip Curtis (ccurtis@zilog.com).)

I had a problem with my Braun and found that the unit's PCB was rather wet. After drying it out and coating it the unit still turned on from time to time and I noticed that during the false runs the transistor was not saturating. It didn't take long to see that the problem is caused by the transistor's base being left wide open. Any noise on the base or small current flow from PCB leakage will cause the transistor to fire and the brush noise is enough to keep it triggering and running on.

The fix; tack a 1M or whatever (no smaller than 47K) resistor from the base of the transistor to ground. The pull-down won't hurt current consumption when the unit is off because the reed switch is open, and the small bias won't make much of a difference when the unit is running.

Inductively coupled charging circuit

This was found in an Interplak Model PB-12 electric toothbrush but similar designs are used in other appliances that need to be as tightly sealed as possible.

A coil in the charging base (always plugged in and on) couples to a mating coil in the hand unit to form a step down transformer. The transistor, Q1, is used as an oscillator at about 60 kHz which results in much more efficient energy transfer via the air core coupling than if the system were run at 60 Hz. The amplitude of the oscillations varies with the full wave rectifier 120 Hz unfiltered DC power but the frequency is relatively constant.

```
     E1           CR2         R1                               E3
  AC o----+----+--|>|-----+---/\/\---+----+----------------+-------+  Coupling
          |   ~|  CR1     |+   1K    |    |                |        ) Coil
        +-+-+  +--|<|--+  |          |    / R2             |        ) 200T
```

```
    RU1 |MOV|     CR3  |  |      C1 _|_   \ 390K           |       ) #30
        +-+-+  +--|>|--|--+   .01uF ---   /         CR5    |    E4 ) 1-1/2"
       E2 |    |  CR4  |       250V  |    \ MPSA +---|<|---|----+--+
  AC o----+----+--|<|--+             |    |   44 |         |    |
              ~        |-     R3     |    | Q1 |/ C    C3 _|_  _|_ C2
                       +-----/\/\----+----+----|     .1uF ---  --- .0033uF
      CR1-CR4: 1N4005  |     15K               |\ E  250V  |    |  250V
                       |                R4       |         |    |
                       +---------------/\/\------+---------+----+
                                        1K
```

The battery charger is nothing more than a diode to rectifier the signal coupled from the charging base. Thus, the battery is on constant trickle charge as long as the hand unit is set in the base. The battery pack is a pair of AA NiCd cells, probably about 500 mA-h.

For the toothbrush, a 4 position switch selects between Off, Low, Medium, and High (S1B) and another set of contacts (S1A) also is activated by the same slide mechanism. The motor is a medium size permanent magnet type with carbon brushes.

```
                                       S1B
                              S1A  +--o->o
                 D1           _|_  |       R1,15,2W
             +---|>|---+------o o--+   L o---/\/\---+
    Coupling |         |                   R2,10,2W |
       Coil  +        _|_ BT1          M o---/\/\---+
       120T (          _  2.4V                      |
        #30 (         ___ .5A-h        H o----------+
     13/16"  +         _                            |
             |         |        +-------+           |
             +---------+--------| Motor |-----------+
                                +-------+
```

Braun electric toothbrush repair

(From: David DiGiacomo (dd@Adobe.com).)

This Braun electric toothbrush (original model) would turn itself on and keep running until its batteries were discharged.

The toothbrush can be disassembled by pulling the base off with slip joint pliers (do not pull too hard because there is only about 1" of slack in the charging coil wires). With the base off, the mechanism slides out of the case.

There is a simple charging circuit, charging LED, 2 NiCd cells, and a reed switch driving the base of an NPN transistor. The transistor collector drives the motor.

I charged the battery, but the problem of the motor running with the reed switch open didn't recur until I held my finger on the transistor for about 10 seconds seconds. Grounding the transistor base turned it off again, and I could repeat this cycle. Since there wasn't anything else to go wrong I decided to replace the transistor. I couldn't read the marking, but it's in a SOT89 package and the motor current is 400-700 mA so it must be something like a BC868. However, I didn't have any surface mount or TO92 transistors that could handle the current, so I used a 2SD882 (small power tab package), which I was able to squeeze into some extra space in the center of the charging coil.

Hand massagers

These are simply motors with an off-axis (eccentric) weight or electromagnetic vibrators. If the unit appears dead, check the plug, cord, on/off switch, internal wiring, and motor for continuity. Confirm that the mechanical parts turn or move freely.

Some have built in infra-red heat which may just be a set of small light bulbs run at low voltage to provide mostly heat and little light (a filter may screen out most of the light as well). Obviously, individual light bulbs can go bad - if they are wired in series, this will render all of them inert.

At least one brand - Conair - has had problems with bad bearings. Actually, poorly designed sleeve bearings which fail due to the eccentric load. If you have one of these and it becomes noisy and/or fails, Conair will repair (actually replace) it for $5 if you complain in writing and send it back to them. They would like a sales receipt but this apparently is not essential.

Hair dryers and blow dryers

A heating element - usually of the NiChrome coil variety - is combined with a multispeed centrifugal blower.

First determine if the problem is with the heat, air, or both.

For heat problems, check the element for breaks, the thermal protector or overtemperature thermostat (usually mounted in the air discharge), the connections to the selector switch, and associated wiring.

Newer models may have a device in the plug to kill power to the unit should it get wet. See the sections: "What is a GFCI?" and "The Ground Fault Circuit Killer (GFCK)".

For air problems where the element glows but the fan does not run, check the fan motor/bearings, connections to selector switch, and associated wiring. Confirm that the blower wheel turns freely and is firmly attached to the motor shaft. Check for anything that may be blocking free rotation if the blower wheel does not turn freely. The motor may be of the induction, universal, or PM DC type. For the last of these, a diode will be present to convert the AC to DC and this might have failed. See the appropriate section for problems with the type of motor you have.

The Ground Fault Circuit Killer (GFCK)

Note: I have heard that the official name for these disasters is: Appliance Leakage Circuit Interrupter (ALCI). I like mine better. :)

This safety 'enhancement' must have been designed by engineers with too much time on their hands (or the wrong sort of incentive bonus plan). Get a few drops of water on one of these appliances and it goes in the garbage.

The irony is that once the GFCK blows, the owner is likely to just cut off the GFCK plug and replace it with a normal plug (rather than throwing the appliance away or having it properly repaired, as was no doubt the intent), thus eliminating the protection altogether!

The GFCK (my designation) is a device contained in an oversize plug which is part of the cordset of some newer hand-held (at least) appliances that may be used in wet areas like kitchens and baths but where there may be no GFCI protection (see the section: What is a GFCI?. I first ran across one of these on a late model Conair blow dryer (which is why this section on GFCKs is here rather than with the GFCI information).

In a nutshell, the GFCK permanently disconnects power to the appliance - at the plug - should electrical leakage of more than a few milliamps be present within the appliance. Unlike a GFCI, ther is NO reset button and no way to get inside short of drilling out the rivets holding the plug together! In fact, the unit I dissected uses an SCR to grossly overdrive and blow out a normal resistor which by its placement holds a mechanical latch in place for a pair of contact releases that disconnect the plugs prongs from the wires of the cord. With the resistor gone, the prongs of the plug go nowhere so everything beyond them becomes totally dead, electrically - forever. Thus, even if dropped into a bathtub, the appliance will not cause electrocution. Sorry, these can't be used as part of murder mystery plots!

Admittedly, the GFCK works regardless of whether the outlet the appliance is plugged into is 2-prong, 3-prong, correct or reverse polarity, or GFCI protected, and thus provides a high level of safety. But, this may be taking cost reduction to an extreme rather than providing a resettable basic GFCI (just H-G faults). Having said that, there is merit to disabling the appliance permanently since there is no way to know how much damage may have been done internally by the water (or whatever caused the GFCK to trip) and it's safety may always be suspect.

All this is mounted inside the plug:

```
            <------------------------ Plug ---------------------->|<- Cord ->
             ___                                                  :
Plug (H) <---o o---+----------------------------------------------o H
             CB1*  |     =====        R1*                         :
                   +-----^^^^^-------/\/\-------------+-------+   :
                   |      L1                          |       |   :
                   |  120 T, #26, 3 layers       Q1 __|__     |   :
                   |  .1"x1" ferrite core    T34557 _\_/_     |   :
                   |                                / |       |   :
            MDC +--+--+   +-----+------+------+----'  |   C2 _|_  :
           Z251 | MOV |   |     |      |      |       | .1uF ---  :
                +--+--+   |     /      |      |       | 250V  |   :
                   |      |  R2 \  C1 _|_ D1 _|_      |       |   :
                   |      | 300 / .22 ---    /_\      |       |   :
                   |      |     \  uF  |      |       |       |   :
                   |      |     |      |      |       |       |   :
                   +------|-----+------+------+-------+-------+   :
             ___   |      |                1N4004                 :
Plug (N) <---o o---+---------------------------------------------------o N
             CB2*         |             R3  1K                    :
                          +--------------/\/\-------------------------o G
                                                                  :
```

* R1 is positioned to hold the latch for CB1 and CB2 in place until it vanishes in a puff of smoke. It is interesting to note that R1 is NOT a flameproof resistor - it looks like an ordinary 1/8 W carbon composition type.

The Ground wire in the cord (G) goes from the circuit in the plug back to the metal parts of the dryer (though as usual with a modern appliance, it is mostly made of plastic). Note that there is no Ground wire to the outlet - just to the appliance. The theory goes that should the device get wet, current is more likely to flow to the nearby metal parts and via the cord's Ground wire to the GFCK than to some other earth ground (including a person touching an earth ground). In fact, this device does NOT sense a current imbalance like a true GFCI - just leakage to its internal Ground wire, but under realistic circumstances, this should be a reliable indication of a fault.

A fault condition would result in current flowing between H and G in the cord. When this exceeds about 3 mA, the

SCR (Q1) triggers putting R1 essentially across the line (maybe limited a bit by L1). R1, which was physically holding the latch for the plug circuit breakers CB1 and CB2, now explodes releasing both these contacts. Power is shut off to the appliance - permanently! Hopefully, the plug doesn't catch fire in the process! :)

As noted, cutting off this fancy plug and replacing it or the entire cordset with a conventional one provides the same level of safety IF AND ONLY IF the appliance is used ONLY in a GFCI protected outlet (the cord Ground wire is left disconnected in this case or can be attached to the third prong of a three prong plug). The alternative of installing a 3-prong plug on the appliance and then only using it in a properly grounded 3-prong outlet doesn't provide the same protection as there can still be enough leakage to be lethal without blowing a fuse or tripping a breaker (and the ground wire in the sample I have wouldn't be adequate to carry a major fault current anyhow).

And, guess what? This Conair blow dryer died not because the GFCK had been activated, but because the soldering to the R1 was defective and it pulled loose!

Curling irons

These are just a sealed heating element, switch, and thermal protector (probably). Check for bad connections or a bad cord or plug if there is not heat. A failed thermal protector may mean other problems. While these are heating appliances, the power is small so failures due to high current usually do not occur.

VCR cassette rewinders

Cassette rewinders typically consist of a low voltage motor powered from a built in transformer or wall adapter, a belt, a couple of reels, and some means of stopping the motor and popping the lid when the tape is fully rewound.

Note that some designs are very hard on cassettes - yanking at the tape since only increased tension is used to detect when the tape is at the end. These may eventually stretch the tape or rip it from the reel. I don't really care much for the use of tape rewinders as normal use of rewind and fast forward is not a major cause of VCR problems. Sluggish or aborted REW and FF may simply indicate an impending failure of the idler tire or idler clutch which should be addressed before the VCR gets really hungry and eats your most valuable and irreplaceable tape.

Problems with tape rewinders are usually related to a broken or stretched belt or other broken parts. These units are built about as cheaply as possible so failures should not be at all surprising. The drive motor can suffer from any of the afflictions of similar inexpensive permanent magnet motors found in consumer electronic equipment. See the section: Small permanent magnet DC motors. A broken belt is very common since increased belt (and tape) tension is used to switch the unit off (hopefully). Parts can pop off of their mountings. Flimsy plastic parts can break.

Opening the case is usually the biggest challenge - screws or snaps may be used. Test the motor and its power supply, inspect for broken or dislocated parts, test the power switch, check and replace the belt if needed. That is about it.

Vacuum cleaners, electric brooms. and line powered hand vacs

Despite all the hype surrounding vacuum cleaner sales, there isn't much difference in the basic principles of operation between a $50 and $1,500 model - and the cheaper one may actually work better.

A vacuum cleaner consists of:

1. **A cordset:** Broken wires or damaged plugs are probably the number one problem with vacuums as they tend to be dragged around by their tails! Therefore, in the case of an apparently dead machine, check this first - even just squeezing and bending the wire may produce an instant of operation - enough to verify the cause of

the problem.

2. **A power switch:** This may be a simple on/off toggle which can be tested with a continuity checker or ohmmeter. However, fancy machines with powered attachments may have interlocks or switches on the attachments that can also fail. Where multiple attachment options are present, do your initial troubleshooting with the minimal set as this will eliminate potential sources of additional interlock or switch complications. With 'microprocessor' or 'computer' controlled vacuum cleaners, the most likely problems are not the electronics.

3. **A high speed universal motor attached to a centrifugal blower wheel:** As with any universal motor, a variety of problems are possible: dirt (especially with a vacuum cleaner!), lubrication, brushes (carbon), open or shorted windings, or bad connections. See the section: Problems with universal motors.

4. **A belt driven carpet brush (uprights):**. The most common mechanical problem with these is a broken rubber belt. (One person who shall remain nameless, mistook the end of the broken belt for the tail of a mouse and promptly went into hysterics!). Replacements for these belts are readily available.

5. **Power nozzles and other powered attachments:** Some of these are an attempt to give canister type vacuum cleaners the power of an upright with its directly powered carpet brush. Generally, these include a much smaller motor dedicated to rotating a brush. Electrical connections are either made automatically when the attachment is inserted or on a separate cable. Bad connections, broken belt, or a bad motor are always possibilities.

6. **A bag to collect dirt:** Vacuum cleaners usually do a poor job of dust control despite what the vacuum cleaner companies would have you believe. Claims with respect to allergies and other medical conditions are generally without any merit unless the machine is specifically designed (and probably very expensive) with these conditions in mind. If the vacuum runs but with poor suction, first try replacing the bag.

Vacuum cleaner mechanical problems

1. **Poor suction:** Check the dirt bag and replace if more than half full. Check for obstructions - wads of dirt, carpet fibers, newspapers, paper towels, etc.

2. **Poor pickup on floors:** Broken or worn carpet brush belt. There should be some resistance when turning the carpet brush by hand as you are also rotating the main motor shaft. If there is none, the belt has broken and fallen off. Replacements are readily available. Take the old one and the model number of the vacuum to the store with you as many models use somewhat similar but not identical belts and they are generally not interchangeable. To replace the belt on most uprights only requires the popping of a couple of retainers and then removing one end of the carpet brush to slip the new belt on.

3. **Vacuum blows instead of sucks:** First confirm that the hose is connected to the proper port - some vacuums have easily confused suction and blow connections. Next, check for internal obstructions such as wads of dirt, balls of newspaper, or other items that may have been sucked into the machine. Note that it is very unlikely - bordering on the impossible - for the motor to have failed in such a way as to be turning in the wrong direction (as you might suspect). Furthermore, even if it did, due to the design of the centrifugal blower, it would still suck and not blow.

4. **Broken parts:** Replacements are available for most popular brands from appliance repair parts distributors and vacuum/sewing machine repair centers.

Vacuum cleaner electrical problems

>

1. **Bad cord or plug:** This is the number one electrical problem due to the abuse that these endure. Vacuum cleaners are often dragged around and even up and down stairs by their tails. Not surprisingly, the wires inside eventually break. Test with a continuity checker or ohmmeter. Squeezing or bending the cord at the plug or vacuum end may permit a momentary spurt of operation (do this with it plugged in and turned on) to confirm this diagnosis.

2. **Bad power switch:** Unplug the vacuum and test with a continuity checker or ohmmeter. If jiggling the switch results in erratic operation, a new one will be required as well.

3. **Bad interlocks or sensors:** Some high tech vacuum cleaners have air flow and bag filled sensors which may go bad or get bent or damaged. Some of these can be tested easily with an ohmmeter but the newest computer controlled vacuum cleaners may be more appropriate to be repaired by a computer technician!

4. **Bad motor:** Not as common as one might think. However, worn carbon brushes or dirt wedged in and preventing proper contact is possible and easily remedied. See the section: Problems with universal motors.

5. **Bad internal wiring:** Not that likely but always a possibility.

Vacuum cleaner hose damage

> "We have been quoted a price of $100 to replace the hose on our Panasonic (Mc-9537) vacuum cleaner. It has a rip in it; next to the plastic housing where the metal tubing starts. Does anyone know if there is a more economical way to solve this problem?"

I have always been able to remove the bad section and then graft what is left back on to the connector. Without seeing your vacuum, there is no way to provide specific instructions but that is what creativity is for! :-) It might take some screws, tape, sealer, etc.

$100 for a plastic hose is obviously one approach manufacturers have of getting you to buy a new vacuum - most likely from some other manufacturer!

Note: Some vacuum cleaners with power nozzles use the coiled springs of the hose as the electrical conductors for the power nozzle. If you end up cutting the hose to remove a bad section, you will render the power nozzle useless.

High tech vacuum cleaners?

Excerpt from a recent NASA Tech Brief:

> "The Kirby Company of Cleveland, OH is working to apply NASA technology to its line of vacuum cleaners. Kirby is researching advanced operational concepts such as particle flow behavior and vibration, which are critical to vacuum cleaner performance. Nozzle tests using what is called Stereo Imaging Velocity will allow researchers to accurately characterize fluid and air experiments. Kirby is also using holography equipment to study vibration modes of jet engine fans."

I suppose there will be degree-credit university courses in the operation of these space age vacuums as well! --- sam

Dustbusters(tm) and other battery powered hand vacs

These relatively low suction battery powered hand vacuums have caught on due to their convenience - certainly not their stellar cleaning ability!

A NiCd battery pack powers a small DC permanent magnet motor and centrifugal blower. A simple momentary pushbutton power switch provides convenient on/off control.

Aside from obvious dirt or liquid getting inside, the most common problems occur with respect to the battery pack. If left unused and unplugged for a long time, individual NiCd cells may fail shorted and not take or hold a charge when the adapter is not plugged back into the wall socket. Sluggish operation is often due to a single NiCd cell failing in this way.

See the appropriate sections on "Batteries" and "Motors" for more information.

Dustbusters left on continuous charge and battery problems

The low current trickle charger supplied with these battery operated hand-vacs allow Dustbusters and similar products to be be left on continuous charge so long as they are then not allowed to self discharge totally (left on a shelf unplugged for a long time). Older ones, in particular, may develop shorted cells if allowed to totally discharge. I have one which I picked up at a garage sale where I had to zap cells to clear a shorts. However, it has been fine for several years now being on continuous charge - only removed when used.

While replacing only selected cells in any battery operated appliance is generally not recommended for best reliability, it will almost certainly be much cheaper to find another identical unit at a garage sale and make one good unit out of the batteries that will still hold a charge. It is better to replace them all but this would cost you as much as a new Dustbuster.

The NiCd cells are soldered in (at least in all those I have seen) so replacement is not as easy as changing the batteries in a flashlight but it can be done. If swapping cells in from another similar unit, cut the solder tabs halfway between the cells and then solder the tabs rather than to the cells themselves if at all possible. Don't mess up the polarities!

In the case of genuine Dustbusters, where a new battery is needed and you don't have a source of transplant organs, it may be better to buy the replacement cells directly from Black and Decker. They don't gouge you on NiCd replacements. B&D is actually cheaper than Radio Shack, you know they are the correct size and capacity, and the cells come with tabs ready to install. They'll even take your old NiCds for proper re-cycling.

Floor polishers

A relatively large universal motor powers a set of counter-rotating padded wheels. Only electrical parts to fail: plug, cord, power switch, motor. Gears, shafts, and other mechanical parts may break.

Heating pads

Heating pads are simply a very fine wire heating element covered in thick insulation and then sealed inside a waterproof flexible plastic cover. Internal thermostats prevent overheating and regulate the temperature. The hand control usually provides 3 heat settings by switching in different sections of the heating element and/or just selecting which thermostat is used.

There are no serviceable parts inside the sealed cover - forget it as any repair would represent a safety hazard. The control unit may develop bad or worn switches but even this is somewhat unlikely. It is possible to disassemble the control to check for these. You may find a resistor or diode in the control - check these also. With the control open, test the wiring to the pad itself for low resistance (a few hundred ohms) between any pair of wires). If these test open, it is time for a new heating pad. Otherwise, check the plug, cord, and control switches.

Extended operationg especially at HIGH, or with no way for the heat to escape, may accelerate deterioration inside the sealed rubber cover. One-time thermal fuses may blow as well resulting in a dead heating pad. One interesting note: Despite being very well sealed, my post mortems on broken heating pads have shown one possible failure to be caused by corrosion of the internal wiring connections after many years of use.

Electric blankets

As with heating pads, the only serviceable parts are the controller and cordset. The blanket itself is effectively sealed against any repair so that any damage that might impact safety will necessitate replacement.

Older style controllers used a bimetal thermostat which actually sensed air temperature, not under-cover conditions. This, it turns out, is a decent measurement and does a reasonable job of maintaining a comfortable heat setting. Such controllers produced those annoying clicks every couple of minutes as the thermostat cycled. Problems with the plug, cord, power switch, and thermostat contacts are possible. The entire controller usually unplugs and can be replaced as a unit as well.

Newer designs use solid state controls and do away with the switch contacts - and the noise. Aside from the plug and cord, troubleshooting of a faulty or erratic temperature control is beyond the scope of this manual.

Humidifiers

There are three common types:

1. **Wet pad or drum:** A fan blows air across a stationary or rotating material which is water soaked. There can be mechanical problems with the fan or drum motor or electrical problems with the plug, cord, power switch, or humidistat.

2. **Spray:** An electrically operated valve controls water sprayed from a fine nozzle. Problems can occur with the solenoid valve (test the coil with an ohmmeter), humidistat, or wiring. The fine orifice may get clogged by particles circulating in the water or hard water deposits. In cleaning, use only soft materials like pointy bits of wood or plastic to avoid enlarging the hole in the nozzle.

3. **Ultrasonic:** A high frequency power oscillator drives a piezo electric 'nebulizer' which (with the aid of a small fan) literally throws fine droplets of water out into the room. Problems with the actual ultrasonic circuitry is beyond the scope of this manual but other common failures can be dealt with like plug, cord, fan motor, control switches, wiring, etc. However, if everything appears to working but there is no mist from the output port, it is likely that the ultrasonic circuitry has failed. See the section: Ultrasonic humidifiers for more details.

Ultrasonic humidifiers

(From: Filip "I'll buy a vowel" Gieszczykiewicz (filipg@repairfaq.org).)

The components of the typical $45 unit are:

- Piezo transducer + electronics (usually in a metal cage - we are talking line current here - not safe!).

- Small blower/fan.

- Float-switch.

- Water tank.

The piezo transducer sets up a standing wave on the surface of the water pool. The level is sensed with a float-switch to ensure no dry-running (kills the piezo) and the blower/fan propels the tiny water droplets out of the cavity. A few manufacturers are nice enough to include a silly air filter to keep any major dust out of the 'output' - do clean/check that once in a while.

Common problems:

- Low output:
  - Minerals from water deposited on surface(s) of the water pool - including the piezo. This disrupts/changes the resonance/output of the piezo - and you see the effect.
  - Clogged air filter - there should be a little 'trap door' somewhere on the case with a little grill. Pop it out and wash the filter found therein. Replace.
  - Driver of the piezo going down that hill. Time to get another one or look for the warranty card if it applies.

  CAUTION: Unless you know what you are doing (and have gotten shocked a few times in your life) DO NOT play with the piezo driver module. Most run at line voltage with sometimes 100+V on heatsinks - which are live.

- No output:
  - Dead piezo driver - get a new unit unless under warranty.
  - Dead wire or float-switch or humidity switch or 'volume'... that should be easy - use an ohmmeter and look for shorts/opens/resistance.
  - Dead fan - should still have mist - just none of it getting out.
  - No power in the outlet you're using ;-)

Note: piezo's in general are driven with voltage, as opposed to current. This explains why you can expect high voltages - even in otherwise low-voltage circuits. Case in point: the Polaroid ultrasonic sonar modules.

(From: Dave VanHorn" (dvanhorn@cedar.net).)

The Devilbiss units I used to repair, used about 1 W at 1 MHz (if I recall correctly into a thick barium titanate transducer. Their most common problem was cracked transducers.

There was a shaped cavity above the transducer, I would guess some sort of Helmholtz resonator. You had to tune the operating frequency around to maximize the plume, and then trim for a certain plume height with the output drive.

Don't stick your finger in the plume. Although the water is not hot, you will discover that your finger is mostly water. It's kind of like slamming your finger in a car door.

(From: Daniel Cilevitz (rpf.20.foobar0@antichef.com).)

Thinking about the above info on ultrasonic humidifiers and their power output, I decided to experiment with an ultra-cheap ultrasonic humidifier (useless for its intended application) and the clear polystyrene front cover of a CD jewel case. With the water level correctly set, placing the plastic sheet at the tip of the plume (cone shaped tip of the water) just above the transducer resulted in a cone-shaped section of material deforming outwards from the center of the wave. In normal operation, a mist of water is ejected from this location. The bottom of the sheet intersects the cone, and the truncated part of the wave doesn't like this and melts its way through. With the sheet in motion, a cut/trough about 3 mm wide appears. Moving slowly results in a slightly larger amount of material being displaced, up to about 5 mm. It doesn't go all the way through the plastic for some reason. The effect is the same as pressing a hot piece of metal against the plastic. The process is continuous and you can draw patterns by moving the material around on top of the standing wave. The deformed plastic was only warm, not hot, though it may have been cooled by contact with the water.

After seeing this firsthand, you will never feel the urge to stick your finger in the plume again! I would not want to discover the effects of a larger humidifier or ultrasonic cleaner on parts of your body. This was with a $25 unit from a store closing special, so imagine what a larger, more powerful one could do!

As an aside: Jewel cases are made from two kinds of polystyrene: General Purpose Polystyrene (GPPS) and High-Impact Polystyrene (HIPS). GPPS is crystal- clear but very brittle, and is used to mold the front and back covers. HIPS is translucent to opaque but more flexible, and is used to mold the tray. The tray needs to be flexible so that the tray hub can grab the disc hub without breaking off. It's unfortunate that the hinged part of the jewel case is made of such a brittle material, as it's always the first thing to break ;)

Ultrasonic waterfalls?

I don't suppose you are likely to encounter these but if you do, servicing procedures will be similar to those described in the section: Ultrasonic humidifiers.

(From: Roger Vaught (vaurw@onramp.net).)

At a local shop they sell small water fall displays made from limestone in a marble catch basin. These are made in China. They use a small water pump for the flow.

When I first saw one I thought the store had placed dry ice in the cavity where the water emerged as there was a constant stream of cloud flowing from it. Very impressive. It turns out they use the ultrasonic piezo gizmo to make the cloud. The driver is a small 3 X 5 X 3 inch box with a control knob on top. If you look into the cavity you can see the piezo plate and a small red LED. The water periodically erupts into vapor. I haven't been able to get a close look at the driver so I can't tell where it is made or if there is a product name or manufacturer. They will sell that part of it for $150!

Ultrasonic cleaners

Ultrasonic cleaning is a means of removing dirt and surface contamination from intricate and/or delicate parts using powerful high frequency sound waves in a liquid (water/detergent/solvent) bath.

An ultrasonic cleaner contains a power oscillator driving a large piezoelectric transducer under the cleaning tank. Depending on capacity, these can be quite massive.

A typical circuit is shown below. This is from a Branson Model 41-4000 which is typical of a small consumer grade unit.

```
               R1        D1
 H o------/\/\-------|>|----------+
        1, 1/2 W  EDA456          |
               C1         D2      |
```

```
         +----||----+----|>|-----+
         |  .1 uF   |  EDA456    |  2
         |  200 V   |      +-----+---+ T1      +---+------->>------+
         |    R2    |     _|_ C2      )::  o 4 |   |               |
         +---/\/\---+     --- .8 uF D ):: +----+   |               |
         |   22K          _|_ 200 V   )::(         +               |
         |   1 W           -      1 o )::(          )::          _|_
         +-----------------+---------+ ::( O        ):: L1       _x_ PT1
         |           R3    |        7  ::(          )::            |
         |      +---/\/\---+   +-----+ ::( 5       +               |
        C \|    | 10K, 1 W     |    F ):: +---+    |               |
      Q1   |--+-+--------------+  6 o )::     |    |               |
        E /|  |  D3     R4       +---+        +----+------->>------+
         |    +--|<|---/\/\--+  _|_
         |           47, 1 W |  ---       Input: 115 VAC, 50/60 Hz
         |                   |   |        Output: 460 VAC, pulsed 80 kHz
N o------+-------------------+---+
```

The power transistor (Q1) and its associated components form an self excited driver for the piezo-transducer (PT1). I do not have specs on Q1 but based on the circuit, it probably has a Vceo rating of at least 500 V and power rating of at least 50 W.

Two windings on the transformer (T1, which is wound on a toroidal ferrite core) provide drive (D) and feedback (F) respectively. L1 along with the inherent capacitance of PT1 tunes the output circuit for maximum amplitude.

The output of this (and similar units) are bursts of high frequency (10s to 100s of kHz) acoustic waves at a 60 Hz repetition rate. The characteristic sound these ultrasonic cleaners make during operation is due to the effects of the bursts occuring at 60 Hz since you cannot actually hear the ultrasonic frequencies they use.

The frequency of the ultrasound is approximately 80 kHz for this unit with a maximum amplitude of about 460 VAC RMS (1,300 V p-p) for a 115 VAC input.

WARNING: Do not run the device with an empty tank since it expects to have a proper load. Do not touch the bottom of the tank and avoid putting your paws into the cleaning solution while the power is on. I don't know what, if any, long term effects there may be but it isn't worth taking chances. The effects definitely feel strange.

Where the device doesn't oscillate (it appears as dead as a door-nail), first check for obvious failures such as bad connections and cracked, scorched, or obliterated parts.

To get inside probably requires removing the bottom cover (after pulling the plug and disposing of the cleaning solution!).

CAUTION: Confirm that all large capacitors are discharged before touching anything inside!

The semiconductors (Q1, D1, D2, D3) can be tested for shorts with a multimeter (see the document: Basic Testing of Semiconductor Devices.

The transformer (T1) or inductor (L1) could have internal short circuits preventing proper operation and/or blowing other parts due to excessive load but this isn't kind of failure likely as you might think. However, where all the other parts test good but the cleaning action appears weak without any overheating, a L1 could be defective (open or other bad connections) detuning the output circuit.

Where the transistor and/or fuse has blown, look for a visible burn mark on the transducer and/or test it (after disconnecting) with a multimeter. If there is a mark or your test shows anything less than infinite resistance, there may have been punch-through of the dielectric between the two plates. I don't know whether this could be caused by running the unit with nothing in the tank but it might be possible. If the damage is localized, you may be able to isolate the area of the hole by removing the metal electrode layer surrounding it to provide an insulating region 1/4 inch in diameter. This will change the resonant frequency of the output circuit a small amount but hopefully not enough to matter. You have nothing to lose since replacing the transducer is likely not worth it (and perhaps not even possible since it is probably solidly bonded to the bottom of the tank).

When testing, use a series light bulb to prevent the power transistor from blowing should there be a short circuit somewhere (see the document: Troubleshooting and Repair of Consumer Electronic Equipment) AND do not run the unit with and empty tank.

Here are some comments on ultrasonic cleaner repair. These would appear to be more for larger units but some of the info should apply to the small ones as well:

(From: B. Clark (bclarkson@primary.net).)

I spend a great deal of time repairing ultrasonic generators from sinks in medical use. I can tell you this. While different manufacturers use different circuits, the basic design is the same everywhere. The most common failure mode is that the switching transistor(s) are shorted. When this happens, does the fuse blow in your case? If this is true, replace the rectifier bridge. If the circuit contains extra diodes, check those for shorts as well. Always replace both transistors at the same time. You can use ECG/NTE equivalents, so long as both are the same - don't count on a new 2N6308 and an ECG283 working together in this case.

Assuming the fuse never blows and the output frequency is around 40 to 50 khz, that rules out most of the small caps and resistors. Most generators that I have worked on produce a wave around 45 khz. A bad cap or resistor would cause it to be off frequency. The transducers should test as open. If they test as anything other than open on an multimeter (after allowing for settling as they are sensitive to vibration), then they could be bad. Transducer failure in my experience is not that common. It may suggest that your customer has been running the unit with the tank empty or only partially full.

The circuit is tuned. 100% of all generators sent to me have one or more shorted transistors. The customer complaint is usually "No ultrasonic action" or "Weak ultrasonic action". 99.999% of the time, using an ohmmeter and replacing shorted semiconductors corrects the problem. I have had one unit where a precision cap was out of tolerance and detuned the circuit. One nearby hospital has sent in three 500 watt units that were ran without the transducers connected. In all cases, the fuse didn't blow, however each of the three caught on fire. One of these has a 1/8 in hole through a coil in the transformer.

If any part drifts out of tolerance, the transistor will short. I have seen perfectly fine circuits short switching transistors when the unit is ran with no water in the tank. Do not attempt to run with one transducer. You will meet with failure. You should attempt to replace with the exact oem part when available. If you cannot find the original and have determined a adequate substitute, replace both of them.

I keep mentioning transistors realizing that small units have only one. The units I work on have 4 to help generate 500 watts of power.

Fog machines

If you don't know what a fog machine does, you probably don't need to read this section!

(From: Lance Edmonds (lanceedmonds@xtra.co.nz).)

Essentially, a fog machine consists of a heater unit and a pump, plus electronics to control the heater temperature, and control how much fog juice is pumped through the heater.

Most common failures are severed remote control leads, burned out pumps, or heating unit blockages.

I've never seen one with a fan, but many folks use a fan to disperse the fog to the desired locations across a stage, etc.

Unlike dry-ice, fog from a "fogger" rises and disperses quite quickly unless there is no ventilation... you can add some perfume (a few drops to the large tank) to reduce the "flavor" of the fog... when it's thick it tastes and smells horrid!

(From: krbjmpr@hotmail.com)

I have examined a couple machines just out of personal curiosity. what I found was, and keep in kind that these were the lower end series, was basically a high power heater and a small fluid pump.

From what I have seen , and can deduce, is that a high wattage heater block constantly is heating a 'transition' tube. Temperature is unknown, but it is damn hot. Temperature was controlled by a simple bimetal strip that looks like it activated a triac or similar device. Heater power was supplied by the triac. The fog fluid was pumped from the reservoir by a small fluid pump that ran on 6 to 12 VDC. The amount of fog produced was controlled by a large rheostat that had 12 volts applied to it, thereby creating a variable voltage divider. Activation of the 12 volts to the pump for fog was through a small relay that was able to be activated either through a switch added to the fog machine that completed a circuit, or the machine was set on a timer (internal) for fixed interval. Switch voltage was also 12 volts. Fog fluid was injected into the transition tube, and the output nozzle was significantly larger than the input. Estimated age of the machines was about 14 years or so.

After I saw the insides of these things, I am amazed that they are able to demand $300 to $400 price tags. I am thinking about making one of these out of a water-cooled resistor and gravity feeding a gallon jug of the juice through an older 24 VAC sprinkler valve. One of those rainy day projects.

From: don@Misty.com (Don Klipstein)

I once fixed a "Ness" brand "Mini-Fogger". Turned out there was a broken solder joint where the jack for the plug-in "remote" button went into a circuit board.

Also sometimes, the pump sticks. Tapping the pump with a screwdriver while attempting to run it may unstick it.

This thing is simple enough and made of parts that are reliable enough, with the possible exception of the pump. I would mostly look for broken connections or bad solder joints or clogs.

Dehumidifiers

Electric dehumidifiers use a refrigeration system to cool a set of coils which condenses water vapor. The heat is then returned to the air and it is returned back to the room. On the surface, this seems like an incredible waste of energy - cooling the air and heating it back up - but it is very effective at removing moisture. A typical large dehumidifier will condense something like 30 pints in 24 hours - which, unless you have it located over a drain - then needs to be dumped by hand.

There is supposed to be a cutoff (float) switch to stop the dehumidifier when the container is full. Hopefully, it works (and you didn't neglect to install it when the unit was new!)

Common problems with these units are often related to the fan, humidistat, or just plain dirt - which tends to collect on the cooling coils. The sealed refrigeration system is generally quite reliable and will never need attention.

An annual cleaning of the coils with a soft brush and a damp cloth is a good idea. If the fan has lubrication holes, a couple of drops (but no more) of electric motor oil should be added at the same time.

The fan uses an induction motor - shaded pole probably - and may require cleaning and lubrication. See the section: Problems with induction motors.

The humidistat may develop dirty or worn contacts or the humidity sensing material - sort of like a hot dog wrapper - may break. If you don't hear a click while rotating the control through its entire range, this may have happened. If you hear the click - and the dehumidifier is plugged into a live outlet - but nothing happens, then there is probably a problem in the wiring. If just the fan turns on but not the compressor, (and you have waited at least 5 minutes for the internal pressures to equalize after stopping the unit) then there may be a problem with the compressor or its starting relay (especially if the lights dim indicating a high current).

A very low line voltage condition could also prevent a refrigeration system from starting or result in overheating and cycling. A sluggish slow rotating or seized fan, or excessive dirt buildup may also lead to overheating and short cycling.

A unit that ices up may simply be running when it is too cold (and you don't really need it anyway). Dehumidifiers may include sensors to detect ice buildup and/or shut off if the temperature drops below about 60 degrees F.

Garbage disposals

A garbage disposal is just an AC induction motor driving a set of centrifugal hammers (they use to use sharp cutters but these were even more dangerous). The cutters throw the food against an outer ring with relatively sharp slots which break up the food into particles that can be handled (hopefully) by the waste system. However, always use generous amounts of cold water (which helps to cool the motor as well) and let it run for a while after there is nothing left in the disposal and it has quieted down. This will assure a trouble free drain. Otherwise, you may be inviting your friendly plumber over for a visit!

Common problems with garbage disposals relate to three areas:

- Something stuck in grinding chamber - disposal hums or trips internal protector (red button) or main fuse or circuit breaker. Unplug disposal! Then use the wrench (or appropriate size hex wrench) that came with the disposal to work rotor back and forth from bottom. If there is no hole for a wrench (or you misplaced yours), try a broom handle from above but NEVER put your hand in to try to unjam it (there are still relatively sharp parts involved). With the disposer unplugged, you can carefully reach in and feel for any objects that may be stuck or which cannot be broken up by the grinding action (like forks, toys, rocks, beef bones, etc.) and fish these out. Once free, restore power (if needed) and/or reset red button ((usually underneath the motor housing - you may have to wait a couple minutes until it will reset (click and stay in). Then run the unit with full flow of cold water for a couple of minutes to clear anything remaining from the grinding chamber and plumbing.

- Motor - although these only run for a few seconds a day, motor problems including shorted windings or defective rotors are possible. Assuming rotor turns freely, these may include a hum but no movement, repeated blown fuses or tripped circuit breakers, or any burning smells.

- Leaking shaft seal - probably what causes most disposals to ultimately fail. The upper seal develops a slight leak which permits water to enter the motor housing damaging the bearing and causing electrical problems. Symptoms include seized rotor, excessive noise or vibration, actual water leaking from inside the motor housing, burning smells, etc.

- Power switch (built into batch feed models) - wall switches can go bad like any other application. The built in magnetic or microswitch in a batch feed disposal can also fail. Intermittent or no operation may result.

- Drain blockage - disposal runs but water doesn't get pumped out of sink or backs up. Use plumber's helper (plunger) or better yet, remove U-trap under sink and use a plumber's (steel) snake to clear blockage in the waste pipe. NEVER NEVER use anything caustic!!! First of all, it will not likely work (don't believe those ads!). More importantly, it will leave a dangerous corrosive mess behind for you or the plumber to clean up. The plunger or snake will work unless the blockage is so impacted or in a bad location (like a sharp bend) in which case a professional will need to be called in any case.

Unless you are the truly die-hard doit-yourselfer, repair of disposals is probably not a good use of your time. The ultimate reliability of all but the most obvious and simple repairs is usually unknown and could be very short. However, other than time, there is nothing to be lost by at least investigating the source of the problem.

Garbage disposal pops reset button but nothing blocked

Even if nothing is stuck in it, is the rotor free - not too tight? If you have that little wrench that comes with many disposers, you should be able to turn the rotor relatively easily (I would say about 1 foot-pound of torque or less if your arm is calibrated). A tight bearing may be the result of a shaft seal leak - see the next section: Garbage disposal seizes repeatedly.

The red reset button is a circuit breaker. Either the motor is drawing too much current due to a shorted winding or a tight bearing or the breaker is faulty. Without an ammeter, it will be tough to determine which it is unless the rotor is obviously too tight.

If you have a clamp-on ammeter, the current while the motor is running should be less than the nameplate value (startup will be higher). If it is too high, than there is likely a problem with the motor. As an alternate you could try bypassing the circuit breaker with a slow blow fuse of the same rating as the breaker (it hopefully will be marked) or a replacement breaker (from another dead garbage disposal!. If this allows the disposer to run continuously your original little circuit breaker is bad. These should be replaceable.

If the bearings are tight, it is probably not worth fixing unless it is due to something stuck between the grinding disk and the base. Attempting to disassemble the entire unit is likely to result in a leak at the top bearing though with care, it is possible to do this successfully.

Garbage disposal is stuck - hums but does not turn

Here are typical problems:

> "I need help. Our garbage disposal is stuck. It hums but doesn't turn. If I leave it on for more than a few seconds it trips the circuit breaker on the unit. Any tips on how to solve this shy of buying a new unit? The unit is 7 years old."

> "I have an ISE In-Sink-Erator (tm), Badger I model. I tried turning mine on a few minutes ago, the motor started then stopped and now nothing happens when I flip the wall switch, not even a click."

Of course, first make sure there is nothing jamming it - use a flashlight to inspect for bits of bone, peach pits, china, glass, metal, etc. Even a tiny piece - pea size - can get stuck between the rotating disk and the shredder ring. WITH THE DISPOSAL UNPLUGGED OR THE BREAKER OFF, work the the rotor back and forth using the hex wrench that came with the unit or a replacement (if your unit is of the type that accepts a wrench from below. If it is not of this type, use the infamous broom handle from above.)

The internal circuit breaker will trip to protect the motor if the rotor doesn't turn. Turn off the wall switch, wait a few minutes for the circuit breaker and motor to cool, and then press the red reset button underneath the disposal. If it does not stay in, then you didn't wait long enough or the circuit breaker itself is defective. Then, turn on the water and try the wall switch again (in-sink switch if it is a batch feed model).

Assuming it is still tight with nothing stuck inside and/or jams repeatedly:

(From: Rob-L (rob-l@superlink.net).)

That's about how long it takes for the nut to rust away on the shredder disc of Insinkerator/Sears units. My comments will address ISE/Sears deluxe models with the stainless disc, for those who might have one.

When the nut/washer rusts away, the disc will wobble and get jammed. With the power off, try to rock the disc inside the unit. You might need to wiggle the motor shaft with a 1/4" hex wrench under the unit.

If you can free things up, and the disc can be rocked, it's the nut/washer. When that goes, so does the gasket, and unfortunately it requires total disassembly of the grinding chamber to replace the little gasket, because the disc will not come out otherwise. And if you don't replace the gasket, water/gunk will run down the motor shaft and into the motor. When those units go, you're better off to get a new disposer.

I think they intentionally use a non-stainless steel nut, because otherwise the units would last a long time. Even the replacement nuts will corrode. The motor shaft will also corrode, but not as fast as the nut. With a stainless shaft and nut/washer, the disposer would give many more years of service. And that's why they don't make 'em that way. :)

One part that is worth replacing is the mounting gasket. It's the part with the flaps that you feed things through. It gets cut-up and damaged by chlorine from sink cleaning or dishwasher discharge. (brittle, rough) It's a $4 part, usually available at Home Depot next to the new disposers, and it slips on in a matter of minutes -- you just disconnect the trap, then drop the disposer down by undoing the retaining ring. Swap the gasket, re-attach things, and your sink drain looks brand new.

Garbage disposal seizes repeatedly

A garbage disposal that doesn't have anything stuck in the cutting chamber but seems to be hard to turn or will work with effort until left alone for a day or two probably has a bad bearing caused by a leak at the shaft seal. Of course, water gushing out of the lower part of the disposal (or *any* amount of water dripping from inside the motor housing) is one indication that there is a leak! This also represents a safety hazard so the disposal should be left unplugged and not be used even if it still runs.

By the time the leak is detected, it is probably too late to save the disposal as corrosion of the steel shaft, excessive wear of the bronze bushing, as well as possible electrical damage has already occurred.

Realistically, there is nothing that could have likely been done in any case. It is virtually impossible to repack such a bearing in such a way to assure that a leak will not develop in the near future.

Garbage disposal replacement (or upgrade)

My general recommendation is to get the approximately $100 1/2-3/4 Hp Sears (ISE In-Sinkerator(tm) manufactured) unit when it is on sale (which is about every week). These now have at least a 4 year warranty.

If your previous garbage disposal was an ISE In-Sinkerator or Sears, then replacement is usually a 10 minute job if the under-sink plumbing is in reasonably good condition (doesn't crumble to dust when you touch it). If the part that mounts to the sink is not corroded and not leaking, I just leave it alone. The only tools required are a screwdriver and wire strippers (possibly) to move the power cord or cable to the new unit and a screwdriver or socket driver and a large adjustable wrench or pliers to unscrew the drain pipe and dishwasher connection (if used). Complete instructions should be provided with the replacement unit.

Sump pumps and utility pumps

Sump pumps come in two major varieties:

1. **Pedestal:** A motor on top of a 3 foot or so pole drives an impeller at the bottom of its long shaft. Only the base may be submerged.

   These motors are quite reliable but the bearing can rot/rust/sieze at the base where it may be under water or at least in a humid environment.

2. **Submersible:** A motor, usually totally enclosed in a sealed pump housing within an oil bath drives an impeller. The entire unit is designed to be fully or partially submerged in the sump hole.

   The casing may leak at the bearing (if not magnetically coupled) or at the wire connections. Repair of these motors is probably not worth the effort.

Utility pumps are often of the submersible variety.

Three types of automatic switches are commonly used:

1. **Float/weight on a wire, rod, or string** pulls on a spring action toggle type switch. The length of the linkage is adjusted for the appropriate low and high water settings. These will be used mostly with pedestal pumps. If properly sized, this type of switch can be quite reliable - I have a sump pump using this type of switch which is easily 30 years old at this point without ever having any problems with the switch.

2. **Mercury tilt switch** sealed inside a rubber float. By fastening its connecting wire to a suitable location, the level of the water will cause the float to pivot from horizontal the more vertical. An enclosed mercury switch then controls power to the pump motor. These are not serviceable but replacements are readily available.

3. **Diaphragm pressure switch** designed to sense the depth of the water from the trapped pressure. As above, these are not really serviceable but can be easily replaced by the same or a mercury type (2).

Most common problems are with switches that are no longer reliable or totally broken. Universal replacements are generally available since the switch is not usually an integral part of the motor/pump unit.

Toys

Since there are a semiinfinite number of variations on electrically powered toys, the only comment I have is that these are almost always combinations of small PM motors, switches, batteries, light bulbs - and totally impossible to identify electronic components. With small kids, physical destruction is probably a much more common occurrence than a part failure!

Incorrect response for remote control toys

The following may apply when there is no response or an uncontrolled response for certain commands like turn left or move backwards:

(From: Pete Peterson (peterson@usaor.net).)

I've repaired a couple with the same problem and its been the motor driver transistors each time. There are two or three direct coupled transistors from each side of the motor (probably equates to an H bridge) and one or all of these go open. Probably under designed for the current they carry. Just trace the wires from the motor out through the circuit and check the first several transistors you come to.

Garage door operators

Typical garage door operators use a 1/3 to 3/4 horsepower induction motor with a belt drive chain or screw mechanism to move the 'trolley' that actually grabs the door. A switch or pair of switches activated at each end of travel stops the motor and toggles the state (up or down) of the controller. Door blockage sensors detect obstructions and stop or reverse travel. A light turns on with motor start and stays on for 3-5 minutes thereafter, controlled by a simple timer.

Parts of a typical garage door operator (chain drive). Details may differ on operators with worm screw or other drive schemes.

1. **Motor:** Single-phase induction motor of about 1/2 horsepower at 862 or 1,725 (or so) RPM. It is electrically reversible with a large ratio V-belt drive (probably about 25:1 for a 1725 RPM motor between motor shaft and chain sprocket).

2. **Chain or screw drive:** This often needs lubrication. Make sure grease will not harden at low temperatures if relevant (e.g., Lubriplate).

3. **Limit switches** set top and bottom positions of door.

4. **Safety stop:** A means of sensing when excessive force is required to move the door. Some types use a compliant motor mount such that excessive torque will result in a twist which closes a set of contacts to reverse or stop the door.

5. **Logic controller:** The 'brains' which consists of some relays or a microcontroller.

6. **Remote receiver:** A radio receiver tuned to the frequency of the hand unit. Logic here or in the controller checks the transmission to determine if the codes match. More sophisticated units employ a pseudo-random code changing scheme to reduce the chance of code theft. This is usually in a box on the wall connected to the motor unit by a pair of wires.

   On units with DIP switches, both transmitter and receiver settings must match exactly. In addition, for older units in particular, the contacts on the switches may be dirty and/or oxidized so flipping each switch back and forth a few times may be needed to make a reliable connection. I have also seen a situation where one bit wouldn't work in one position - the other position was fine.

7. **Light bulbs and timer:** In many Sears as others, the timer is a bimetal strip heated to operate a set of contacts. The on-time is determined by how long it takes for the bimetal strip to cool. These fail after about 10 years but replacements are readily available. More modern units may switch and time the light from the microcontroller.

General garage door operator problems

1. No response from remote or local buttons. Test power to both the motor unit and control box (they may be separate) outlets. The operator or some other device might have blown a fuse or tripped a circuit breaker. Verify that the connection between the wall box and the motor unit is in tact - check the screw terminals on the motor unit - a wire may have fallen off. Check the circuit breaker (red button) on the motor unit - an overload or an undetected cycling condition (an obstruction causing the door to keep going up and down continuously) may have tripped it. Warning: pressing this button may result in the door starting to move immediately.

2. Local (inside) buttons work but remote unit is dead. Check and/or replace batteries in the remote unit, confirm that the the code settings have not accidentally changed (unit dropped, for example), go through the set up procedure outlined in your users manual. Find a cooperative neighbor with the same model and try their remote unit (after writing down their settings and reprogramming it for your door). If this works, your remote unit is bad. If this does not work, you have a receiver problem.

3. Remote unit has reduced range. Of course, first replace the batteries. If possible check with an identical model remote set to the same code to see if it is a problem with the hand unit or the receiver. Make sure any antenna wire (remote and/or receiver) hasn't fallen off or become disconnected. It is also possible that radio frequency emissions from something in the area is interfering with reception. Have you added any electronic equipment or even just rearranged its location recently - even a VCR or TV? What about your neighbors?

4. Motor operates (you can hear it) but door does not move. This can be caused by a broken or loose belt, snapped door counterbalance spring, locked door, disconnected or broken trolley, logic problems causing the motor be turning in the wrong direction, and other mechanical problems. If the motor runs for about the normal time, then the trolley is probably moving but not attached to the door. If it runs until forever or the overload pops, then a broken belt is likely.

5. Door opens or closes part way and reverses, stops, or twitches back and forth:

   - The tracks may need lubrication, there may be an obstruction like a broom that fell over into the vertical rails.

   - The gear timing may be messed up. The upper and lower limits may be determined by switches operated from a cam separate from the trolley that moves the door. If you just reassembled the mechanism, this is a likely possibility.

   - The safety stop sensors may be set to be too sensitive.

   - In extremely cold weather, the grease may simply be too viscous or just gummed up.

6. Door opens and closes at random. There can be several possible causes:

   - A neighbor has a similar model and has selected the same code (probably the factory default - did you actually ever pick your own code?).

   - Interference from nearby high power amateur, CB, or military or commercial radio transmitters may be confusing the receiver. Suggest to them that they relocate. :-)

     Are there such things as IR remote controls for garage door openers instead of the usual radio frequency variety?

   - The push button switch on your one of your remotes or receiver module is defective - a weak or broken spring - and it is activating the door due to vibration or just because it feels like it. Test the switches. On the hand units, you can just remove the batteries for a day and see if the door stops misbehaving.

Garage door operator light does not work correctly

Assuming the unit otherwise operates normally and you have tried replacing the light bulb(s):

For many types (Sears, Genie, etc.), there is a thermally operated time delay consisting of a coil of resistance wire, a bimetal strip, and a set of contacts. When the operator is activated, power is applied to the heater which causes the bimetal strip to bend and close the contacts turning on the light. Due to the mass of the bimetal strip, it takes a couple of minutes to cool down and this keeps the light on.

The most common failure is for the fine wire in the heater to break at some point. If you can locate the break, it may be repairable at least as a temporary solution. You cannot solder it, however, so a tiny nut and bolt or crimp will be needed. However, sticking contacts resulting in a light that does not always go off are also possible. Cleaning the contacts may help.

This part is very easily accessed once the sheetmetal cover is removed. It is probably somewhere in the middle of the unit fastened with three screws. Just remember to unplug the operator first!

Depending on the manufacturer, the original part may be available. I know that it is for Sears models.

You could also use a time delay relay or a solid state circuit (RC delay controlling a triac, for example) but an exact replacement should be just a whole lot less hassle.

Garage door operator loses track of where it is

You press the button to close the door and it works fine. However, next time you press the button to make the door go up and it tries to go down into the ground.

When it gets to the end of the track - be it at the top or bottom, there must be something that it trips to shut down the motor. At the same time, this is supposed to set things up so that the next activation will reverse the door.

Does the door stop and shut off when it reaches the end or does it eventually just give up and trip on the safety?

When it trips the switch to stop at the end of its travel, some mechanism is toggled to change the 'state' of the door logic so that it knows to go up the next time it is activated. It is probably this device - be it a latching relay, mechanical two position switch, or a logic flip flop - that is not being properly toggled.

I would recommend attempting to determine what device that switch is actually supposed to toggle - it probably is in the operator unit itself (not the control box).

Garage door remotes behave differently

> "I've got 2 Genie garage door remotes. One of them works from about 100 yards away; the other I almost have to be right next to receiver. I suspect that the antenna is the problem; either too short, or blocked by something."

First compare the antennas on the two remotes. If they are the same and there are no broken connections, your problem lies elsewhere. The chance of the wire itself being bad is pretty slim.

It could also be that the receiver and transmitter frequencies are not quite identical. If the remote units have been abused, this is more likely. I don't know about Genie but my (old) Sears has trimmers and I was able to adjust it *very* slightly to match that of the receiver and boost sensitivity.

CAUTION: If you try this (1) mark the exact position where it was originally and (2) do it only on the transmitter that has the problem. This will minimize the possibility of shifting the frequency to where it might interfere with other devices. See the section: Adjusting garage door operator remote unit for more information.

Adjusting garage door operator remote unit

This situation may arise if one hand unit operates normally but the other has a very short range. If you have only one hand unit, it might also be the problem though not likely to have just happened on its own - either it was improperly set up at the factory (if new) or hand unit was dropped once too often.

It should not work at all if the switches are set improperly. In such a case, first test and/or replace the battery. If this does not help, check the switch settings.

The tuning is done via a variable capacitor trimmer (probably).

There will probably be a trimmer inside the hand unit (don't touch the one in the receiver). Position yourself at a reasonable distance and use a plastic tool to adjust it until the door operates while holding the button down. The door will respond at increasing distances as you approach the optimal setting.

Note: mark the original position first in case this has no effect!

This assumes there is an adjustment - if there is none, you may have an actual electronic failure, bad connections, etc.

Improving sensitivity of garage door openers receivers

Where a garage is constructed with aluminum siding, the remote signal may be significantly attenuated and of insufficient strength to activate the receiver module (inside the garage) of the opener at any useful distance or at all. Assuming the system operates normally otherwise (i.e., activation is normal with the door open), two approaches (either or both together) can be taken to solve this problem:

1. Locate the receiver module (well, actually, its antenna) in an area of unsided wood, glass window, or other non-metallic area of the building. Note that construction insulation may use aluminum foil as part of its vapor barrier so there could be problems even in an area with no siding.

2. Extend the antenna on the receiver module. This may not always work but is worth a try. A 1 or 2 foot length of copper wire may help dramatically.

3. There are external antenna kits available for some door openers. The antenna goes outside, and connects to the receiver through a hole in the wall using coaxial cable. You will probably have to go directly to the manufacturer of your garage door opener or a garage door opener service company.

Universal remote/receiver units for garage door operators

So you lost your garage door remote or it got run over by your 4x4 :-). Or, it just expired due to age. There are alternatives other than an entire new operator if the remote is no longer available:

(From: Kirk Kerekes (redgate@tulsa.oklahoma.net).)

Go to a home center, and wander over to the garage door openers. Nearby, you will find GDO accessories, and among the accessories will be a universal replacement remote kit that includes a receiver, a transmitter and possibly a power supply. For about $40, you can by and install the receiver in place of the existing receiver. If your home center carries Genie openers, you can even get an Intellicode add-on unit that uses Genie's scanner-proof code-hopping technology.

Garage door operator doesn't work reliably in cold weather

First, check the lubrication. The most common problem is likely to be gummed up grease in the chain drive (if used) or the bearings of the rollers. Note: the track itself generally doesn't require lubrication.

Increasing the safety override force settings may help but are not a wise solution as the door will then be more of a hazard to any legitimate obstructions like people and pets.

Another possibility is that the motor start/run capacitor has weakened and is not permitting the motor to provide the proper torque. You can test the capacitor if you have a DMM with a capacitance scale or LCR meter. Better yet, just replace it.

Chamberland garage door opener repair?

> "My remote broke for my very old (defunct) chamberlain automatic garage door opener.
>
> Chamberlain tech support told me they suggest I buy a whole new unit. Is there any other way to make my door usable with a different remote, or some other arrangement?"

(From: Panayiotis Panayi (panikos@mishka.win-uk.net).)

Which Chamberlain operator is it, i.e., which model number. You can buy the handsets for Chamberlain operators up to 5 years old. If it is older you will have to buy a new Rx & Tx for it. Most operators have three screw terminals on the back for the attachment of Rxs. The old Chamberlain operators conformed to this. The new ones have the Rx built onto the main PCB inside the operator and have 4 screws externally for pushbuttons and infra red safety beams. If yours has 4 screws you will have to provide a separate PSU for the new Rx or solder two pieces of wire after the step down transformer on the PCB. You must do it before the rectifiers. Otherwise the current drain from the Rx will be too big for them. Besides almost all modern separate Rxs take 24 VAC.

Garage door operator security

While manufacturers of garage door operators make excellent claims of security, this is of no value if you don't take advantage of whatever features are included in your unit.

If there is access to your house from the garage, this security is even more critical. Once inside the garage, a burglar can work in privacy at their leisure - and a nice set of tools is probably there for their convenience in getting through your inside door! Filling up a good sized car or truck with loot - again in complete privacy - drive out and close the door behind. No one will be the wiser until you get back.

1. DIP switches. Many garage door operators use a set of 8, 12, 16, or more little switches to set the codes of the remote and base unit. If you have never set these, then your are probably still using the manufacturer's default - and all instances of the same model probably have the same code! Change it to something random - pick a number out of a random page in a telephone directory or something like that. Do not select something cute - others, perhaps with not totally honest intentions - will think the same way. You don't have to remember it so an arbitrary totally random setting is fine. However, even the types with 24 switches - that is over 16 million possible codes - can be sniffed: a relatively simple device can monitor your transmission as you open the door and program a special remote unit to duplicate it.

2. More sophisticated units incorporate a scheme whereby the codes change each time the operator is used in a pseudo-random manner which is almost impossible to duplicate. Even sniffing such a code is of no use as the next instance is not predictable.

3. Don't leave your remote unit prominently displayed in your car - it is an inviting target. Theft is not necessary - just a moment to copy down the switch settings may be enough. Lock your car! Also, leave a bogus remote unit in plain view (from your previous operator).

4. Just because the codes are secure doesn't mean that you are safe. The keylocks that are present on many operators to open the door from the outside are pretty pathetic. They can be picked in about the same time it takes to use a key - with ordinary tools - or often with any key that will fit the keyhole. My advice: replace with a high quality pick resistant keyswitch. A well designed electronic lock may be best. When going away for an extended period, use the physical lock on the garage door itself as added protection and unplug the garage door operator.

Identifying unknown transformer ratings in garage door operator

In a garage door operator, the transformer likely powers the controller and receiver. If you can look at where its outputs go, you may be able to infer something about the voltage even if the transformer is a charred mass.

- If there are AC relays in the box, they almost certainly run off the transformer and their coil voltage will be the same if it is the only one).

- Check the capacitors in the power supplies of the controller and/or receiver. They will give an indication of the approximate secondary voltage of the transformer. Their voltage rating will typically be 1.5 to 2 times the RMS of the transformer.

- Many of these transformers include a thermal fuse under the outer wrappings of insulating material. These may fail from old age or due to a fault. If the transformer works fine without overheating when replaced (or bypassed temporarily on a fused circuit), then it may be fine. However, shorted windings can cause a thermal fuse to blow and there is then no electrical test that will reveal the proper output voltage. See the docuemnt: Notes on the Troubleshooting and Repair of AC Adapters, Power Supplies, and Battery Packs.

- Disassemble the transformer and count the number of turns of the primary and secondary windings. The ratio multiplied by 115 is the output voltage.

- Get a 24 V transformer (it is probably not more than this) and connect its primary to a Variac and its secondary to the opener. Slowly increase the variac until everything works. (check every volt or so from 5 to 24). Measure the output voltage of the transformer, add 10-20%, you've probably got the secondary rating. If it is near a standard value like 12 or 24, this is most likely correct.

- Buy a new opener.

Electromechanical doorbells and chimes

Most of these consist of a low voltage transformer powered directly from the house wiring providing 10 to 20 VAC at its output, one or more switches for the front door(s), one or more switches for the back door(s), and an electromagnetic chimes unit.

All of the switches for a given location (i.e., inside and outside the storm door) are wired in parallel. There will be three terminals on the chimes unit - Common (C), Front (F), and Back or Rear (B or R). This notation may differ slightly for your unit. Typical wiring is shown below. An optional second chimes unit is shown (e.g., in the basement or master bedroom - more can be added in parallel as long as the bell transformer had an adequate VA rating.)

```
             Bell Transformer                               Chimes
          H o----+                                           Unit
                 )||       X      _|_ Front door               F
                 )|| +-----+------- -------------------o
                 )||(      |
```

```
    115 VAC    )||(      |      _|_ Back door        B
(Junction box) )||(      +------- -------------------o
               )||(
               )||(      Y                           C
               )|| +---------------------------------o
               )||
       N o----+
```

- The primary side of the transformer is generally wired permanently inside a junction box. This could be almost anywhere but the most common location is near the main electrical service panel.

- The common goes to terminal 1 of the transformer (the designation 1 and 2 is arbitrary - it may not be marked).

- All the front door buttons are wired in parallel and this combination connects between terminal 2 of the transformer and the F terminal of the chimes unit.

- All the back door buttons are wired in parallel and this combination connects between terminal 2 of the transformer and the B or R terminal of the chimes unit.

Where the pushbuttons are lighted, a small incandescent bulb is wired across the switch contacts and mounted inside the button unit. It is unlikely that this bulb will ever burn out since it is run at greatly reduced voltage. However, if the button does not light but the bell works, this has happened. Replace the pushbutton/light combination - locating a replacement bulb may not worth the effort though Radio Shack is supposed to have something that will work.

Most 'not-chiming' problems are due to the one or more of the following:

- **Defective switches:** These do go bad due to weather and use. Test with a multimeter on the AC voltage range. You should see the transformer voltage across the switch when it is not pressed and near 0 voltage across it when it is pressed. If only one location does not work, a defective switch is likely. Sometimes the wires just come loose or corrode at the terminals. These can be cleaned - with fine sandpaper if necessary - and reconnected.

  Note: where multiple switches operate the chimes from similar locations, multiple wires may be connected to each switch terminal. Don' mix these up or lose them inside the wall!

- **Bad connections:** These could be anywhere but unless you just did some renovation which may have damaged the wiring, the most likely locations are at the switches, transformer terminals, or chimes. However, this sort of installation might have been done by just twisting wires together when extra length was needed and these can go bad. They could be anywhere. Good luck finding the corroded twists! Then, use Wire Nuts(tm) or solder them together to assure reliability in the future.

  If just a single location doesn't work, that should narrows down the problem. If only one switch does not work, first test the switch. If disconnecting the wires from the switch does not result in full transformer voltage across the wires, then there is a bad connection between you and the transformer, the transformer has no power, is defective, or there is a short circuit somewhere.

- **Incorrect wiring at chimes unit:** This commonly happens when someone replaces the chimes unit and forgets to label the wires. :-(It is often difficult to follow the wires since they pass through door jams, finished basement ceilings, and may not be color coded. But checking it is easy to with a multimeter or the chimes themselves. An assistant would be helpful - else you can just short across the front or back buttons as required below.

  1. Disconnect the wires from the chimes unit terminal block.

2. Have your assistant press the front door button.

3. Determine which pair of wires has full voltage - use the multimeter or touch them between C and F on the chimes unit. Make a note of which ones they are. One of these wires is will be C and the other is F.

   Note: due to coupling between the wires, there may be some voltage across all combinations. The most will be across the relevant one (and this will be the only combination that will sound the chimes if you are using them as a voltage indicator).

4. Have you assistant press the back door button.

5. Determine which pair of wires now has voltage.

6. Connect the wire that is the same as one of those in (3) to the C terminal, the other wire of the pair to B, and the remaining wire to F.

- **Bad transformer or loss of power to transformer:** The transformer will often be located near the main service panel but not always. Sometimes it is a challenge to locate! To test, proceed as follows (this can be done with power on - the low voltage is safe but test first to make sure you have the correct transformer!):

  1. Disconnect one of the wires from its output terminals and then test across it with a multimeter on the AC voltage range. There should be the full rated transformer voltage across these terminals (actually, it will probably be 10 to 20 percent greater). The rated voltage of the transformer should be marked on it somewhere.

     - If there is voltage and it is approximately equal to the transformer's rated voltage, the transformer is probably good.

     - If there is none, check for a blown fuse, tripped breaker, or tripped GFCI; some other equipment may have overloaded the circuit. Actual failure of the transformer blowing a fuse or tripping a breaker is rare.

       A quick test to determine if the transformer is being powered is to feel it! The transformer should be warm but not hot to the touch. If it is stone cold, either there is no power or a bad connection in the input line) circuit.

     - If there is voltage and it is approximately equal to the transformer's rating, the transformer is probably good.

     - If the voltage is much lower than the rated voltage, the transformer may be bad. In this case, it will likely be quite hot due to a short circuit inside.

  2. Assuming the voltage checks out, reconnect the wire your previously removed.

     - If it is now low or 0, there is a short circuit somewhere. Note: a short on the secondary of this type of transformer will cause it to run quite hot but may not result in a blown fuse or tripped breaker or even any permanent damage to the transformer.

     - If the chimes sound as you reconnect the wire, there is a short in or at one of the pushbutton switches or associated wiring.

- If the voltage remains the same, then the transformer is probably good and the problem lies elsewhere - bad switch, bad connection, defective chimes.

3. **Dirty or defective chimes:** Most common problems are not electrical but mechanical - the plungers that strike the actual chime or gong do not move freely due to dirt and grime (especially in a kitchen location) or corrosion. Usually, wiping them clean or some light sanding will restore perfect operation. Do not lubricate as the oil will just collect crud and you will be doing this again in the near future. If they move freely, then you have an electrical problem. Also note that these chimes are designed to be mounted with the plungers moving vertically. There is likely a 'this side up' indication on the unit - if you are experiencing problems with a new installation in particular, verify your mounting!

   Test for voltage between the Common and Front or Back terminals when the appropriate button is pressed.

   - If correct voltage is present, disconnect the non-common wire and check the resistance between the Common and the terminal for the chime that is not working - it should be reasonably low, under 100 ohms. If the resistance is infinite, the coil is open. Unless you can locate the broken wire, the chimes unit will need to be replaced.

   - If the voltage is missing, the problem is probably elsewhere.

   - If the voltage is low, there may be a partial short in the coil, the transformer may be underrated for your chimes (not all chimes take the same amount of power), or there may be a high resistance somewhere else in the wiring.

Weak or erratic mechanical chimes

This can be due to several things:

- A transformer that doesn't put out enough voltage - 10 V instead of 16 V, for example. Modern chimes usually want 16 V - some transformers can be jumpered for multiple output voltages - check and change the jumper or replace if needed.

- A transformer with inadequate VA rating - quite likely if you have been adding additional chimes units to a house the size of Bill Gates' mansion. Install a larger transformer. The package will list the number of typical chimes that can be used.

- Bad buttons (especially if only one location is a problem). Use a screwdriver or paper clip to short between connections at each button. If this produces reliable chiming, the button probably needs to be replaced.

- Bad connections at transformer, chimes unit, buttons, or wire splices. Inspect and tighten if needed.

- Gummed up or defective chimes unit. Inspect, clean, or repair or replace as needed.

- Chimes unit mounted incorrectly (upside-down or on its side). Yes, they have a proper orientation! The weight of each plunger and its spring must balance - especially for the one that goes 'ding-dong'. :-) So, if you just installed this thing - quick, check it! :)

Adding an additional set of chimes

There are at least two ways of doing this (though the first one is more straightforward and intuitive and therefore generally preferred).

1. Locate the wires going to the first chimes unit. There will be either 2 or 3 (both front and back door). Connect the new chimes unit to these same wires in parallel:

```
          Bell Transformer                         Chimes    Chimes
       H o----+                                    Unit 1    Unit 2
               )||       X      _|_ Front door        F         F
               )|| +-----+------- --------------------o---------o
               )||(      |
    115 VAC    )||(      |      _|_ Back door         B         B
(Junction box) )||(      +------- --------------------o---------o
               )||(
               )||(      Y                            C         C
               )|| +----------------------------------o---------o
               )||
       N o----+
```

The only concern is whether the existing transformer that operates the chimes has enough capacity - you may need to replace it with one with a higher 'VA' rating (the voltage rating should be the same). These are readily available at hardware and electrical supply stores and home centers.

Some people might suggest just paralleling an additional transformer across the original one (which may be possible if the output phases match). I would really recommend simply replacing it. (This is probably easier mechanically in any case.) Unless the transformers output voltages as designed are identical, there will be some current flowing around the secondaries at all the times. At the very least, this will waste power ($$) though overheating is a possibility as well.

2. Each additional chimes unit or group of chimes units can use its own transformer but share the doorbell pushbuttons. Just wire point 'X' of the transformers together and each point 'Y' separately to the C (common) terminal on its respective chimes unit(s):

```
          Bell Transformer                         Chimes    Chimes
       H o----+                                    Unit 1    Unit 2
               )||       X      _|_ Front door        F         F
               )|| +-----+------- --------------------o---------o
               )||(      |
    115 VAC    )||(      |      _|_ Back door         B         B
(Junction box) )||(      +------- --------------------o---------o
               )||(
               )||(      Y                            C         C
               )|| +----------------------------------o    +----o
               )||                                         |
       N o----+        From output Y of identical o--------+
                        second bell transformer
                        (H, N, X, wired in parallel)
```

However, since the 'Y' outputs of the transformers are connected at all times to the 'C' terminals of the of the chimes units AND the 'X' outputs are tied together, any voltage difference between the 'Y' outputs will result in current flow through the chimes coils even if no button is pressed. Thus, the transformers must be phased such that there is no (or very little) voltage between 'Y' outputs. Test between 'Y' outputs with a multimeter set on AC Volts after you have the transformers powered: if you measure about double the transformer voltage rating (e.g., 32 VAC), swap ONE set of transformer leads (input or output but not both) and test again. If it is still more than a couple volts, your transformers are not matched well enough and you should purchase identical transformers or use the approach in (1), above.

Note: For either of these schemes, beyond some number of chimes units, the current rating of the pushbutton switches will be exceeded resulting in early failure. However, this should not happen unless your house is similar in size to Bill Gates' mansion.

3. Another alternative: If you have an unused baby monitor type intercom (your kid is now in college and you remembered to remove the old batteries which might otherwise now be a congealed mass of leaked goo), stick the transmitter next to the main chimes and put the receiver in your workshop or wherever you want it :-).

How to add an addition button to a door bell

Refer to the diagram in the section: Electromechanical doorbells and chimes.

Another button can be added in parallel with any of the existing ones (i.e., between points X and F or X and B in the diagram). The only restriction is that you may not be able to have more than one lighted button in each group as the current passing through the lighted bulbs may be enough to sound the chimes - at least weakly.

If you cannot trace the wiring (it is buried inside the wall or ceiling) the only unknown is which side of the transformer to use. If you pick the wrong one, nothing will happen when you press the button.

Wireless doorbells or chimes

The transmitter and receiver portion of these units are virtually identical to those of garage door operators. See the relevant sections on those units for problems with activation.

The bell or chimes portion may be either an electromechanical type - a coil forming an electromagnet which pulls in a plunger to strike a gong or bell. See the section: Electromechanical doorbells and chimes.

Others are fully electronic synthesizing an appropriate tone, series of tones, or even a complete tune on demand. Repair of the electronics is beyond the scope of this document. However, there are several simple things that can be done:

- Check for dead batteries and dirty battery contacts in both the pushbutton and chimes unit.
- Confirm that the channel selection settings have not accidentally been changed on the pushbutton or chimes unit. Flick each switch back and forth (where switches are used) just to make sure they are firmly seated.
- Check for improper programming or program loss due to a power failure (if AC operated) on units that are more sophisticated than a personal computer.

Doorbell rings on its own

- For mechanical chimes, this is almost certainly an intermittent short circuit in the button wiring or a defective button. First check or replace the outside pushbutton switches as this is the most likely location due to environment and small multilegged creatures.
- For electronics chimes, the problem could either be in the transmitter(s) or chimes unit or due to external

interference. Someone in your vicinity could have the model also set to the default code (which is probably what you have, correct?).

First, remove the batteries or kill power to all transmitters and wait see if the problem still occurs.

- If it does, either the chimes unit is defective or there is an external source of interference.

- If it now behaves, try each one individually to identify the culprit. In some cases, a low battery could produce these symptoms as well.

Old garage door operator guts for wireless chime

Don't toss the electronic remains of that old garage door operator. It would probably be possible to use it as the basis for a wireless doorbell. Instead of starting the motor, use its output to enable an electronic chime or buzzer. The RF transmitter and receiver for a wireless chime is virtually identical to that of a typical garage door operator.

TV antenna rotators

These consist of a base unit with some sort of direction display and knob and a motor unit to which the TV antenna is mounted. Of course, the troubleshooting of these installations is complicated by the remote and somewhat inaccessible location of the motor unit. :-(Before climbing up on the third story roof, confirm that you haven't lost power to the motor unit and/or base station and that the connections between them are secure.

A common type of motor that may be used in these is a small AC split phase or capacitor run induction motor. The relative phase of the main and phase coils determines the direction. These probably run on 115 VAC. A capacitor may also be required in series with one of the windings. If the antenna does not turn, a bad capacitor or open winding on the motor is possible. See the chapter: Motors 101 for more info on repair of these types of motors.

The base unit is linked to the motor unit in such a way that the motor windings are powered with the appropriate phase relationship to turn the antenna based on the position of the direction control knob. This may be mechanical - just a set of switch contacts - or electronic - IR detectors, simple optical encoder, etc.

Here is some info on connections for some types:

(From: Will Shears (wshearsN@wyzz.sbgnet.com).)

The rotor is operated on 24 volts AC. The wires are used like this:

- Pin 1 is a common
- Pin 2 is a forward direction lead
- Pin 3 is the reverse direction lead
- Pin 4 is a contact closure that will close regularly as the rotor operates.

This was connected to a knob switch, which also turned. Scenario is: the unit is pointed halfway through the circle. turn the knob left, the rotor turns and the indicator turns with it. when the rotor turns the same number of "clicks" as you turned the knob, it stops. same for reverse.

OR, the third lead was a meter lead, and the rotor turned a pot that changed the meter reading according to the position of the pots' turning. The rest is the same.

Inside the box was a 70 uF, 50 V or so NON POLARISED capacitor, or an AC capacitor. Usually the capacitor was connected across the #2 and #3 lead. It provided a phase shift for the motor, and you put 24 volts from #1 to #2 for forward, and to #1 and #3 for reverse. The other lead will either pulse as the rotor turns, or the voltage will change between the #1 & #4 lead, assuming there is a load resistor across the terminals. I would try a 470 ohm 1 watt resistor to start, and probably a 100 to 200 will be right. If you have a VOM, check for resistance across 1 and 4, if you get some, not a short, it is the second type, if you get a short or open, it is a pulse type.

(From: Al Cunniff (acunniff@erols.com).)

Here is one place that is devoted to antenna rotors if you give up:

- Norm's Rotor Service

5263 Agro Drive
Frederick, MD 21703
Phone 301-874-5885
Web: http://www.rotorservice.com/

Note: They don't have email built into their site, but the site tells you just about everything else you need to know about their business and service. It has a good rotor FAQ section too.

I'm not connected in any way with Norm's,

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Power Tools

Types of motors found in power tools

A variety of motor types are used depending on the type of tool. AC powered portable tools usually use a universal motor due to it high power/weight ratio and ease of electronic speed control. Cordless tools usually use a high performance permanent magnet DC motor. Stationary power tools almost always use some form of AC induction motor except where variable speed is required.

See the sections on these types of motors for more details than the following summaries provide.

Motors in AC line operated portable tools

Line operated portable (corded) power tools usually use a universal type AC motor providing 3,000 to 30,000 RPM at the motor shaft. For the same power rating, these will be significantly lighter than an induction motor.

A single or multiple stage gear reducer drops the relatively high speed at which these motors are most efficient to whatever the tool actually requires, increasing the torque as well.

Universal motors can also be speed controlled relatively easily using a variant of a simple light dimmer type circuit. Excellent torque is maintained over a very wide range extending to nearly 0 RPM.

Motors in cordless power tools

These are usually high performance permanent magnet DC motors using advanced high strength and exotic magnetic materials. They are very compact and light weight for their power output. As with all DC (brush type) motors, brush wear is a common problem.

Speed control is easily accomplished by low cost electronic circuits which chop the power (pulse width modulation) rather than simply using a rheostat. This is much more efficient - extremely important with any battery operated device.

Motors in stationary power tools

Stationary power tools which do not require continuous speed control will generally use some type of AC induction motor - split phase or capacitor start/run. The motors generally operate at a fixed speed of around either 1725 or 3450 RPM (U.S., 60 Hz power). Stepped pulleys or continuous mechanical speed/torque changers are used to obtain (usually) lower work piece speeds.

For example, a typical drill press may have one or two sets of stepped pulleys providing 3 to 15 or more speeds by changing belt positions. A continuously variable cone drive is also available as an option on some models. This is extremely convenient but does add cost and is usually not found on less expensive models.

An internal thermal overload protector may be incorporated into larger motors. WARNING: this may be self resetting. If the tool stops on its own, switch off and unplug it before attempting to determine the cause.

Generally, these induction motors are virtually maintenance-free though cleaning, tensioning, and lubrication may be required of the drive system.

However, electronic speed control of induction motors, while possible, is relatively complex and expensive requiring a variable frequency variable voltage power supply. Therefore, universal motors may be used on stationary tools like scroll saws with continuously variable electronic speed control.

As technology marches on, there will be increasing use of electronically controlled motors in all sorts of appliances and power tools. Greatly increased efficiency and finer control are possible by using 3 phase permanent magnet motors - similar to larger versions of brushless DC fan motors - with integrated power control electronics. But, for these applications, that is largely in the future (currently: Spring 2000).

About horsepower ratings

One horsepower is equal to 746 watts of electrical power (100% efficiency). Therefore, the most you can get continuously from a normal 115 V 15 A outlet is about 2 HP. Any claims (for air compressors, for example) of higher ratings on a normal outlet are totally bogus. Companies such as Sears (Craftsman) like to specify 'Reserve Power' for their power tools which as best as I can determine refers to the power available for a short time and may relate to the mass - and inertia - of the rotating parts but not the continuous power available. This may be useful to help saw through a tough knot in a piece of hardwood but may not be terribly meaningful for a wet/dry vacuum! Therefore, pay most attention to the continuous power ratings if they can be found anywhere. A good indication is probably the maximum amps required for the electrical service.

As with over-the-counter drugs, extra strength does not necessarily translate into faster relief, higher current does not always mean better performance, and horsepower ratings much above what you would compute from V x A may be more of a marketing gimmick than anything really beneficial.

Cords for AC line operated portable power tools

Really old power tools had two wire cord plugs and no safety ground yet were of all metal (solid and heavy!) construction. I would recommend that as a matter of policy, these be retrofitted with a 3 wire grounded cordset.

Newer ones have the grounded cordset while the newest 'double insulated tools' are of mostly plastic construction and are back to a 2 wire ungrounded cord.

As with any electrical appliances, inspect cords regularly and repair or replace any that are seriously damaged - if the inner wiring is showing, nicked, or cut; if the plug is broken or gets hot during use, or where the cord is pulled from or broken at the strain relief.

Portable drills

The portable electric drill (now the rage is cordless) is probably one of the two first tools that any handyman should own (the other being a saber saw). It is used for many things in addition to drilling little holes - drilling large holes, sanding, polishing, driving screws, etc. Therefore, these tools get a lot of use - and abuse.

AC line powered drills

An AC line powered electric drill is just a universal motor with a two stage (typical) gear reduced powering a chuck to hold the drill bit or attachment. A continuous range speed control with a reversing switch is now standard on most AC line powered drills.

Typical problems include:

- **Worn bearings:** These may be replaceable. Also see the section: Upgrading the bearings on a Craftsman drill.

- **Worn motor brushes:** Replacements should be available. from the manufacturer or a motor/appliance repair shop.

- **Broken or chipped gears:** This is rare under normal conditions but if the drill was abused, then failure is possible.

- **Bad cord or plug:** Repair or replace for safety reasons.

- **Bad speed controller/reversing switch:** Replacement trigger assemblies are available but may cost half as much as an entire new drill. One common wear item is the linear potentiometer operated by the trigger and this is not likely to be a standard component. The drill may work fine as a single speed model if this control fails (either as-is or by bypassing the triac). You could always use an inexpensive external motor speed controller in this case.

- **Bad motor:** Failures are possible but unless abused, not nearly as common as other simple problems like bad brushes or bearings. It may not be cost effective to replace a bad armature or stator unless this is an expensive high quality drill or you have a similar model available for parts.

- **Rusted or gummed up chuck (or, lost chuck key!):** The chuck is replaceable. Depending on type, it may mount with a right or left hand screw thread and possibly a right or left hand retaining screw through the center. See the owner's manual to determine what your drill uses as you could be attempting to tighten rather than loosen the chuck if you turn the wrong way. If by some slight chance you do not have the owner's manual, a reversible drill will usually have a left hand (reversed) thread on the chuck and a retaining screw with a right hand (normal) thread. A non-reversible drill will only have a right hand thread on the chuck and probably no retaining screw. There may be a hole to insert a locking rod to prevent the shaft from turning as you attempt to loosen the chuck. Inserting the chuck key or a suitable substitute and gently tapping it with a hammer in the proper direction may be useful as well to free the chuck.

  A gummed up but not too badly rusted chuck can be rescued with penetrating oil like WD40 or Liquid Wrench: spray it into the chuck, let it sit for few minutes, then use the chuck key to start working it back and forth. Pretty soon it should be free - rotate through its entire range back and forth. Spray and spin a couple more times and it should be fine for another 20.000 holes.

Upgrading the bearings on a Craftsman drill

Very inexpensive models (like the $30 Father's day specials) may use sleeve bearings in various locations instead of better quality longer lived ball or roller bearings. One particular bearing tends to deteriorate rapidly, especially if the drill is used for sanding or in dusty work environments (as opposed to clean rooms :-)). This is the motor bearing at the handle end. The lubrication dries out or is absorbed by dust particles, the bearing runs dry, wears, and fails with an ear shattering squeal. Even if you use ear plugs, the speed and power are not adequate as the motor is laboring and overloaded and motor failure would result from prolonged operation.

I have upgraded a couple of these drills to ball bearings. The substitution is straightforward requiring disassembly of the drill - removing of the front gear reducer and then one side of the case. At this point, the old sleeve bearing is easily freed from its mounting (just the plastic of the case) and pulled from the shaft. The shaft is likely undamaged unless you attempted to continue running the drill even after going deaf.

The drills I upgraded had bearings that were 7/8" OD, 5/16" thick, and with a 5/16" ID center hole. The old ones were worn by almost 1/32" oversize for the center hole but the motor shaft was undamaged. I found suitable replacement double sealed ball bearings in my junk box but I would assume that they are fairly standard - possibly even available from Sears Parts as I bet they are used in the next model up.

If the gear reducer needs to come apart to access the motor, take note of any spacer washers or other small parts so you can get them back in exactly the correct locations. Work in a clean area to avoid contaminating the grease packing.

The bearing should be a press fit onto the shaft. Very light sanding of the shaft with 600 grit sandpaper may be needed - just enough so that the new bearing can be pressed on. Or, gently tap the center race with hammer (protected with a block of wood). Make sure that the bearing is snug when mounted so that the outer race cannot rotate - use layers of thin heat resistant plastic if needed to assure a tight fit (the old sleeve bearing was keyed but your new ball bearing probably won't have this feature).

These drills now run as smoothly as Sears' much more expensive models.

Cordless drills

Cordless drills use a permanent magnet DC motor operating off of a NiCd (usually) battery pack. Manufacturers make a big deal out of the voltage of the pack - 6, 7.2, 9.6, 12, 14, 18, etc. - but this really isn't a sure measure of power and time between charges as a motor can be designed for any reasonable voltage. A gear reducer follows the motor driving a chuck for holding the drill or screwdriver bit, or attachment. These are most often have a single or two speeds with reverse.

In addition to the problems listed in the section: AC line powered drills, these are also subject to all the maladies of battery operated appliances. Cordless tools are particularly vulnerable to battery failure since they are often use rapid charge (high current) techniques.

- **Bad NiCd batteries:** Reduced capacity or shorted cells. In most cases, a new pack will be required.
- **Bad power/speed selection/reversing switch:** Replace.
- **Bad motor:** These are usually permanent magnet brushed type motors. Worn brushes and bearings are common problems. In addition, a partially shorted motor due to commutator contamination is also possible - see the sections on PM DC motors. Disassembly, cleaning, and lubrication may be possible.

Other direct drive tools

- **Rotary (Moto) tools:** high speed compact universal or PM motors with a variety of chucks and adapters for holding tiny bits, grinding stones, cutters, etc.
- **Routers, biscuit cutters:** high speed (30,000 RPM typical) universal motor with a 1/4" (fixed size, router) chuck for common router bits.

  Ball bearings are used which have long life but are probably replaceable if they fail (noisy, excessive runout, etc.).

  The plug, cord, trigger, and interlock switches are prone to problems and should be checked if the tool doesn't run at all.
- **String trimmers:** Universal motor on long handle with trigger control. Check for a bad cord, switch, and dirt in the motor if the unit appears dead. The motor brushes could also be worn or not seating properly.

Saber saws, reciprocating saws

These use a universal motor which drives a gear reducer and reciprocating mechanism. Better models have a variable speed control so that the sawing rate can be optimized to the work. All but the most inexpensive allow the head to be rotated or rotate automatically based on feed direction adding a bit of complexity.

A reciprocating saw is very similar but uses a much larger motor and beefier gearing.

In addition to motor problems, there can be problems with damage, dirt, or need for lubrication of the reciprocating mechanism.

Electric chain saws

WARNING: Read and follow all safety instructions using any type of chain saw.

These have a high power universal motor and gear reducer. Most have the motor mounted transversely with normal pinion type gears driving the chain sprocket. A few models have the motor mounted along the axis of the saw - I consider this less desirable as the gyroscopic character of the rotating motor armature may tend to twist the saw as it is tilted into the work.

Inexpensive designs suffer from worn (plain) bearings, particularly at the end of the motor opposite the chain since this is exposed to the elements. Normal maintenance should probably include cleaning and oiling of this bearing. A loud chattering or squealing with loss of speed and power is an indication of a worn and/or dry bearing Replacement with a suitable ball bearing is also a possibility (see the section: Upgrading the bearings on a Craftsman drill since the approach is identical.

Keep the chain sharp. This is both for cutting efficiency and safety. A dull chain will force you to exert more pressure than necessary increasing the chance of accidents. Chains can be sharpened by hand using a special round file and guide or an electric drill attachment. Alternatively, shops dealing in chain saws will usually have an inexpensive chain sharpening service which is well worth the cost if you are not equipped or not inclined to do it yourself.

One key to long blade and bar life is the liberal use of the recommended chain oil. Inexpensive models may have a manual oiler requiring constant attention but automatic oilers are common. These are probably better - if they work. Make sure the oil passages are clear.

The chain tension should be checked regularly - the chain should be free to move but not so loose that it can be pulled out of its track on the bar. This will need to snugged up from time-to-time by loosening the bar fastening nuts, turning the adjustment screw, then retightening the nuts securely.

There may be a slip clutch on the drive sprocket to protect the motor if the chain gets stuck in a log. After a while, this may loosen resulting in excessive slippage or the chain stopping even under normal conditions. The slip clutch can generally be tightened with a screwdriver or wrench.

Circular saws, miter, and cutoff saws

These have a high power universal motor either directly driving the blade or driving a gear reducer (high torque/large blade variety).

Miter and cutoff saws are similar but are mounted on a tilting mechanism with accurate alignment guides (laser lights in the most expensive!).

Grinding wheels

A dual shaft induction motor drives rotating grinding stones (or other tools like wire brushes). Most common are fixed speed - usually around 3450 RPM but variable speed operation is highly desirable to avoid overheating of tempered metal during sharpening. All but the most inexpensive use sealed ball bearings requiring no routine maintenance.

Small light duty grinders may be 1/4 HP or less. However, this is adequate for many home uses.

Wet wheels may run at much slower speeds to keep heat to a minimum. Being in close proximity to water may in itself create problems.

Polishers, rotary sanders

A gear reduced universal motor drives a rubber (usually) mounting plate to which a sanding disk or polishing pad is attached.

Due to the nature of their use, sanders in particular may accumulate a lot of dust and require frequent cleaning and lubrication.

Orbital sanders and polishers

In addition to the usual universal motor and its bearings, the orbital mechanism may require cleaning and greasing periodically.

Belt sanders, power planers

A typical portable belt sander uses a gear or belt reduced universal motor driving one of the rollers that the sanding belt rotates on under tension. In decent quality tools, these should use ball or roller bearings which require little attention.

A power planer is similar in many ways but the motor drives a set of cutters rather than a sanding belt.

Air compressors

A direct or belt drive induction motor (probably capacitor start) powers a single or multiple cylinder piston type compressor. Typical continuous motor ratings are between 1/4 and 2 HP (for a 115 VAC line). Over and under pressure switches are used to maintain the pressure in an attached storage tank within useful - and safe - limits. Most will include an unloading valve to remove pressure on the pistons when the compressor stops so that it can be easily restarted without damage to the motor and without blowing fuses or tripping circuit breakers.

I much prefer a belt driven compressor to a direct drive unit. One reason is that a motor failure does not render the entire compressor useless as any standard motor can be substituted. The direct drive motor may be a custom unit and locating a replacement cheaply may be difficult.

Drain the water that collects in the tank after each use.

Inspect the tank regularly for serious rust or corrosion which could result in an explosion hazard.as well.

Paint sprayers

Traditional air powered paint sprayers may simply be an attachment to an air compressor or may be a self contained unit with the compressor built in. Since the active material is paint which dries into a hard mass (what a concept!), cleaning immediately after use is essential. Otherwise, strong solvents will be needed to resurrect a congealed mess - check your user's manual for acceptable deadly chemicals.

Portable airless paint sprayers use a solenoid-piston mechanism inside the spray head itself. There is little to go wrong electrically other than the trigger switch as long as it is cleaned after use.

Professional airless paint sprayers use a hydraulic pump to force the paint through a narrow orifice at extremely high pressure like 1000 psi.

With all types, follow the manufacturer's recommendations as to type and thickness of paint as well as the care and maintenance before and after use and for storage.

Warning: high performance paint sprayers in particular may be a safety hazard should you put your finger close to the output orifice accidentally. The pressures involved could be sufficient to inject paint - and anything else in the stream - through the skin resulting in serious infection or worse.

Heat guns

These are similar to high performance hair dryers and subject to the same problems - bad cord or switch, open heating element, defective thermostats, universal motor problems, and just plain dirt and dust buildup.

Paint strippers

These are just a high power heating element attached to a cord. If there is no heat, check for a bad plug, cord, or open element with your multimeter.

Soldering irons

Simple pencil irons use an enclosed heating element is attached to the 'business' end in some manner - screw thread, set screw, clamping ring, etc. Failure to heat may be due to a bad plug, cord, bad connections, or defective element.

Some types package the heating element and replaceable tip in a separate screw-in assembly. These are easily interchangeable to select the appropriate wattage for the job. Damage is possible to their ceramic insulator should one be dropped or just from constant use.

High quality temperature controlled soldering stations incorporate some type of thermostatic control - possibly even with a digital readout.

Soldering guns

The common Weller Dual Heat soldering gun is a simple transformer with the tapped primary winding in the bulk of the case and a single turn secondary capable of 100 or more amps at around 1.5 V. The soldering element is simply a piece of copper (possible with a shaped tip) which is heated due to the high current passing through it even though it is made mostly of copper. The 'headlight(s)' (flashlight bulbs) operate off of a winding on the transformer as well.

Possible problems include:

- **No response to trigger:** Bad cord, bad switch, open transformer primary.
- **Low or high (dual heat models) does not work:** Bad switch, bad transformer primary.
- **Lack of sufficient heat:** Bad connections where soldering element mounts. Clean and/or tighten. Tin the tip if needed (not permanently tinned). Use the high setting (dual heat models).
- **Tip too hot:** Use the lower setting (if dual heat). Do not keep the trigger depressed for more than 30 seconds or so at a time. Manually pulse width modulate the power level.
- **Entire unit overheats:** This could be a shorted winding in the transformer but more likely is that you are simply not giving it a chance to cool. These are not designed for continuous operation - something like 2 minutes on, 5 minutes off, is usually recommended.
- **No light:** Bad bulbs, bad connections, bad winding (unlikely).

Note: a soldering gun is not a precision instrument and should not be used for fine electronics work - you will ruin ICs and printed circuit boards.

Wet-dry vacs, yard blowers/vacs

A powerful universal motor driving a centrifugal blower is all there is in this equipment. Unfortunately, many common models use cheaply made motors which may fail simply due to use or from the dust and proximity to liquids. The blower sucks air and whatever else into the holding tank. A filter is supposed to prevent anything from getting through. The motor itself should be sealed against direct contact with the dust/liquid section of the machine.

Problems occur with bad cords, switch, motor brushes, bearings, or a burnt out motor from excessive use under adverse conditions.

As with inexpensive electric drills, sleeve bearings (usually, the top bearing which is exposed somewhat) in the motor can become worn or dry. Replacing with a ball bearing is a worthwhile - but rather involved - undertaking if this happens. See the section: Upgrading the bearings on a Craftsman drill as the technique is similar (once you gain access - not usually a 10 minute job).

Hedge trimmers

A gear reduced universal motor drives a reciprocating mechanism not too dissimilar to a saber saw. In addition to the usual motor/electrical problems, lubrication may be needed periodically. Should you accidentally try to trim a steel fence instead of a bush, damage to one or more teeth may occur. In this case, light filing may be needed to remove nicks and burrs.

Of course, you probably will not get away without cutting the power cord a couple of times as well! See the sections on power cords. One way to avoid the humiliation (other than being half awake) is to wrap a cord protector around the first 2 or 3 feet of cord at the tool. This will make the cord larger in diameter than the inter-tooth spacing preventing accidental 'chewups'.

Electric lawn mowers

A large universal or permanent magnet DC motor drives one or two sets of rotating blades. A load or dead short may be thrown across the motor to act as a dynamic brake when stopping. As usual, when the mower does not operate, check for bad plug, cord, switch, brushes, dirt, etc. See the sections on motors.

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Incandescent Light Bulbs, Lamps, and Lighting Fixtures

Editor's note: More information on incandescent light bulbs can be found at: http://www.misty.com/~don/.

Incandescent light bulbs - single and three way

The basic incandescent lamp operates on the same basic principles as the original carbon filament lamp developed by Thomas Edison. However, several fundamental changes have made it somewhat more efficient and robust. However, modern bulbs are hardly efficient at producing lighte. Typically, only about 3 to 7 percent of the electrical energy used by a typical incandescent light bulb is turned into useful (visible) light. The rest goes to waste (usually) as heat.

Tungsten replaced carbon as the filament material once techniques for working this very brittle metal were perfected (Edison knew about tungsten but had no way of forming it into fine wire). Most light bulbs are now filled with an inert gas rather than containing a vacuum like Edison's originals. This serves two purposes: it reduces filament evaporation and thus prolongs bulb life and reduces bulb blackening and it allows the filament to operate at a higher temperature and thus improves color and brightness. However, the gas conducts heat away so some additional power is wasted to heating the surroundings.

Incandescent lamps come in all sizes from a fraction of a watt type smaller than a grain of wheat to 75 kW monster bulbs. In the home, the most common bulbs for lighting purposes are between 4 W night light bulbs and 250-300 W torch bulbs (floor standing pole lamps directing light upwards). For general use, the 60, 75, and 100 W varieties are most common. Recently, 55, 70 and 95 W 'energy saving' bulbs have been introduced. However, these are just a compromise between slightly reduced energy use and slightly less light. My recommendation: use compact fluorescents to save energy if these fit your needs. Otherwise, use standard light bulbs.

Most common bases are the Edison medium (the one we all know and love) and the candelabra (the smaller style for night lights, chandeliers, and wall sconces.

Three-way bulbs include two filaments. The three combinations of which filaments are powered result in low, medium, and high output. A typical 3-way bulb might be 50 (1), 100 (2), and 150 (1+2) W. If either of the filaments blows out, the other may still be used as a regular bulb. Unfortunately, 3-way bulbs do tend to be much more expensive than ordinary light bulbs. There may be adapters to permit a pair of normal bulbs to be used in a 3-way socket - assuming the space exists to do this safely (without scorching the shade).

The base of a 3-way bulb has an additional ring to allow contact to the second filament. Inexpensive 3-way sockets (not to be confused with 3-way wall switches for operation of a built-in fixture from two different locations) allow any table lamp to use a 3-way bulb.

Flashlight bulbs are a special category which are generally very small and run on low voltage (1.5-12 V). They usually have a filament which is fairly compact, rugged, and accurately positioned to permit the use of a reflector or lens to focus the light into a fixed or variable width beam. These usually use a miniature screw or flange type base although many others are possible. When replacing a flashlight bulb, you must match the new bulb to the number and type of battery cells in your flashlight.

Automotive bulbs are another common category which come in a variety of shapes and styles with one or two filaments. Most now run on 12 V.

Other common types of incandescent bulbs: colored, tubular, decorative, indoor and outdoor reflector, appliance, ruggedized, high voltage (130 V).

Why do my light bulbs seem to burn out at warp speed?

The lifespan of an average incandescent bulb is 750-1000 hours which is about 1.5 months if left on continuously or roughly 4 months if used 8 hours a day. So, if you are seeing a 3-4 month lifespan, this may not be that out of line depending on usage. With a lot of bulbs in a house, you may just think you are replacing bulbs quite often.

Having said that, several things can shorted lamp life:

1. Higher than normal voltage - the lifespan decreases drastically for slight increases in voltage (though momentary excursions to 125 V, say, should not be significant).

2. Vibration - what is the fixture mounted in, under, or on?

3. High temperatures - make sure you are not exceeding the maximum recommended wattage for your fixture(s).

4. Bad switches bad connections due to voltage fluctuations. If jiggling or tapping the switch causes the light to flicker, this is a definite possibility. Repeated thermal shock may weaken and blow the filament.

A bad neutral connection at your electrical service entrance could result in certain circuits in your house having a higher voltage than normal - multimeter would quickly identify any.

It may be possible to get your power company to put a recording voltmeter on your line to see if there are regular extended periods of higher than normal voltage - above 120 to 125 V.

To confirm that the problem is real, label the light bulbs with their date (and possibly place of purchase or batch number - bad light bulbs are also a possibility). An indelible marker should be satisfactory.

Of course, consider using compact or ordinary fluorescent lamps where appropriate. Use higher voltage (130 V) bulbs in hard to reach places. Bulbs with reinforced filament supports ('tuff bulbs') are also available where vibration is a problem.

Halogen bulbs

(From: Don Klipstein (don@misty.com).)

A halogen bulb is an ordinary incandescent bulb, with a few modifications. The fill gas includes traces of a halogen, often but not necessarily iodine. The purpose of this halogen is to return evaporated tungsten to the filament.

As tungsten evaporates from the filament, it usually condenses on the inner surface of the bulb. The halogen is chemically reactive, and combines with this tungsten deposit on the glass to produce tungsten halides, which evaporate fairly easily. When the tungsten halide reaches the filament, the intense heat of the filament causes the halide to break down, releasing tungsten back to the filament.

This process, known as the halogen cycle, extends the life of the filament somewhat. Problems with uneven filament evaporation and uneven deposition of tungsten onto the filament by the halogen cycle do occur, which limits the ability of the halogen cycle to prolong the life of the bulb. However, the halogen cycle keeps the inner surface of the bulb clean. This lets halogen bulbs stay close to full brightness as they age. (recall how blackened an ordinary incandescent bulb can become near the end of its life --- sam).

In order for the halogen cycle to work, the bulb surface must be very hot, generally over 250 degrees Celsius (482 degrees Fahrenheit). The halogen may not adequately vaporize or fail to adequately react with condensed tungsten if the bulb is too cool. This means that the bulb must be small and made of either quartz or a high-strength, heat-resistant grade of glass known as "hard glass".

Since the bulb is small and usually fairly strong, the bulb can be filled with gas to a higher pressure than usual. This slows down the evaporation of the filament. In addition, the small size of the bulb sometimes makes it economical to use premium fill gases such as krypton and xenon instead of the cheaper argon. The higher pressure and better fill gases can extend the life of the bulb and/or permit a higher filament temperature that results in higher efficiency. Any use of premium fill gases also results in less heat being conducted from the filament by the fill gas, meaning more energy leaves the filament by radiation, meaning a slight improvement in efficiency.

Efficiency, lifetime, and failure modes of halogen bulbs

A halogen bulb is often 10 to 20 percent more efficient than an ordinary incandescent bulb of similar voltage, wattage, and life expectancy. Halogen bulbs may also have two to three times as long a lifetime as ordinary bulbs, sometimes also with an improvement in efficiency of up to 10 percent. How much the lifetime and efficiency are improved depends largely on whether a premium fill gas (usually krypton, sometimes xenon) or argon is used.

Halogen bulbs usually fail the same way that ordinary incandescent bulbs do, usually from melting or breakage of a thin spot in an aging filament.

Thin spots can develop in the filaments of halogen bulbs, since the filaments can evaporate unevenly and the halogen cycle does redeposit evaporated tungsten in a perfect, even manner nor always in the parts of the filament that have evaporated the most. However, there are additional failure modes which result in similar kinds of filament degradation.

It is generally not a good idea to touch halogen bulbs, especially the more compact, hotter-running quartz ones. Organic matter and salts are not good for hot quartz. Organic matter such as grease can carbonize, leaving a dark spot that absorbs radiation from the filament and becomes excessively hot. Salts and alkaline materials (such as ash) can sometimes "leach" into hot quartz, which typically weakens the quartz, since alkali and alkaline earth metal ions are slightly mobile in hot glasses and hot quartz. Contaminants may also cause hot quartz to crystallize, weakening it. Any of these mechanisms can cause the bulb to crack or even violently shatter. For this reason, halogen bulbs should only be operated within a suitable fully enclosed fixture. If a quartz halogen bulb is touched, it should be cleaned with alcohol to remove any traces of grease. Traces of salt will also be removed if the alcohol has some water in it.

Use of dimmers with halogen bulbs

Dimming a halogen bulb, like dimming any other incandescent lamp, greatly slows down the formation of thin spots in the filament due to uneven filament evaporation. However, "necking" of the ends of the filament remains a problem. If you dim halogen lamps, you may need "soft-start" devices in order to achieve a major increase in bulb life.

Another problem with dimming of halogen lamps is the fact that the halogen cycle works best with the bulb and filament at or near specific optimum temperatures. If the bulb is dimmed, the halogen may fail to "clean" the inner surface of the bulb. Or, tungsten halide that results may fail to return tungsten to the filament.

Halogen bulbs should work normally at voltages as low as 90 percent of what they were designed for. If the bulb is in an enclosure that conserves heat and a "soft-start" device is used, it will probably work well at even lower voltages, such as 80 percent or possibly 70 percent of its rated voltage.

Dimmers can be used as soft-start devices to extend the life of any particular halogen bulbs that usually fail from "necking" of the ends of the filament. The bulb can be warmed up over a period of a couple of seconds to avoid overheating of the "necked" parts of the filament due to the current surge that occurs if full voltage is applied to a cold filament. Once the bulb survives starting, it is operated at full power or whatever power level optimizes the halogen cycle (usually near full power).

The dimmer may be both "soft-starting" the bulb and operating it at slightly reduced power, a combination that often improves the life of halogen bulbs. Many dimmers cause some reduction in power to the bulb even when they are set to maximum.

(A suggestion from someone who starts expensive medical lamps by turning up a dimmer and reports major success in extending the life of expensive special bulbs from doing this.)

The humorous side of light bulbs

Also see the document: Engineering, Science, and Other (Pretty Clean) Jokes Collection for all the light bulb jokes you could never want.

(From: Susanne Shavelson (shavelson@binah.cc.brandeis.edu).)

People have often mentioned experiencing epidemics of light-bulb-death after moving into a new (to them) house. The same thing happened to us for a few months after moving last year into a 55-year-old house. After most of the bulbs had been replaced, things settled down. I am persuaded by the theory advanced by David (?) Owen in his wonderfully informative and witty book "The Walls Around Us" that houses undergo a sort of nervous breakdown when a new occupant moves in, leading to all sorts of symptoms like blown bulbs, plumbing problems, cracks in the walls, and so forth. Now that the house has become more accustomed to us, the rate at which strange phenomena are occurring has slowed.

Notes on bulb savers

These are usually either Negative Temperature Coefficient (NTC) thermisters or simple diodes.

When cold, NTC thermisters have a high resistance. As they warm up, the resistance decreases so that the current to the light bulb is ramped up gradually rather than being applied suddenly.

With a properly selected (designed) thermistor, I would not expect the light output to be affected substantially. However, while reducing the power on surge may postpone the death of the bulb, the filament wear mechanism is due to evaporation and redeposition of the tungsten during normal operation. This is mostly a function of the temperature of the filament.

A thermistor which was not of low enough hot resistance would be dissipating a lot of power - roughly .8 W/volt of drop for a 100W bulb. Any really substantial increase in bulb life would have to be due to this drop in voltage and not the power-on surge reduction. The bulb saver (and socket) would also be heating significantly.

The bulb savers that are simply diodes do not have as much of a heat dissipation problem but reduce the brightness substantially since the bulbs are running at slightly over half wattage. Not surprisingly, the life does increase by quite a bit. However, they are less efficient at producing light at the lower wattage and it is more orange. If you are tempted to then use a higher wattage bulb to compensate, you will ultimately pay more than enough in additional electricity costs to make up for the longer lived bulbs.

My recommendation: use high efficiency fluorescents where practical. Use 130 V incandescents if needed in hard to reach places where bulb replacement is a pain. Stay away from bulb savers, green plugs, and other similar products claiming huge energy reduction. Your realized savings for these products will rarely approach the advertised claims and you risk damage to your appliances with some of these.

Can you prove that bulb savers do not work?

No, sorry, I don't have conclusive proof. I would love to be proved wrong - I could save a lot on light bulbs. However, new bulbs do not fail upon power on. Old bulbs do. If you examine the filament of a well worn light bulb, you will see a very distinct difference in surface appearance compared to a brand new one. The surface has gone from smooth to rough. This change is caused by sustained operation at normal light bulb temperatures resulting in unequal evaporation of the filament.

Reducing the power on surge with a thermistor will reduce the mechanical shock which will postpone the eventual failure. 5X or even 20 % increase in life is pushing it IMHO.

I do believe that Consumer Reports has tested these bulb savers with similar conclusions (however, I could be mistaken about the kind of bulb savers they tested - it was quite awhile ago).

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Motors 101

Small motors in consumer electronic equipment

A large part of the functionality of modern appliances is based on the use of motors of one form or another. They are used to rotate, blow, suck, sweep, spin, cut, grind, shred, saw, sand, drill, plane, time, and control.

Motors come in all shapes and sizes but most found in small appliances can be classified into 5 groups:

1. **Universal motors:** Run on AC or DC, speed may be varied easily. Relatively efficient but use carbon brushes and may require maintenance.

2. **Single-phase induction motors:** AC, fairly fixed speed except by switching, windings, very quiet. Quite efficient and low maintenance.

3. **Shaded pole induction motors:** AC, somewhat fixed speed, very quiet, not very efficient and low maintenance.

4. **Small permanent magnet DC motors:** DC, variable or constant speed, often cheaply made, fairly quiet, prone to problems with metal brushes.

5. **DC brushless motors:** DC usually (but some may have built in rectifiers to run on AC), somewhat variable or fixed speed, very quiet, low maintenance.

6. Synchronous timing motors: Constant speed absolutely tied to power line. The long term accuracy of clocks based on the AC line exceed that of most quartz oscillator based time pieces since the ultimate reference is an atomic frequency standard.

Each type of motor has its advantages and disadvantages. More than one type may be suitable for any particular application.

Identifying type of unknown motor

Determining the actual type of motor is the first step toward being able to test to see if it is being powered properly or if there is a fault in the motor itself.

Open frame motors in line operated appliances with a single coil off to one side are almost always shaded pole induction motors. To confirm, look for the copper 'shading rings' embedded in the core. There will usually be either 1 or 2 pairs of these. Their direction is determine by the orientation of the stator frame (position of the shading rings).

For enclosed motors, first check to see if there are carbon brushes on either side of a commutator made of multiple copper bars. If so, this is almost certainly a series wound 'universal' motor that will run on AC or DC though some may be designed for DC operation only.

If there are no brushes, then it is likely a split phase induction or synchronous motor. If there is a capacitor connected to the motor, this is probably used for starting and to increase torque when running.

Where there is a capacitor, it is likely that how this is wired to the motor determines the direction of rotation - make sure you label the connections!

Very small motors with enclosed gear reducers are usually of the synchronous type running off the AC line. Their direction of rotation is often set by a mechanical one-way clutch mechanism inside the casing.

Motors used in battery operated tools and appliances will usually be of the permanent magnet DC type similar to those found in toys and electronic equipment like VCRs and CD players. Most of these are quite small but there are exceptions - some electric lawnmowers use large versions of this type of motor, for example. These will be almost totally sealed with a pair of connections at one end. Direction is determined by the polarity of the DC applied to the motor.

For universal and DC permanent magnet motors, speed control may be accomplished with an internal mechanical governor or electronic circuitry internal or external to the motor. On devices like blenders where a range of (useless) speeds is required, there will be external switches selecting connections to a tapped winding as well as possibly additional electronic circuitry. The 'solid state' design so touted by the marketing blurb may be just a single diode! A similar approach may also be used to control the speed of certain types of induction motors (e.g., ceiling fans) but most are essentially fixed speed devices.

Once identified, refer to the appropriate section for your motor.

COLIN Electric Motor Service has a page with some Motor Connection Diagrams for large motors that may be of some value (though more so if you have a few' 100 horsepower three-phase motors in your concrete processing plant!).

Universal motors

The Universal motor is the most common type of high speed motor found in appliances and portable line operated power tools. Typical uses include vacuum cleaners, floor polishers, electric drills, routers, and sewing machines. They are likely to be found anywhere medium power, high speed, and/or variable speed control are required capabilities. Note that quiet operation is NOT a feature of these motors. Therefore, they will not often be found in electronic equipment.

Construction consists of a stationary set of coils and magnetic core called the 'stator' and a rotating set of coils and magnetic core called the 'armature'. Incorporated on the armature is a rotating switch called a 'commutator'. Connection to the armature is via carbon (or metal) contacts called 'brushes' which are mounted on the frame of the motor and press against the commutator. Technically, these are actually series wound DC motors but through the use of steel laminated magnetic core material, will run on AC or DC - thus the name universal.

Speed control of universal motors is easily achieved with thyristor based controllers similar to light dimmers. However, simply using a light dimmer as a motor speed controller may not work due to the inductive characteristics of universal motors.

Changing direction requires interchanging the two connections between the stator and the armature.

This type of motor is found in blenders, food mixers, vacuum cleaners, sewing machines, and many portable power tools.

Problems with universal motors

These motors can fail in a number of ways:

- Open windings - this may result in a bad spot, a totally dead motor, lack of power, or excessive sparking. Windings can open from a major overload/overheating episode either melting the wire or solder connections (the latter on the armature usually), defective manufacturing and thermal cycling, or damage during servicing.

  However, the source of the open may not be the windings but a blown thermal fuse - see below.

- Shorted windings - this may result in excessive current, severe sparking, reduced speed and power, and overheating. The thermal protector, fuse, or circuit breaker may trip. Continuing to run such a motor may result in a meltdown or burned coils and insulation - i.e., a burned out motor.

- Worn carbon brushes - while these usually last for the life of the appliance, this is not always the case. The result could be erratic or sluggish operation, excessive sparking, damage to the commutator, or a motor that does a pretty good imitation of a paper weight :-).

  For appliances subject to dust or dirt like vacuum cleaners and woodworking toole (and others as well), the brushes may just get stuck from accumulated debris and not be able to make consistent contact. Carefully remove the brushes and clean them and their mounting channels so they slide in and out freely.

  Note: Whenever removing carbon brushes, make a note as to their exact orientation as replacing them in the same way will minimize wear and break-in time.

- Dry/worn bearings - this may result in a tight or frozen motor or a motor shaft with excessive runout. The result may be a spine tingling squeal during operation and/or reduced speed and power, and overheating. Running such a motor may eventually lead to burnout due to overheating from the increased load.

- Faulty speed control or speed regulator. There are several types in common use:

  - Switch which selects between various taps on the field winding. This type common in blenders and portable food mixers.

- A mechanical speed control inside the motor - a set of weights with adjustable spring tension so that the current to the motor is reduced when the set speed is reached. If the motor only runs at full speed, except for obvious mechanical problems, check for a shorted component like a resistor or capacitor across the contacts - or welded contacts. Where it doesn't run at all, check for an open resistor or bad connection. Bypass the governor if possible and see if the motor will run.

- Electronic control - This is similar to a light dimmer and uses a triac to regulate current to the motor. See the section: Dimmer switches and light dimmers.

Sometimes, there is a thermal fuse buried in the windings that will blow due to overheating before any serious damage has occurred. If so, cleaning and relubing the bearings or remedy of whatever other problem caused the overload and replacement of the thermal fuse may be all that is needed. See the section: Thermal protection devices - thermal fuses and thermal switches for precautions when replacing these and the document: Notes on the Troubleshooting and Repair of AC Adapters, Power Supplies, and Battery Packs.

WARNING: Don't just bypass the protection device or the next time you may be dealing with your fire insurance company!

Testing of universal motors

Test the field coils for continuity with an ohmmeter. An open winding is bad and will require replacement of the entire stator assembly unless the break can be located. Compare the resistance of the two windings - they should be nearly equal. If they are not, a short in one of the windings is likely. Again, replacement will be necessary.

Also test for a short to the frame - this should read infinity. If lower than 1 M or so, the motor will need to be replaced unless you can locate the fault.

An open or shorted armature winding may result in a 'bad spot' - a position at which the motor may get stuck. Rotate the motor by hand a quarter turn and try it again. If it runs now either for a fraction of a turn or behaves normally, then replacement will probably be needed since it will get stuck at the same point at some point in the future. Check it with an ohmmeter. There should be a periodic variation in resistance as the rotor is turned having several cycles per revolution determined by the number of commutator segments used. Any extremely low reading may indicate a shorted winding. Any erratic readings may indicate the need for brush replacement or cleaning. An unusually high reading may indicate an open winding or dirty commutator. Cleaning may help a motor with an open or short or dead spot.

A motor can be tested for basic functionality by disconnecting it from the appliance circuit and running it directly from the AC line (assuming it is intended for 115 VAC operation - check to be sure).

CAUTION: series wound motors can overspeed if run without a load of any kind and spectacular failure may result due to centrifugal disassembly of the armature due to excess G forces. In other words, the rotor explodes. This is unlikely with these small motors but running only with the normal load attached is a generally prudent idea.

About commutators and brushes in universal motors

A commutator is essentially a rotating switch which routes power to the appropriate windings on the armature so that the interaction of the fixed (stator) and rotating (armature) magnetic fields always results in a rotational torque. Power is transferred to the commutator using carbon brushes in most motors of this type. The carbon is actually in the form of graphite which is very slippery as well. Despite that fact that graphite is a relatively soft material, a thin layer of graphite is worn off almost immediately as the motor is started for the first time and coats the commutator. After this, there is virtually no wear and a typical set of carbon brushes can last thousands of hours - usually for the life of the appliance or power tool.

A spring presses the brush against the rotating commutator to assure good electrical contact at all times. A flexible copper braid is often embedded in the graphite block to provide a low resistance path for the electric current. However, small motors may just depend on the mounting or pressure spring to provide a low enough resistance.

The typical universal motor will have between 3 and 12 armature windings which usually means a similar number of commutator segments. The segments are copper strips secured in a non-conductive mounting. There are supposed to be insulating gaps between the strips which should undercut the copper. With long use, the copper may wear or crud may build up to the point that the gaps between the copper segments are no longer undercut. If this happens, their insulating properties will largely be lost resulting in an unhappy motor. There may be excessive sparking, overheating, a burning smell, loss of power, or other symptoms.

Whenever checking a motor with a commutator, inspect to determine if the commutator is in good condition - smooth, clean, and adequately undercut. Use a narrow strip of wood or cardboard to clean out the gaps assuming they are still present. For larger motors, a hacksaw blade can be used to provide additional undercutting if needed though this will be tough with very small ones. Don't go too far as the strength of the commutator's mounting will be reduced. About 1/32 to 1/16 inch should do it. If the copper is pitted or worn unevenly, use some extra fine sandpaper (600 grit, not emery cloth or steel wool which may leave conductive particles behind) against the commutator to smooth it while rotating the armature by hand.

Since the carbon brushes transmit power to the rotating armature, they must be long enough and have enough spring force behind them to provide adequate and consistent contact. If they are too short, they may be unstable in their holders as well - even to the point of being ripped from the holder by the commutator causing additional damage.

Inspect the carbon brushes for wear and free movement within their holders. Take care not to interchange the two brushes or even rotate them from their original orientation as the motor may then require a break-in period and additional brush wear and significant sparking may occur during this time. Clean the brushes and holders and/or replace the brushes if they are broken or excessively worn.

An appliance, vacuum cleaner, or motor repair shop may have replacement carbon brushes. However, even if you cannot locate an exact replacement, buy a set of slightly larger ones. They can usually be filed down to fit rather easily (the graphite is soft but messy).

I don't know whether the following approach is viable but it may be worth a try if you can't locate a proper replacement carbon brush. I wonder if the brand of battery matters? :-)

(From: rtotman@oanet.com).

Why on earth would you not make new brushes yourself from the carbon rod from the center of a cheap battery. You can file or grind the graphite to just the size you need. Free too.

I have done this many times with motors as small as an electric shaver to ones as large as vacuum cleaners. There is very little difference I can see in both the life of the new brushes and of the commutator segments they bear on. Electric drills are hard on brushes if you use them a lot and they get hot. I have re-brushed several drills and they are all still in service.

Repairing small universal motors

Too bad that the Sears lifetime warranty only applies to hand (non-power) tools, huh?

Which part of the motor is bad? The armature or stator? How do you know? (A smelly charred mess would probably be a reasonable answer).

Rewinding a motor is probably going to way too expensive for a small appliance or power tool. Finding a replacement may be possible since those sizes and mounting configurations were and are very common.

However, I have, for example, replaced cheap sleeve bearings with ball bearings on a couple of Craftsman power drills. They run a whole lot smoother and quieter. The next model up used ball bearings and shared the same mounting as the cheaper sleeve bearings so substitution was straightforward.

Single-phase induction motors

Where a fixed speed is acceptable or required, the single-phase induction motor is often an ideal choice. It is of simple construction and very robust and reliable. In fact, there is usually only one moving part which is a solid mass of metal.

Most of the following description applies to all the common types of induction motors found in the house including the larger fractional horsepower variety used in washing machines, dryers, and bench power tools.

Construction consists of a stationary pair of coils and magnetic core called the 'stator' and a rotating structure called the 'rotor'. The rotor is actually a solid hunk of steel laminations with copper or aluminum bars running lengthwise embedded in it and shorted together at the ends by thick plates. If the steel were to be removed, the appearance would be that of a 'squirrel cage' - the type of wheel used to exercise pet hamsters. A common name for these (and others with similar construction) are squirrel case induction motors.

These are normally called single-phase because they run off of a single-phase AC line. However, at least for starting and often for running as well, a capacitor or simply the design of the winding resistance and inductance, creates the second (split) phase needed to provide the rotating magnetic field.

For starting, the two sets of coils in the stator (starting and running windings) are provided with AC current that is out of phase so that the magnetic field in one peaks at a later time than the other. The net effect is to produce a rotating magnetic field which drags the rotor along with it. Once up to speed, only a single winding is needed though higher peak torque will result if both windings are active at all times.

Small induction motors will generally keep both winding active but larger motors will use a centrifugally operated switch to cut off the starting winding at about 75% of rated speed (for fixed speed motors). This is because the starting winding is often not rated for continuous duty operation.

For example, a capacitor run type induction motor would be wired as shown below. Interchanging the connections to either winding will reverse the direction of rotation. The capacitor value is typical of that used with a modest size fan motor.

```
                            1
      Hot o------+------------+
                 |             )||
                 |             )|| Main winding
                 |            2 )||
  Neutral o---+---------------+
              |  |
              |  |    C1     3          C1: 10 uF, 150 VAC
              |  +----||------+
              |               )||
              |               )|| Phase winding
              |             4 )||
              +---------------+
```

Speed control of single-phase induction motors is more complex than for universal motors. Dual speed motors are possible by selecting the wiring of the stator windings but continuous speed control is usually not provided. This situation is changing, however, as the sophisticated variable speed electronic drives suitable for induction motors come down in price.

Direction is determined by the relative phase of the voltage applied to the starting and running windings (at startup only if the starting winding is switched out at full speed). If the startup winding is disconnected (or bad), the motor will start in whichever direction the shaft is turned by hand.

This type of motor is found in larger fans and blowers and other fixed speed appliances like some pumps, floor polishers, stationary power tools, and washing machines and dryers.

Shaded pole induction motors

These are a special case of single-phase induction motors where only a single stator winding is present and the required rotating magnetic field is accomplished by the use of 'shading' rings which are installed on the stator. These are made of copper and effectively delay the magnetic field buildup in their vicinity just enough to provide some starting torque.

Direction is fixed by the position of the shading rings and electronic reversal is not possible. It may be possible to disassemble the motor and flip the stator to reverse direction should the need ever arise.

Speed with no load is essentially fixed but there is considerable reduction as load is increased. In many cases, a variable AC source can be used to effect speed control without damaging heating at any speed.

This type of motor is found in small fans and all kinds of other low power applications like electric pencil sharpeners where constant speed is not important. Compared to other types of induction motors, efficiency is quite poor.

Problems with induction motors

Since their construction is so simple and quite robust, there is little to go bad. Many of these - particularly the shaded pole variety - are even protected from burnout if the motor should stall - something gets caught in a fan or the bearings seize up, for example.

Check for free rotation, measure voltage across the motor to make sure it is powered, remove any load to assure that an excessive load is not the problem.

If an induction motor (non-shaded pole) won't start, give it a little help by hand. If it now starts and continues to run, there is a problem with one of the windings or the capacitor (if used).

For all types we have:

- Dirty, dry, gummed up, or worn bearings - if operation is sluggish even with the load removed, disassemble, clean, and lubricate with electric motor oil. The plain bearings commonly used often have a wad of felt for holding oil. A add just enough so that this is saturated but not dripping. If there is none, put a couple of drops of oil in the bearing hole.

- Open coil winding - test across the motor terminals with your ohmmeter. A reading of infinity means that there is a break somewhere - sometimes it is at one end of the coil and accessible for repair. For those with starting and running windings, check both of these.

- Shorted coil winding - this will result in loss of power, speed, and overheating. In extreme cases, the motor may burn out (with associated smelly byproducts) or blow a fuse. The only way to easily test for a winding that is shorted to itself is to compare it with one from an indentical good motor and even in this case, a short which is only a few turns will not show up (but will still result in an overheating motor).

- Coil shorted to the frame - this will result in excessive current, loss of power, overheating, smoke, fire, tripped breaker or overload protector, etc.

If any of these faults are present, the motor will need to be replaced (or rewound if economical - usually not for typical appliance motors). The only exception would be if the location of the open or short is visible and can be repaired. They usually are not.

For capacitor run type:

- A bad capacitor may be the cause of a motor which will not start, has limited power, excessive hum, or overheats. A simple test with your ohmmeter on the high resistance scale can give some indication of whether the capacitor is good. remove at least one lead of the capacitor and measure across it. A good capacitor will show an initially low reading which will quickly climb to infinity. If there is no low reading at all or it remains low, then the capacitor is bad (open or shorted respectively). This does not really prove the capacitor is good but if the test shows open shorted, it is definitely bad. Substitution is best.

For larger induction motors with centrifugal starting switches:

- A centrifugal switch which does not activate the starting winding will result in a motor that will not start on its own but will run if it is rotated initially by hand. A centrifugal switch that does not cut off when the motor is up to speed will result in excessive power use, overheating, and may blow a line fuse or trip a circuit breaker. These are usually pretty simple and a visual inspection (may require disassembly) should reveal broken, worn, or otherwise defective parts. Check for proper switch contact closing and opening with a continuity tester or ohmmeter. Inspect the rotating weights, springs, and the sliding lever for damage.

- Bad rotor - this is somewhat rare but repeated heating and cooling cycles or abuse during starting can eventually loosen up the (supposedly) welded connections of the copper bars to the end rings. The result is a motor that may not start or loses power since the required shorted squirrel cage has been compromised. One indication of this would be a rotor that is asymmetric - it vibrates or has torque at only certain large angular positions indicating that some of the bars are not connected properly. Normally, an induction motor rotor is perfectly symmetric.

Disassembling and reassembling a universal or induction motor

The description below assumes that the construction is of an enclosure with an integral stator and brush holder. For those with an internal structural frame, remove the outer casing first.

For the case of induction motors, ignore any comments about brushes as there are none. With shaded pole motors, the entire assembly is often not totally enclosed with just stamped sheet metal brackets holding the bearings.

Follow these steps to minimize your use of 4 letter expletives:

1. Remove the load - fan blades, gears, pulleys, etc. If possible, label and disconnect the power wiring as well as the motor can them be totally removed to the convenience of your workbench.

2. Remove the brushes if possible. Note the location of each brush and its orientation as well to minimize break-in wear when reinstalled. Where the brushes are not easily removable from the outside, they will pop free as the armature is withdrawn. Try to anticipate this in step (6). (Universal motors only).

3. Confirm that there are no burrs on the shaft(s) due to the set screw(s) that may have been there. For motors with plain bearings in particular, these will need to be removed to allow the shaft(s) to be pulled out without damage to the bushing. For ball bearing motors, the bearings will normally stay attached to the shaft as it is removed.

4. Use a scribe or indelible pen to put alignment marks on the covers so that they can be reassembled in exactly the same orientation.

5. Unscrew the nuts or bolts that hold the end plates or end bells together and set these aside.

6. Use a soft mallet if necessary to gently tap apart the two halves or end bells of the motor until they can be separated by hand.

7. Remove the end plate or end bell on the non-power shaft end (or the end of your choice if they both have extended shafts).

8. Remove the end plate or end bell on the power (long shaft) end. For plain bearings, gently ease it off. If there is any resistance, double check for burrs on the shaft and remove as needed so as not to damage the soft bushing.

9. Identify any flat washers or spacers that may be present on the shaft(s) or stuck to the bushings or bearings. Mark down their **exact** location and orientation so that they may be replaced during reassembly. Clean these and set aside.

Inspect all components for physical damage or evidence of overheating or burning. Bad bearings may result in very obvious wear of the shaft or bushings or show evidence of the rotor scraping on the stator core. Extended overloads, a worn commutator, or shorted windings may result in visible or olfactory detected deterioration of wire insulation.

While it is apart, brush or blow out any built up dust and dirt and thoroughly clean the shaft, bushings, commutator, and starting switch (present in large induction motors, only).

Relubrication using electric motor oil for plain bearings and light grease for non-sealed ball/roller bearings.

CAUTION: cleanliness is absolutely critical when repacking bearings or else you will be doing this again very soon.

Badly worn ball bearings will need replacement. However, this may be better left to a motor rebuilding shop as they are generally press fit and difficult to remove and install.

Reassemble in reverse order. If installation of the brushes needs to be done before inserting the armature, you will need to feed them in spring end first and hold them in place to prevent damage to the fragile carbon. Tighten the nuts or bolts evenly and securely but do not overtighten.

Wiring up a capacitor run induction motor

The following assume that the wires are unmarked and the motor is for use on 110 VAC, 60Hz (make appropriate changes if 220 VAC):

Measure the resistance between each pair of windings to determine the common. That goes to the AC Neutral.

The one with the higher resistance is probably the phase winding. The other winding goes directly to the AC Hot. If the resistances are similar, it doesn't matter which you use. If the resistances are very different, it may be a split phase induction motor that doesn't even need a capacitor. (It won't hurt to try it without for a short time. If the motor has enough torque and doesn't overheat, no cap is needed.)

Select a capacitor value so that its impedance at 60 Hz (1/2pifC) is between 1 and 2 times the resistance of the winding. It has to be a cap rated for 250 VAC, continuous duty. The value I gave is sort of a guess but will get it running. The idea is to maximize the phase shift while still getting useful power to the phase winding. For a small motor, a few uF should work. The cap goes between AC Hot and the phase winding.

This should get it going. If torque is too low, the uF value of the cap may need to be increased. Check that the motor isn't overheating once you have it running.

Also see the section: Single-phase induction motors.

Determining wiring for multispeed induction motor

Many motors have a wiring diagram on their nameplate. However, where this is not the case, some educated guessing and experimentation will be necessary.

Here is an example for a common multispeed furnace blower motor. In this case there is no capacitor and thus there are few unknowns.

> "Here's the problem - I have a squirrel cage fan that I would like to wire up. Unfortunately, there's only these four wires hanging there and I would hate to burn it up trying combinations. Here's what I know:
>
> - The motor came out of a furnace.
> - It's marked with three amp ratings (4.5, 6.1, 7.5) - three speeds, right?
> - The wires look like they were white, black, red and blue.
>
> - With a ohm meter set on 200, I tried the following combinations:
>
> ```
>          White   Black   Blue   Red
> -----------------------------------
>  White    0       1.5     2.2    2.9
>  Black    1.5     0        .7    1.3
>  Blue     2.2      .7     0       .7
>  Red      2.9     1.3      .7    0
> ```
>
> So, how do I connect the motor?"

From the resistance readings, it would appear that the Black, Blue, and Red are all taps on a single winding. My guess (and there are no warranties :-) would be: White is common, black is HIGH, blue is MEDIUM, red is LOW.

I would test as follows:

- Put a load in series with the line. Try a 250 W light bulb. This should prevent damage to the motor if your connections are not quite correct.

- Connect each combination of White and one other color. Start with black. It should start turning - not nearly at full speed, however. If it does turn, then you are probably safe in removing the light bulb.

  Alternatively, if you have a Variac (variable autotransformer) of sufficient ratings, just bring up the voltage slowly.

If it does not make any effort to start turning - just hums, go to plan B. It may require a starting/running capacitor and/or not be a 3 speed motor.

Small permanent magnet DC motors

These are constructed like small versions of universal motors except that the stator field is provided by powerful ceramic permanent magnets instead of a set of coils. Because of this, they will only operate on DC as direction is determined by the polarity of the input voltage.

Small PM DC motors are used in battery or AC adapter operated shavers, electric knives, and cordless power tools.

Similar motors are also used in cassette decks and boomboxes, answering machines, motorized toys, CD players and CDROM drives, and VCRs. Where speed is critical, these may include an internal mechanical governor or electronic regulator. In some cases there will be an auxiliary tachometer winding for speed control feedback. This precision is rarely needed for appliances.

As noted, direction is determined by the polarity of the input power and they will generally work equally well in either direction.

Speed is determined by input voltage and load. Therefore, variable speed and torque is easily provided by either just controlling the voltage or more efficiently by controlling the duty cycle through pulse width modulation (PWM).

These motors are usually quite reliable but can develop shorted or open windings, a dirty commutator, gummed up lubrication, or dry or worn bearings. Replacement is best but mechanical repair (lubrication, cleaning) is sometimes possible.

Problems with small PM motors

These motors can fail in a number of ways:

- Open or shorted windings - this may result in a bad spot, excess current drain and overheating, or a totally dead motor.
- Partial short caused by dirt/muck, metal particle, or carbon buildup on commutator - this is a common problem in CD player spindle and cassette deck motors but not as common a problem with typical appliances.
- Dry/worn bearings - this may result in a tight or frozen motor or a motor shaft with excessive runout. The result may be a spine tingling squeal during operation and/or reduced speed and power.

Testing of small PM motors

An open or shorted winding may result in a 'bad spot' - a position at which the motor may get stuck. Rotate the motor by hand a quarter turn and try it again. If it runs now either for a fraction of a turn or behaves normally, then replacement will probably be needed since it will get stuck at the same point at some point in the future.

Check across the motor terminals with an ohmmeter. There should be a periodic variation in resistance as the rotor is turned having several cycles per revolution determined by the number of commutator segments used. Any extremely low reading may indicate a shorted winding. An unusually high reading may indicate an open winding or dirty commutator. Cleaning may help a motor with an open or short or dead spot as noted below. Erratic readings may indicate the need for cleaning as well.

Also check between each terminal and the case - the reading should be high, greater than 1M ohm. A low reading indicates a short. The motor may still work when removed from the equipment but depending on what the case is connected to, may result in overheating, loss of power, or damage to the driving circuits when mounted (and connected) to the chassis.

A motor can be tested for basic functionality by disconnecting it from the appliance circuit and powering it from a DC voltage source like a couple of 1.5 V D Alkaline cells in series or a DC wall adapter or model train power pack. You should be able to determine the the required voltage based on the battery or AC adapter rating of the appliance. If you know that the appliance power supply is working, you can use this as well.

Identifying voltage and current ratings small PM motors

If the carcass of the device or appliance is still available, the expected voltage may be determined by examining the original power supply - batteries, voltage regulator, wall adapter, etc.

The following applies to the common DC permanent magnet (PM) motors found in tape players and cassette decks used for the capstan.

- This motor may have an internal speed regulator. In that case, you can determine the appropriate voltage by using a variable supply and increasing it slowly until the speed does not increase anymore. This will typically be between 2 and 12 V depending on model. The motor should then run happily up to perhaps 50% more input voltage than this value.

  Note that many motors are actually marked with voltage and current ratings. Internal regulators may be electronic or mechanical (governor). One way to tell if there is an internal electronic regulator is to measure the resistance of the motor. If it is more than 50 ohms and/or is different depending on which direction the meter leads are connected, then there is an electronic regulator.

Motors without internal speed regulators are used for many functions in consumer electronics as well as toys and small appliances.

- If it does not have an internal regulator, typical supply voltages are between 1.5 and 12 V with typical (stopped) winding resistances of 10 to 50 ohms. Current will depend on input voltage, speed, and load. It *cannot* be determined simply using Ohms law from the measured resistance as the back EMF while running will reduce the current below what such a calculation would indicate.

The wire color code will probably be red (or warm color) for the positive (+) lead and black (or dark cool) color for the minus (-) lead.

Reviving a partially shorted or erratic PM motor

Dirt or grime on the commutator can result in intermittent contact and erratic operation. Carbon or metal particle buildup can partially short the motor making it impossible for the controller to provide enough voltage to maintain desired speed. Sometimes, a quick squirt of degreaser through the ventilation holes at the connection end will blow out the shorting material. Too much will ruin the motor, but it would need replacement otherwise anyway. This has worked on Pioneer PDM series spindle motors.

Another technique is to disconnect the motor completely from the circuit and power it for a few seconds in each direction from a 9 V or so DC source. This may blow out the crud. The long term reliability of both of these approaches is unknown.

WARNING: Never attempt to power a motor with an external battery or power supply when the motor is attached to the appliance, particularly if it contains any electronic circuitry as this can blow electronic components and complicate your problems.

It is sometimes possible to disassemble the motor and clean it more thoroughly but this is a painstaking task best avoided if possible. See the section: Disassembling and reassembling a miniature PM motor.

Disassembling and reassembling a miniature PM motor

Note: for motors with carbon brushes, refer to the section: Disassembling and reassembling a universal or induction motor. This procedure below is for those tiny PM motors with metal brushes.

Unless you really like to work on really tiny things, you might want to just punt and buy a replacement. This may be the strategy with the best long term reliability in any case. However, if you like a challenge, read on.

CAUTION: disassembly without of this type should never be attempted with high quality servo motors as removing the armature from the motor may partially demagnetize the permanent magnets resulting in decreased torque and the need to replace the motor. However, it is safe for the typical small PM motor found in appliances and power tools.

Select a clean work area - the permanent magnets in the motor will attract all kinds of ferrous particles which are then very difficult to remove.

Follow these steps to minimize your use of 4 letter expletives:

1. Remove the load - fan blades, gears, pulleys, etc. Label and disconnect the power wiring as well as the motor will be a whole lot easier to work on if not attached to the appliance or power tool. Note: polarity is critical - take note of the wire colors or orientation of the motor if it is directly soldered to a circuit board!

2. Confirm that there are no burrs on the shaft(s) due to the set screw(s) that may have been there. For motors with plain bearings in particular, these will need to be removed to allow the shaft(s) to be pulled out without damage to the bushing.

3. Use a scribe or indelible pen to put alignment marks on the cover so that it can be replaced in the same orientation.

4. Make yourself a brush spreader. Most of these motors have a pair of elongated holes in the cover where the power wires are connected to the commutator. These allow the very delicate and fragile metal brushes to be spread apart as the armature is removed or installed. Otherwise, the brushes will get hung up and bent. I have found that a paper clip can be bent so that its two ends fit into these holes and when rotated will safely lift the brushes out of harm's way.

5. Use a sharp tool like an awl or dental pick to bend out the 2 or 3 tabs holding the cover in place.

6. Insert the brush spreader, spread the brushes, and pull the cover off of the motor. If done carefully, no damage will be done to the metal brushes.

7. The armature can now be pulled free of the case and magnets.

8. Identify any flat washers or spacers that may be present on the shaft(s). Mark down their **exact** location and orientation so that they may be replaced during reassembly. Clean these and set aside.

Inspect all components for physical damage or evidence of overheating or burning. Bad bearings may result in very obvious wear of the shaft or bushings or show evidence of the rotor scraping on the stator core. Extended overloads, a worn commutator, or shorted windings may result in visible or olfactory detected deterioration of wire insulation.

Check that the gaps in the commutator segments are free of metal particles or carbonized crud. Use a sharp instrument like an Xacto knife blade to carefully clear between the segments. Clean the brushes (gentle!), shafts, and bushings.

When reassembling, make sure to use your brush spreader when installing the cover.

DC brushless motors

These are a variation on the small DC motors described above and uses a rotating permanent magnet and stationary coils which are controlled by some electronic circuitry to switch the current to the field magnets at exactly the right time. Since there are no sliding brushes, these are very reliable.

DC brushless motors may be of ordinary shape or low profile - so called pancake' style. While not that common in appliances yet, they may be found in small fans and are used in many types of A/V and computer equipment (HD, FD, and CD drives, for example). Fortunately, they are extremely reliable. However, any non-mechanical failures are difficult to diagnose. In some cases, electronic component malfunction can be identified and remedied. Not that common in appliances but this is changing as the technology matures.

Direction may be reversible electronically (capstan motors in VCR require this, for example). However, the common DC operated fan is not reversible.

Speed may be varied over a fairly wide range by adjusting the input voltage on some or by direct digital control of the internal motor drive waveforms.

The most common use for these in appliances are as small cooling fans though more sophisticated versions are used as servo motors in VCRs and cassette decks, turntables, and other precision equipment.

Disassembling and reassembling a DC brushless fan

This is the type you are likely to encounter - modify this procedure for other types.

1. Remove the fan from the equipment, label and disconnect the power wires if possible.

2. Remove the manufacturer's label and/or pop the protective plastic button in the center of the blade assembly. Set these aside.

3. You will see an E-clip or C-clip holding the shaft in place. This must be removed - the proper tool is best but with care, a pair of fine needlenose pliers, narrow screwdriver, dental pick, or some other similar pointy object should work. Take great care to prevent it from going zing across the room.

4. Remove the washers and spacers you find on the shaft. Mark down their positions so that they can be restored exactly the way you found them.

5. Withdraw the rotor and blades from the stator.

6. Remove the washers and spacers you find on the shaft or stuck to the bushings. Mark down their positions so that they can be restored exactly the way you found them.

For fans with plain bearings, inspect and clean the shaft and the hole in the bushing using a Q-tip and alcohol or WD40 (see there is a use for WD40!). Check for any damage. Lubricate with a couple drops of electric motor oil in the bushing and any felt pads or washers.

For fans with ball bearings, check the bearings for free rotation and runout (that they do not wobble or wiggle excessively). If bad, replacement will be needed, though this may not be worth the trouble. These are generally sealed bearings so lubrication is difficult in any case. On the other hand, they don't go bad very often.

Reassemble in reverse order.

Synchronous timing motors

Miniature synchronous motors are used in mechanical clock drives as found in older clock radios or electric clocks powered from the AC line, appliance controllers, and refrigerator defrost timers. These assemblies include a gear train either sealed inside the motor or external to it. If the motor does not start up, it is probably due to dried gummed up lubrication. Getting inside can be a joy but it is usually possible to pop the cover and get at the rotor shaft (which is usually where the lubrication is needed). However, the tiny pinion gear may need to be removed to get at both ends of the rotor shaft and bearings.

These consist of a stator coil and a magnetic core with many poles and a permanent magnet for the rotor. (In many ways, these are very similar to stepper motors). The number of poles determines the speed precisely and it is not easily changed.

Direction is sometimes determined mechanically by only permitting the motor to start in the desired direction - they will usually be happy to start either way but a mechanical clutch prevents this (make note of exactly how is was positioned when disassembling). Direction can be reversed in this manner but I know of no actual applications where it would be desirable. Others use shading rings like those in a shaded pole induction motor to determine the direction of starting.

Speed, as noted, is fixed by construction and for 60 Hz power it is precisely equal to: 7200/(# poles) RPM. Thus, a motor with 8 poles will run at 900 RPM.

Disassembling and reassembling a small timing motor

The best approach is usually replacement. In some designs, just the rotor and gear unit can be replaced while retaining the stator and coils.

However, if your motor does not start on its own, is sluggish, or squeals, cleaning and lubrication may be all that is needed. However, to get to the rotor bearing requires removal of the cover and in most cases the rotor as well. This may mean popping off a press-fit pinion gear.

1. Remove the motor from the appliance and disconnect its power wires if possible. This will make it a lot easier to work on.

2. Remove the cover. This may require bending some tabs and breaking an Epoxy seal in some cases.

3. Inspect the gears and shafts for gummed up lubrication. Since these motors have such low torque, the critical bearing is probably one for the main rotor. If there is any detectable stiffness, cleaning and lubrication is called for.

4. You can try lubricating in-place but this will usually not work as there is no access to the far bearing (at the other end of the shaft from the pinion gear). I have used a small nail or awl to pop the pinion gear from the shaft by gently tapping in the middle with a small hammer.

5. Withdraw the rotor from the motor.

6. Identify any flat washers or spacers that may be present on the shaft. Mark down their **exact** location and orientation so that they may be replaced during reassembly. Clean these and set aside.

7. Inspect and clean the shaft and bushings. Lubricate with electric motor oil.

8. Reinstall the rotor and washers or spacers. Then press the pinion gear back onto the shaft just far enough to allow a still detectable end-play of about .25 to .5 mm. Check for free rotation of the rotor and all gears. Replace the cover and seal with household cement once proper operation has been confirmed.

Motor bearing problems

A dry or worn bearing can make the motor too difficult to turn properly or introduce unacceptable wobble (runout) into the shaft as it rotates.

Feel and listen for a dry bearing:

The shaft may be difficult to turn or it may turn with uneven torque. A motor with a worn or dry bearing may make a spine tingling high pitched sound when it is turning under power. A drop of light machine oil (e.g. electric motor oil) may cure a dry noisy bearing - at least temporarily.

Runout - wobble from side to side - of a motor shaft is rarely critical in a small appliance but excessive side-to-side play may result in noise, rapid bearing wear, and ultimate failure.

Motor noise

If the noise is related to the rotating motor shaft, try lubricating the motor (or other suspect) bearings - a single drop of electric motor oil, sewing machine oil, or other light oil (NOT WD40 - it is not a suitable lubricant), to the bearings (at each end for the motor). This may help at least as a temporary fix. In some cases, using a slightly heavier oil will help with a worn bearing. See the section: Lubrication of appliances and electronic equipment.

For AC motors in particular, steel laminations or the motor's mounting may be loose resulting in a buzz or hum. Tightening a screw or two may quiet it down. Painting the laminations with varnish suitable for electrical equipment may be needed in extreme cases. Sometimes, the noise may actually be a result of a nearby metal shield or other chassis hardware that is being vibrated by the motor's magnetic field. A strategically placed shim or piece of masking tape may work wonders.

Finding a replacement motor

In many cases, motors are fairly standardized and you may be able to find a generic replacement much more cheaply than the original manufacturer's part. However, the replacement must match the following:

1. Mechanical - you must be able to mount it. In most cases, this really does mean an exact drop-in. Sometimes, a slightly longer shaft or mounting hole out of place can be tolerated. The pulley or other drive bushing, if any, must be able to be mounted on the new motor's shaft. If this is a press fit on the old motor, take extreme care so as not to damage this part when removing it (even if this means destroying the old motor in the process - it is garbage anyway).

2. Electrical - the voltage and current ratings must be similar.

3. Rotation direction - with conventional DC motors, this may be reversible by changing polarity of the voltage source. With AC motors, turning the stator around with respect to the rotor will reverse rotation direction. However, some motors have a fixed direction of rotation which cannot be altered.

4. Speed - depending on the type appliance, this may or may not be that critical. Most induction motors run at slightly

under 900, 1800, or 3600 RPM (U.S., 60 Hz power). DC motor speed can vary quite a bit and these are rarely marked.

MCM Electronics, Dalbani, and Premium Parts stock a variety of small DC replacement motors. Appliance repair shops and distributors may have generic replacements for larger motors. Junk and salvage yard or your local dump may actually have what you want for pennies on the pound or less!

Is motor rebuilding economical?

So you left your electric cement mixer mixing away and forgot about it - for 3 days. Now the motor is a black charred ruin. You can rent a jack hammer to break up the cement but the motor is a lost cause. The manufacturer has been out of business for 20 years. What should you do besides give the tool a decent burial?

Here is a possible option for, in this case, a planer:

(From: Ed Schmitt (easchmitt@penn.com).)

I located a person who rewinds motors and had the job done for $60.00. That was over 7 years ago, and the planer is still working. Look around and find some of our elderly craftsman who know how to rewind motors. You'll save a bundle, and have a working tool.

(From: Michael Sloane (msloane@worldnet.att.net).)

That is an interesting thought - I have a 1942 Cat road grader with burned out wiring in the 6 V wiper motor. Cat wants $200(!) for a new one, so I would like to find someone who would rewind the old one (and make it 12 V at the same time). I wouldn't even bother with the so-called auto-electric guys, all they do is replace the brushes and diodes on starters and alternators.

Motor armature testing - or - what is a growler?

A common fault that cannot always be reliably identified with a simple ohmmeter test is a couple of shorted turns in the winding that do not affect the total resistance significantly.

A growler is basically an AC electromagnet exciting the windings in the armature. A shorted armature winding will act as a the secondary of a transformer resulting in a high current flow and high induced magnetic field.

Hold a piece of spring steel like a hacksaw blade as a probe over the armature as you rotate it slowly on the electromagnet. A shorted winding will show up as a strong audible vibration of the 'probe' - thus the name growler.

Small motor repair and replacement

(From: mjsrnec (mjsrnec@prairie.lakes.com).)

Most motor shops won't bother with the universal motors because they are much cheaper to replace than repair. However, if yours is a special be prepared to pay standard rates for the service. Email the Electrical Apparatus Service Association found at: http://www.easa.com/ to find the EASA shop nearest you.

If you think the motor may be fairly common pick up a Grainger catalog or go to: Grainger or: Grainger Universal Motor Index.

If this is for a power tool, contact the tool manufacturer for the authorized service center nearest your location.

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Large Appliances

Editor's note: Yes, I know this is supposed to be the "Small Appliance FAQ" but so be it. Until and if I write a "Large Appliance FAQ", this chapter will have to do. :-)

Web resources for large appliance troubleshooting

There are a number of Web sites dedicated to large appliance repair. Most are companies selling parts or manuals but they may also have on-line forums, replies to requests for assistance via email, or other free DIY information. However, very few, if any, have the sort of in-depth treatment of appliance repair provided by a good book on the subject. These are listed in more-or-less alphabetical order:

- A-1 Appliance Parts. Mostly a parts supplier but includes an on-line appliance repair forum. They used to have a tech-tips/diagnostics area but that seems to have disappeared.

- All Appliance Parts, Inc.. This is basically an appliance parts supplier but includes "Appliance Troubleshooting Live Chat Sessions" and free help via email. Alternate site: http://applianceparts.net/.

- Appliance411 Includes information on purchasing, service, and repair parts, as well as links and a Q and A forum.

- Appliance Aid. Lots of info including how appliances work, links, model specific help, help by email, parts and manual suppliers, etc.

- Appliance Clinic. Tips (often by manufacturer/model) for clothes washers, dryers, and refrigerators/icemakers. Also, some parts, other info, free email replies.

- Appliance Repair Net. This site is selling repair manuals for large appliances. I do not have any idea if they are any good. This appears to be the same as: EB Repair Manuals.

- Appliance Service Center. Another parts supplier but includes an appliance repair BBS, repair tips for various large appliances, and more. There is also another forum which is associated with this site: Appliance Service Center Forum.

- Braun service manuals (Courtesy of The Mending Shed).

- Fixit.com. Large appliances includes some tips, discussion group, direct email replies.

- Garrell's Appliance Center. Washers, dryers, stoves, ovens, refrigerators, air conditioners. Parts, manufacturers, manuals, free email replies.

- Gracie Appliance. Heating and air conditioning. They used to have an extensive DIY area with troubleshooting information but apparently that wasn't profitable enough so a new smaller page may be forthcoming. :(

- RepairClinic.com. Large appliances including a wee bit on microwave ovens. Parts supplier but does have some tips and direct email help.

- The Fridge Doctor. Basic information on principles of operation, maintenance, and repair of refrigerators and freezers. He's also trying to sell his book.

- The Virtual Repairman. Some basic info and free email repair advice.

- Point and Click Appliance Repair. Parts and free repair help.

The USENET newsgroups alt.home.repair, misc.consumers.house, and sci.electronics.repair may be appropriate for appliance repair questions as well.

There may be additional links in the "Appliance Sites/Information" section of Sam's Neat, Nifty, and Handy Bookmarks.

Electric oven calibration

If your cakes come out all drippy or your chicken breasts end up hard as a rock and charred, this discussion is for you! It is possible that the thermostat on your oven needs calibration. However, major errors in temperature may be the result of a bad heating element, blown fuse or tripped breaker, a door that doesn't close or seal properly, etc. Confirm that the oven is in otherwise good operating condition before attempting calibration.

The procedure given below assumes that your oven has a mechanical thermostat which is still the most common type. For an electronic thermostat - one in which the set-point is entered via a touchpad - the adjustment (if any) will likely be on the controller circuit board rather than under the temperature knob. If you do attempt calibration of an electronic thermostat, make double sure that you have located the correct adjustment screw!

(Portions from: ken859@sprynet.com).

Most thermostats have a calibration screw located under the knob. Try pulling the knob off and look at the shaft. Some shafts have a small screw located in the center. Rotating this screw will change the trip point at which the thermostat will turn on and off. This is determined by the sensor located inside the oven itself.

You can also have your oven calibrated by an appliance service technician by locating them in your yellow pages and have him/her make a house call but you wouldn't be reading this if you wanted someone else to do it!

The following procedure can be performed by almost anyone who knows which end of a screwdriver to poke into the screw head :-).

1. Locate 2 thermometers that are oven safe and place them inside the oven on a shelf approximately in the center of the oven. Make sure the actual sensing elements of the thermometers do not touch anything.

2. Remove the knob from the thermostat and locate an appropriate screwdriver for the adjusting screw. Re-install the knob.

3. Turn on the oven and set it for 300 degrees F. Allow it to come up to temperature (set light goes out). Then wait an additional 10 minutes.

4. Look at the temperature of the thermometers (averaging the two) and determine the error amount and direction. Note: if the error is large (greater than, perhaps, 50 degrees F) then there may be a problem with the oven (such as a

bad temperature sensor) which will not be remedied by calibration.

5. Remove the knob and adjust the screw in the shaft one way or the other depending on which way the oven set-point is off. If the direction is not marked to increase or decrease the temperature, just pick one - there is no standard. You may be wrong on the first attempt :-(.

   Note: Rotate the adjustment in small increments!

6. Place the knob back on the shaft.
7. Again wait 10 minutes after the oven set light goes off.
8. Look at the temperature of the thermometers and see how far off the error is now.
9. Repeat the steps above until this set-point is accurate.
10. Now set the thermostat to 400 degrees F and repeat the steps above for this setting.
11. The oven set-point should now be a lot closer to the actual temperature.

If you really want to be the oven to be accurate, Turn the oven off and allow it to completely cool. The, repeat the above complete procedure 2 more times or until the accuracy you desire is achieved.

Repeating this procedure may seem redundant but some thermostats because of their mechanical nature have a margin of error. Also due to the mechanical nature, some settling of the parts inside does occur.

As long as the heating elements in the oven do not fail. The oven should maintain its accuracy for quite some time. A simple check of the oven once every 6 months or once every year will assure you that your baking temperatures will be accurate.

Heat control in electric range surface units

The typical electric range surface unit has two spiral elements. In older ranges, they are used in various combinations across the 120 and 240. We have a GE range like this which has 5 heat settings (and off) for each 'burner'.

Given 2 element and 2 voltages there are 8 possible connection possibilities. I don't know which 5 my GE range uses.

Newer ranges use a single element or just parallel the two elements and use variable power control (pulse width modulation or thyristor phase control) to obtain arbitrary heat levels and/or a thermostat to sense the actual temperature.

BTW, this GE range is about 46 years old and still going strong (except for the 1 hour timer which died about 5 years ago.)

(The following experiments from: Mark Zenier (mzenier@netcom.com).)

From my multiple renovations of my mother's stove of a similar vintage:

Warm is 120 volts applied to both elements of a burner in series.

Low is 120 volts applied to one of the two elements. The burners are wired so that they are not the same. Half of the burners used the center element, the others used the rim element. Usually split between front burners and rear. (This is a GE, other companies used two interleaved spiral elements.)

Third is 120 volts applied to both elements.

Second is 240 volts applied to one element, like Low, it varies from burner to burner.

High is 240 volts applied to both elements.

Electric range top element does not work properly

If all the elements are dead, check for blown fuses/tripped circuit breakers. There may be some in the range unit itself in addition to your electrical service panel.

If one element is completely dead on all heat settings, the control is probably bad or there is a broken wire. If it is stuck on high for all control settings or is erratic, the control is bad - replacements are readily available and easily installed.

On ranges with push button heat selection, a pair of heating elements are switched in various combinations across 120 and/or 240. If some heat settings do not work, the most likely cause is that one of the heatings elements is burnt out although a bad switch is also possible. Kill power to the range and test the heating elements for continuity. Replacements are available from appliance parts stores or the places listed in the section: Parts suppliers.

Improvised welding repair of heating elements

Due to the high temperatures at which they operate, welding may provide better long term reliability of heating elements than mechanical fasteners. However, in most cases, the following extreme measures are not really needed.

Warning: only consider the following if you are absolutely sure you understand the safety implications of working directly with line voltage - it is not very forgiving. There is both an electrocution and fire hazard involved.

(From: Donald Borowski (borowski@spk.hp.com).)

I have had success with welding heating element wires back together using a "carbon arc torch". I did this on a ceramics kiln recently.

I extracted the carbon rods from two carbon/zinc D cell ('Classic' or 'Heavy Duty' variety, alkalines do hot have carbon rods). I filed one end to a point.

I wired a circuit as follows:

- Hot side of line to one connection of 1500 electric heater.
- Other connection of heater to one carbon rod.
- Second carbon rod connected to neutral.
- I twisted together the heater wires to be welded, making a pigtail about 3/4" long.

Then I touched the carbon rods together and drew them apart, producing a carbon arc. I moved the carbon rods and arc to position the tip of the heater wire pigtail in the arc. I slowly moved the arc in along the pigtail until a molten ball of nichrome formed between the two wires of the pigtail. When this happened, I immediately withdrew the arc.

Of course, all safety warnings apply: Dangerous power line voltages, welder's mask needed for protect eyes, possible dangerous chemicals in D cell, etc.

This should work for other types of Nichrome coiled or ribbon heating elements as well.

I vaguely recall seeing many years ago a suggestion of making a paste of borax and putting it over the twisted-together ends. I guess it was supposed to act as a self-welding flux. Anyone else recall this?

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Induction cooktops

These operate by generating a high frequency current in a coil under the cooking container using it's bottom as the (shorted) secondary of a transformer. The very high currents result in heating of the contain and its contents, but little power is wasted elsewhere (though the power drive circuits aren't 100 percent efficient).

(Portions from: K. T. Chan (ktchan@hk.gin.net).)

The circuit inside is a chipset handling the generation the of driving signal to the MOSFET power invertor. Control by the Q of the resonance power coil. If the load ia low the Q is high and the circuit cuts the drive. And then sends out probing pulses to test the load (your pan). If the load is big enough, the drive will be turned on to the power circuit. There has to be a large enough load - a wedding ring won't do it!

I damaged the 110 V one and opened up an old 200 V one.

I wanted to repair one before but the spare parts and circuit diagram are rare. And the product is cheap (at least in some parts of the world. Check at Sunpentown. (Too bad it is mostly in Chinese!). The one I had been using for 10 years. The price is less then $200 US. I had the first one from Japan, a 110 V model.

Range, oven, and furnace electronic ignition

Many modern gas stoves, ovens, furnaces, and other similar appliances use an electronic ignition rather than a continuously burning pilot flame to ignite the fuel. These are actually simple high voltage pulse generators.

- Where starting is manual (there is a 'start' position on the control(s), a set of switch contacts on the control(s) provides power to the ignition module.
    - A problem of no spark with only one control indicates that the fault is with it or its wiring.
    - A problem with continuous sparking even with all the controls off or in their normal positions indicates a short - either due to a defective switch in one of the controls or contamination (e.g., spilled liquid) bypassing the switch contacts.
- Where starting is automatic, an electronic sensor, thermocouple, or bimetal switch provides power to the ignition module as needed.

The Harper-Wyman Model 6520 Kool Lite(tm) module is typical of those found in Jenne-Aire and similar cook-tops. Input is 115 VAC, 4 mA, 50/60 Hz AC. C1 and D1 form a half wave doubler resulting in 60 Hz pulses with a peak of about 300 V and at point A and charges C2 to about 300 V through D2. R2, C3, and DL1 form a relaxation oscillator triggering SCR1 to dump the charge built up on C2 into T1 with a repetition rate of about 2 Hz.

```
           C1                A       D1                     T1 o
    H o----||----------------+-------|>|-------+-------+       +-----o HVP+
         .1 uF     D2 1N4007 |     1N4007      |       |  o ::(
         250 V   +----|>|----+                 |       +--+ ::(
                 |           |                 |           )::(
                 +---/\/\----+                 |       #20 )::( 1:35
                 |  R1 1M    |             C2 _|_          )::(
                 |        R2 /           1 uF ---      +--+ ::(
                 |       18M \    DL1   400 V  |     __|__  ::(
                 |           /    NE-2         |     _\_/_     +-----o HVP-
                 |           |    +--+         |     / |
                 |           +----|oo|----+---------'  | SCR1
                 |       C3  |    +--+    |    |       | S316A
                 |  .047 uF _|_        R3 /    |       | 400 V
                 |    250 V ---       180 \    |       | 1 A
                 |           |            /    |       |
         R4 2.7K |           |            |    |       |
    N o---/\/\---+-----------+------------+----+-------+
```

Before you blame the ignition module for either lack of spark or continuous spark, make sure the wiring is in good condition and completely dry and clean (well reasonably clean!). Confirm that proper voltage is reaching the module with a multimeter or neon test lamp. The modules are actually quite robust:

- Any liquid that may have dripped into the module may result in temporary or permanent failure. Fortunately, as with the model cited above, it may be possible to pop off the bottom cover (with power OFF or the module removed!) and clean it. The most likely failure would be the SCR if you are into component level repair. Else, just replace it.

  WARNING: There are several capacitors inside that may be charged to as much as 300 volts. The charge they can hold is probably not dangerous but may be painful or startling. Discharge these before touching anything inside or attempting to check components. Use a screwdriver blade or test clips and then confirm that they are discharged with your multimeter.

- Contamination of the controls from spilled liquid (did your tea kettle boil over?) may result in continuous activation of the ignition module since any electrical leakage across the switch contacts will likely be enough to activate it - only a few mA are required. Remove the control panel cover and dry it out or unplug the range or oven for a couple of days. If the contamination is not just plain water, it is a good idea to clean it thoroughly to prevent future problems.

- Spills into the area of the electrodes at the gas burner assembly may short out the ignition for ALL the burners since they probably use the same module. Again, clean and dry it out or let it dry out on its own (if just water).

These are probably standard modules and replacements should be available from your local appliance repair shop or parts supplier. An exact mechanical match is not needed as long as the specifications are compatible.

Oven door seal repair

(From: Brian Symons (brians@mackay.net.au).)

If you need a high temp silastic (e.g., for refitting glass windows in ovens) then the Black silastic sold for car windscreen sealing from the local service station or garage is the stuff. Works well. Someone here waited several months and paid $80 for what he could buy down the road for $10 - it was even the same brand.

Freezer is normal but fresh food compartment isn't even cool ---

Some possibilities:

- The door is not properly closing for some reason.
- Someone messed with the controls accidentally.
- Something is blocking the passageway between the evaporator and the fresh food compartment.
- The defrost cycle is not working and ice has built up in the evaporator coils. This could be due to a bad defrost timer (most likely), bad defrost heater, or bad defrost thermostat.
- The interior light is not going out when the door is closed - that small amount of heat can really mess up the temperature (remove the bulb(s) as a test if you are not sure.
- Low Freon can result in problems of this type but that is a lot less likely. (These refrigeration systems are hermetically sealed (welded). Slow leaks are unlikely.)

If you are handy, you can narrow down the problem and possible fix it - a defrost timer can be easily replaced. See the section: Defrost system operation and wiring.

Refrigerator not cooling after a week

First, clean the condenser coils. It is amazing how much dust collects there and interferes with proper cooling.

If you just turned it on a week ago and it is not acting up, a failure of the defrost timer is quite likely. On an old fridge, the grease inside dries out/gunks up and restarting from cold results in it not running. It takes about a week for enough ice to build up to be a problem.

This is a $12 repair if you do it yourself or $100 or so if you call someone.

Could be other things but that is what I would check first. On a GE, it is usually located at the bottom front and there is a hole in the front in which you can poke your finger to turn it clockwise by hand. Turn it until you hear a click and the fridge shuts off. You should not get melting in the evaporator compartment and water draining into the pan at the bottom. The fridge compressor should start up again in 10-20 minutes but I bet in your case it won't as the timer needs replacement.

Defrost system operation and wiring

The most common type of defrost system on a no-frost refrigerator or freezer usually consists of:

- Defrost timer - motor driven (typically) switch which selects between the compressor and its associated devices (like the evaporator fan) and the defrost heater (located adjacent to the evaporator coils). The timer motor likely only runs when the main thermostat calls for cooling.

- Defrost heater - resistance element located in the evaporator compartment to melt ice built up on the coils

- Defrost thermostat - closed when the temperature is below about 32 degrees F to allow current to flow to the defrost heater. Shuts off once the ice melts as indicated by the temperature rising above 32 degrees F.

Testing: It should be possible to easily identify the bad components. For the following, it is assumed that the main thermostat is set such that the compressor is on.

- Usually, it is possible to manually turn the defrost timer shaft (through a hole in the timer case) with a finger or small screwdriver - try both directions - one should rotate easily with a slight ratcheting sound until a distinct 'click' is heard.

- The click indicates that the switch has changed position. The compressor should shut off (or start up if it was stuck in defrost). Over 90% of the rotation range enables the compressor with a short time (e.g., 20 minutes) for defrost. The total time is several hours (6 typical).

- At this point, the defrost heater should come on if there is enough ice to keep the defrost thermostat below 32 F. You will know it comes on because there will be crackling sounds as ice melts and parts expand and the element may even glow red/orange when hot. Water should start flowing to the drip pan. If there is no sign of heating:

    - Test (with power off) the resistance of the element - it should measure under 100 ohms (31 ohms typical).

      If open - at the terminals of the element - it is bad.

    - Test (with power applied) for AC voltage across the element. If there is none, test across the defrost thermostat - there should be none. Or, test across the series combination of the defrost heater and thermostat. There should be full line voltage across the series combination.

      If there is still none, the contacts on the defrost timer may be bad, you may be in the normal cycle by mistake, the main thermostat may be defective or not calling for cooling, the wiring may be incorrect or have bad connections, or there may be no power to the outlet.

      If there is voltage across the defrost thermostat, it is defective or the temperature is above 32 F. Confirm by jumpering across the defrost thermostat and see if the defrost heater comes on.

- If ice buildup is modest, the defrost thermostat should shut off the heater in a few minutes. In any case, the timer should advance and switch to the normal position with the compressor running and defrost heater shut off in about 10 to 20 minutes.

  If the timer never advances, the motor is likely not running due to gummed up lubrication, a broken or loose gear, or a broken wire. On some of these timers, the connections to the motor are to the moving contacts and break after a few years. These can be repaired by soldering them to a more stable location.

  One indication that the motor is not being powered is for it to be ice cold even after several hours with the compressor (and thus the timer) being on. Normally, the coil runs warm to hot. If the timer never advances even with a toasty winding, the lubrication is gummed up or a gear has broken.

Defrost timers are readily available at appliance parts distributors. A generic timer will cost about $12. An exact replacement, perhaps up to $35. If you call in a service person, expect to pay over $100 for the part and labor.

Generally, the defrost timer is an SPDT switch operated by a cam on a small motor with a 4 to 8 hour cycle (depending on model). For an exact replacement, just move the wires from the old timer to the same terminals on the new unit. For a generic replacement, the terminal location may differ. Knowing what is inside should enable you to determine the corresponding terminal locations with a multimeter.

The terminal numbering and wire color code for the defrost timer in a typical GE refrigerator is shown below:

```
                     Black (4)
    Gray (3)      /o---------o Normal position - Compressor, evaporator fan.
H* o-----+------/
         |         o---o Blue (2)
       Timer           |         Defrost heater  Defrost Thermostat
       Motor (3180     o------------/\/\/\------------o/o----------+
         |    ohms)                 31 ohms          32 F          |
         |                                                         |
         | Orange (1)                                              |
         o---------------------------------------------------------+--o Common


   * H is the Hot wire after passing through the main thermostat (cold control)
     in the fresh food compartment.
```

Since the defrost timer only runs when the compressor is powered, it will defrost more frequently when the fridge is doing more work and is likely to collect more frost. This isn't perfect but seems to work.

Compressor starting relays

Most refrigeration compressors use a current mode relay to engage the starting winding of their split phase induction motor. However, a PTC (Positive Temperature Coefficient) thermistor might also be used.

A starting relay senses the current flowing to the run winding of the compressor motor (the coil is a few turns of heavy wire in series with the run winding) and engages the starting winding when that current is above a threshold - indicating that the rotor is not up to speed.

A PTC thermistor starts with a very low resistance which increases to a high value when hot. Proper operation depends on the compressor getting up to speed within a specific amount of time.

For testing only, you can substitute an external switch for the starting device and try to start it manually.

CAUTION: Do not bypass a faulty starting device permanently as the starting winding is not intended to run continuously and will overheat and possibly burn out if left in the circuit.

Assuming you have waited long enough for any pressures to equalize (five minutes should do it if the system was operating unless there is some blockage - dirt or ice - inside the sealed system), you can test for proper operation by monitoring the voltage on the start and run windings of the compressor motor. If there is line voltage on both windings and it still does not start up - the overload protector switches off or a fuse or circuit breaker pops - the compressor is likely bad.

Refrigeration compressor wiring

The following applies to a typical GE refrigerator compressor. YOURS MAY BE DIFFERENT! There may be a wiring diagram tucked in with your customer information, attached to the back of the unit, or hidden underneath somewhere.

The sealed unit has 3 pins usually marked: S (Start), R or M (Run or Main), and C (Common). The starting relay is usually mounted over these pins in a clip-on box. The original circuit is likely similar to the following:

```
                      |<- Starting Relay ->|<---- Compressor Motor ---->|

               ___            L
     AC H o----o o--------------+--o/   S    S
            "Guardette"         |    o---->>-------------+
             (Thermal           +-+                      |
             Protector)            )||                   +-+
                        Relay Coil )||                      )||
                                   )||                      )|| Start
                                +-+                         )|| Winding
                                |                           )||
                                |      M    R/M          +-+
                                +-------->>------+       |
                                                  )||    |
                                         Run/Main )||    |
                                          Winding )||    |
                                                  )||    |
                                               +-+       |
                                            C   |        |
     AC N o------------------------------>>-----+--------+
```

The Starting Relay engages when power is applied due to the high current through the Run winding (and thus the relay coil) since the compressor rotor is stationary. This applies power to the Start winding. Once the compressor comes up to speed, the current goes down and the Starting Relay drops out.

Note the Thermal Protector (often called a "Guardette" which I presume is a brand name). This shuts off power to the compressor if the temperature rises too high due to lack of proper cooling (defective compressor/condenser cooling fan, missing cardboard baffle, or clogged up (dusty) comdensor; an overload such as a blockage in the sealed system (bad news), or low line voltage.

Changing the temperature range of a small refrigerator

It is simple in principle. The cold control - the thing with the knob - needs to be modified or replaced. It is a simple on/off thermostat. You may be able to figure out how to adjust its limits (mechanical) or simply locate a suitable thermostat and install it in place of the existing unit. Note: if it uses a capillary tube to a sensing bulb, don't attempt to modify that part - it is sealed and should remain that way. The mechanism it operates may still be adjustable. However, you will likely loose the low end of your temperature range.

Washer sometimes spins

When it should be spinning, is the motor running? Does it complete the cycle in the normal time?

I would guess that the solenoid to shift it into spin is binding or erratic. Thus opening the door gives switches it on and off like the timer but since it sometimes works, it sometimes works by cycling the door switch.

Clothes washer does not fill (cold or hot)

This assumes the unit has power and otherwise operates normally. However, determining this may be difficult if the completion of the cycle is dependent on a water weight or volume sensor.

There are several possibilities:

1. The appropriate water inlet filter is clogged. This will be accessible by unscrewing the hose connection. Clean it.

2. The solenoid is bad. If you are electrically inclined, put a multimeter on the cold water valve to see if it is getting power.

3. The temperature selector switch is bad or has bad connections.

4. The controller is not providing the power to the solenoid (even for only hot or cold, these will have separate contacts).

Maytag washer timer motor repair

The following applies to many Maytag models manufactured over the last 25 or 30 years. A typical example is "A106" of 1970s vintage but much more recent models use the same mechanism. After 20 or 30 years, even a Maytag washer may need a service call. :) It also likely applies to other makes of washers.

One common failure is of the motor that drives the electromechanical controller. And, the problem may be a 2 cent plastic gear! The symptoms are that the timer never advances. The cause is that due to age, use, or gummed up grease, the pinion gear on the rotor of the timing motor cracks and the timer fails to move. As of 2001, the entire motor was available from Maytag for about $55, and generic versions from other appliance parts suppliers for around $30. (An Internet search of "Maytag parts" will turn up several possible suppliers.) However, a repair may be possible. There is no way to order just the gear but what's left of it is usually salvageable. Whether the repair lasts a week or 10 years, no guarantees but it is fairly easy. Here is the sequence of steps to perform the repair:

- Unplug the washer!!!! Provide a container to hold small parts so they won't get lost. :)

- Remove the sheet metal cover over the controls by unscrewing two screws on top.

- Use a thin tool like a butter knife to pop off the decorative center piece on the knob.

- Pop off the metal clip on the shaft and remove the knob, spring, and dial plate.

- Note which way the controller assembly is oriented and then use a socket driver to remove the two hex screws holding it to the control panel. Hold onto it while removing the screws and rest it on something soft to prevent damage. The motor will be visible on the side which used to face the front panel.

- Pull off the two wires of the motor from their terminals and note where they went.

- Remove the two screws holding the motor in place and remove the motor.

- Test the motor by carefully connecting it to a source of 115 VAC. There should be a hum but the drive gear won't move, or will be easily stopped. This confirms that the motor is the problem. If it's difficult or impossible to stop the drive gear from moving, the motor is probably not the problem. The controller may be really gummed up or damaged.

- Using a power drill or drill press, drill out the two rivets holding the motor shell together. Take care to only drill deep enough to remove the rivet shoulder - the shafts are needed to align the shells upon reassembly. Take care that the half with the gears doesn't fall apart.

- Examine the pinion gear on the metal shaft. This is a piece of plastic/rubber material (orange in the samples I've seen) that is supposed have a slot on one end into which fits two projections from the rotor. Typically, the gear fractures at this point.

- Use a small file, knife, or other suitable tool to trim the remaining end flat and then fashion some new slots in what's left. Remove only the minimum material necessary. It doesn't have to be a perfect fit.

- Clean both the gear and rotor where they mate and use some quick setting adhesive to join them together. I've had success with an initial use of SuperGlue(tm) followed by an overcoat of windshield sealer. In another case I used some hot melt glue. Make sure the gear and rotor don't get stuck to the shaft (which doesn't rotate!).

- Since the gear is now shorter than before, it will be necessary to add some sort of spacer to keep it (and the rotor) in position. If a suitable washer isn't handy, make something from a tiny bit of plastic. Make sure there is still a small amount of end clearance when the two halves are put back together.

- Check lubrication of the gear train. A few drops of light machine or electric motor oil won't hurt.

- Reassemble the motor shell temporarily and power it up to check that it now rotates. It should start reliably and be very difficult or impossible to stop by grabbing the gear.

- Reinstall the motor in the controller using the same two screws that were there originally. Put the wires back onto their respective terminals (which one doesn't matter as long as they are the same terminals!).

- Flip the controller over and remove the sheet metal cover concealing the gears that drive the switch mechanism by bending the tab holding it in place.

- Clean up the old, possibly dried or caked grease on these gears, and then lubricate with new light grease. Replace the cover. PROBLEMS WITH LUBRICATION HERE MAY IN FACT BE THE ACTUAL CAUSE OF THE MOTOR GEAR FAILURE so don't neglect this step!

- Reassemble the controller, knob, and cover. Plug the washer in.

Now you (or your spouse) will have no excuses to deal wtih those piles of dirty laundry!

Window air conditioner preventive maintenance

Very little needs to be done to get many years of service from a typical window air conditioner.

Of course, clean the inside filter regularly. This is usually very easy requiring little or no disassembly (see your users manual). Some slide out without even removing the front cover (e.g., Emerson Quiet Kool).

I generally do not bother to open them up each year (and we have 4). Generally, not that much dirt and dust collects inside. A cover during the winter also helps.

Use a vacuum cleaner on the condenser coils in the back and any other easily accessible dirt traps.

If you do take the cover off, check the fan motor for free rotation. If it is tight indicating bad bearings or lack of lubrication, it will have to be disassembled, cleaned, and lubricated - or replaced. If there are lubrication holes at the ends of the motor, put a couple drops of electric motor oil in there while you have it open.

These units have a sealed freon system - so if anyone's been into it before - you can tell from obvious saddle valves clamped on. Generally, if it cools and the air flow is strong, it is OK.

These units tend to be very reliable and low maintenance.

Window air conditioner doesn't cool

This means the fan runs but you do not hear the compressor kick in.

It could be several things:

- If you hear the 'click' of the thermostat but nothing happens (Your room lights do not dim even for a second) and there is no other sound, it could be bad connections, bad thermostat, dirty switch contacts, bad compressor, etc. Or, you have it set on fan instead of cool. Try cycling the mode selector switch a couple times.

- If you do not hear a click at all, then the thermostat is probably bad or it is cooler in your room than you think! Try tapping on the thermostat. Sometimes they just stick a bit after long non-use.

- If you get the click and the lights dim and then a few seconds later there is another click and the lights go back to normal, the compressor, or its starting circuitry is bad. It is trying to start but not able to get up to speed or rotate at all.

Except for a bad compressor, all these are repairable relatively inexpensively but if it is real old, a new high efficiency model may be a better solution.

Air conditioner freezes up

When this happens, airflow is reduced greatly since ice is blocking the evaporator. Turning the unit off for a while or running it on fan-only will clear the ice but this may indicate the need for maintenance or an actual problem. Similar comments apply to window and central air conditioners as well as heat pumps.

The three major causes of an air conditioner freezing up are:

1. Reduced airflow due to a dirty filter or clogged evaporator. If you are not aware that there is a filter to clean, this is probably the cause :-).

2. Low Freon. While your intuition may say that low Freon should result in less cooling, what happens is that what is there evaporates too quickly and at the input end of the evaporator coils resulting in lower temperatures than normal at that end (which results in condensed water vapor freezing instead of dripping off) but part of the evaporator will likely be too warm.

   You cannot fix this yourself without specialized equipment. For a room air conditioner that isn't too old, it may be worth taking it in to a reputable shop for an evaluation. For a central air conditioner, you will have to call an HVAC service company for repairs.

   The fact that the Freon is low means that there is a leak which would also need to be repaired. Freon does not get used up.

3. Outside and/or inside temperature may be very low. The unit may not be designed to operate below about 65 degrees F without freezing up.

If it is 90 degrees F and you have full air flow with the fan set on high and still get the freezup on a part of the evaporator, then low Freon is likely.

Comments on electric clothes dryer problems and repair

For quite a lot of useful information, do a web search for 'appliance repair'. There are a couple of decent sites with DYI information.

(From: Bernie Morey (bmorey@aardvark.apana.org.au).)

I've repaired our electric dryer several times over the years and kept it going well beyond its use-by date.

My main problems have been:

1. Mechanical timer failure. Easy fix.

2. Leaking steam damaging the element. Have replaced element twice -- fairly easy job. Had to replace some stainless stand-offs at the same time. Elements readily available and equivalent of USD24 each.

3. Bearing replacement -- have to be done carefully or they don't last.

4. Belt replacement. (Make sure you center the belt with respect to the idler and rotate the drum by hand to double check it before buttoning things up. Else, it may pop off the first time the motor starts. --- sam).

5. Exhaust fan bearing replacement. This was the trickiest, although far from impossible. It is a sealed unit subject to high heat and dust contamination -- not a good environment.

The only problem for the past two years has been the dryer throwing the exhaust fan belt. Cleaning up the fluff fixes it for another year.

Did all these without any guide -- just carefully inspecting the work before starting and making diagrams of wiring and ESPECIALLY the main drum belt. I generally have to get my wife to help me with the main belt -- hard to get the tensioner in position while stopping the belt slipping down the far side of the drum.

These things are mechanically and electrically pretty simple -- if it's not working the fault is usually obvious.

(From: Larry Brackett (appliparts@aol.com).)

Here are some things to check for a Kenmore or Whirlpool dryer not running. These things will apply to any dryer. The difference being the identification and location of these parts in different dryers. Always look at the wiring picture for your product to see what these are. The identifying numbers and letters here will not apply to all Whirlpool dryers. Please remember this.

- Power supply: Check at terminal block where the cord connects. There should be 220V on the two outer terminals. Should read 110V from center terminal to either of the two outer terminals. Unplug the dryer.

- Timer contact: Remove wires from Y & BG on timer. Set timer to timed dry. Read across Y & BG with ohm meter. Should read continuity if timer contact good.

- Door switch: Remove wires from door switch. Read with ohm meter. Should read continuity with switch depressed.

- Thermal fuse: If the dryer has a thermal fuse, read with an ohm meter. Should show continuity. The thermal fuse is located in the blower housing air duct. It is normally white in color.

- Push to start switch: Read across CO to NO with switch depressed. Should read continuity.

- Broken wires between these components.

- If all the above are OK, then check the motor.

- This is how I check a dryer motor. I unplug the dryer. Remove all 5 wires coming from controls to the motor. Do not remove the 3 wires going from the external switch into the motor. Put a test cord [any cord that you can devise to put 110V to the motor] on terminals 4 & 5 on the motor switch. Plug the test cord in. If the motor will not run, it is normally defective. Again, 4 & 5 are the wires in use for many years on lots of motors to put 110V on to make them run. But you should check your wiring picture to be certain of terminals to use for checking and running components on your dryer.

Dryer shuts down after a few minutes

There are multiple thermostats in a dryer - one that sets the air temperature during normal operation (and controls power to the heating element) and one or more that sense fault conditions (and may shut everything down) such as those described below.

(From: Bernie Morey (bmorey@aardvark.apana.org.au).)

The dryer is likely cutting out because a thermostat is tripping. The fundamental reason is probably that the exhaust air is too hot. And the air flow is probably too hot because it is restricted -- lower volume of air at higher temperature. Check these things out:

1. Lint filter. Although these can look clean (and I assume you do clean it after every load!) the foam variety can gradually clog up with very fine dust and restrict air flow. If it's a foam disk, a new one is fairly cheap.

2. Can you feel the exhaust air? If not, the exhaust fan belt may be worn broken or slipping. The exhaust fan bearing could be partly seized -- try turning the fan by hand and check for stiffness.

3. Air outlet blockage. Lint and dust may have built up in the exhaust side of the machine. Check for restrictions. Our machine just vents up against the laundry wall as it is too difficult to vent it to the outside.

   Outside vents are often plastic tubing with a spiral spring steel coil for stiffness -- check for kinks or obstructions.

4. 'Clutching at straws' Dept #1: Element may have developed a hot-spot near a thermostat. Involves dismantling the machine and checking the element. NB -- if you dismantle the machine, make a diagram of how the drive belt fits over the drum, motor, and idler!

5. 'Clutching at straws' Dept #2: The drum may be restricted from turning freely. This would slow the motor and hence the exhaust fan. Check for socks, women's knee-highs (these thing seem to breed everywhere!) & caught near the bearings (probably the front).

You cannot completely check the thermostat with a meter -- they are either open or closed. To test it properly you would have to know the temperature at which it opens (from the manufacturer's specs), and then measure the temperature of the exhaust air with a probe while watching the thermostat.

Why has my dryer (or other high current) plug/socket burned up?

This sort of failure is not unusual. The brass (or whatever) corrodes a bit over time and/or the prongs loosen up. It doesn't take much resistance at 20 or 30 Amps to produce a substantial amount of heat. The hotter it gets, the more the resistance goes up, heating increases, it loosens more, and so on until something melts. The power is I*I*R (where I is current and R is the resistance) so at 20 A, a .1 ohm resistance at the contact results in 40 W - think of the heat of a 40 W light bulb.

An exact cause would be hard to identify. However, only the plug and receptacle are involved - this is not a case of an outside cause. Such a failure will not normally blow a fuse or trip a breaker since the current does not increase - it is not a short circuit.

It is definitely wise to replace both the plug and receptacle in such cases since at the very least, the socket has lost its springiness due to the heating and will not grip well.. Make sure that the prongs on the new plug make a secure fit with the socket.

On plugs having prongs with a pair of metal strips, spreading them out a bit will make much better contact in an old receptacle.

In general, if a plug is noticeably warm, corrective action should be taken as it will likely get worse. Cleaning the prongs (with 600 grit sandpaper) and spreading the metal strips apart (if possible) should be done first but if this does not help much, the plug and/or socket should be replaced. Sometimes, the original heating problem starts at the wire connections to the plug or socket (even inside molded units) - loose screws, corroded wires, or deteriorated solder joints.

Four year old gas dryer just started popping GFCI

Why is it on a GFCI in the first place? A grounded outlet is all the protection that is needed and any type of appliance with a motor or transformer could be a potential nuisance tripper with a GFCI (though not always).

As to why it is now different, I assume that this is a dedicated outlet so nothing else you added could affect it. Thus you are left with something changing in the dryer or the GFCI somehow becoming overly sensitive.

It is possible that there is now some electrical leakage in the dryer wiring just from accumulated dirt and grime or dampness. This could be measured with an AC milliamp meter or by measuring the resistance between the AC wires and the cabinet. If this test shows up nothing, I would recommend just putting on a grounded outlet without a GFCI. It could also be that due to wear, the motor is working harder at starting resulting in just a tad more of an inductive current spike at startup.

Checking dishwasher solenoids

(From: Filip "I'll buy a vowel" Gieszczykiewicz (filipg@repairfaq.org).)

Greetings. Well, since it's a moist/damp environment... I'd suspect a bad connection first. You will need to pop off the front bottom panel and get at the wires that actually connect the solenoid to the timer motor (and/or wire harness). You will need an ohmmeter to check the resistance of the coil - if it's OK (20-200 ohms I would guess), that's not the problem. Well, that leaves you with pretty much the wires that connect the timer motor (a MULTI-contact switch driven by a timer motor like those found in old clocks that plugged into outlets) and the switch itself. I hope the dishwasher is unplugged... Since the dishwasher operates as a closed system (because of the "darned" water :-) it will be difficult to test it in circuit. I suggest that you try to trace the wires that come off the solenoid to their other ends... and then test the wires themselves. If you feel this is too much for you, call the repair folks - ask around... see if anyone else knows a particular service that has a good record...

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Electrical Wiring Information and Problems

Safe electrical wiring

This chapter is in no way intended to be a comprehensive coverage of wiring issues but includes a discussion of a few of the common residential wiring related questions. For more information, see the official Usenet Electrical Wiring FAQ or a DIY book on electrical wiring. The NEC (National Electrical Code) handbook which is updated periodically is the 'bible' for safe wiring practices which will keep honest building inspectors happy. However, the NEC manual is not what you would call easy to read. A much more user friendly presentation can be found at the CodeCheck Web Site. This site includes everything you always wanted to know about construction codes (building, plumbing, mechanical, electrical) but were afraid to ask.

In particular, the following series of sections on Ground Fault Circuit interrupters is present at the CodeCheck web site and includes some nice graphics as well. Specifically: GFCI by Sam Goldwasser.

What is a GFCI?

A Ground Fault Circuit Interrupter (GFCI) is a device to protect against electric shock should someone come in contact with a live (Hot) wire and a path to ground which would result in a current through his/her body. The GFCI operates by sensing the difference between the currents in the Hot and Neutral conductors. Under normal conditions, these should be equal. However, if someone touches the Hot and a Ground such as a plumbing fixture or they are standing in water, these currents will not be equal as the path is to Ground - a ground fault - and not to the Neutral. This might occur if a short circuit developed inside an ungrounded appliance or if someone was working on a live circuit and accidentally touched a live wire.

Continuing with the water analogy used elsewhere in this document, the Hot is equivalent to the water supply and the Neutral is equivalent to the drain. The flow rate (current) can be high and do work like running a pump as long as all the water goes down the drain. But if there is a leak and the water splashes out on to the ground, then the the water equivalent of a GFCI will trip and shut off the water.

The (electrical) GFCI will trip in a fraction of a second at currents (a few mA) well below those that are considered dangerous. Note that a GFCI is NOT a substitute for a fuse or circuit breaker as these devices are still required to protect equipment and property from overloads or short circuits that can result in fire or other damage.

GFCIs can be installed in place of ordinary outlets in which case they protect that outlet as well as any downstream from it. There are also GFCIs that install in the main service panel. Either will provide the same level of safety but the breaker will automatically protect everything on its circuit no matter how it is wired while the outlet version will only protect the outlet and other outlets downstream from it.

Note that it may be safe and legal to install a GFCI rated at 15 A on a 20 A circuit since it will have a 20 A feed-through. Of course, the GFCI outlet itself can then only be used for appliances rated 15 A or less.

Many (if not most) GFCIs also test for a grounded neutral condition where a low resistance path exists downstream between the N and G conductors. If such a situation exists, the GFCI will trip immediately when power is applied even with nothing connected to the protected outlets.

GFCIs, overloads, and fire safety

A GFCI is NOT a substitute for a fuse or circuit breaker (unless it is a combined unit - available to replace circuit breakers at the service panel).

Therefore, advice like "use a GFCI in place of the normal outlet to prevent appliance fires" is not really valid.

There may be some benefit if a fault developed between Hot and Ground but that should blow a fuse or trip a circuit breaker if the outlet is properly wired. If the outlet is ungrounded, nothing would happen until someone touched the metal cabinet and an earth ground simultaneously in which case the GFCI would trip and provide its safety function. See the section: Why a GFCI should not be used with major appliances for reasons why this is not generally desirable as long as the appliance or outlet is properly grounded.

However, if a fault occurs between Hot and Neutral - a short in the motor, for example - a GFCI will be perfectly happy passing almost any sort of overload current until the GFCI, wiring, and appliance melts down or burns up - a GFCI is not designed to be a fuse or circuit breaker! That function must be provided separately.

How does a GFCI work?

GFCIs typically test for the following condition:

1. A Hot to Ground (safety/earth) fault. Current flows from the Hot wire to Ground bypassing the Neutral. This is the test that is most critical for safety.

2. A grounded Neutral fault. Due to miswiring or a short circuit, the N and G wires are connected by a low resistance path downstream of the GFCI. In this case, the GFCI will trip as soon as power is applied even if nothing is connected to its protected (load) circuit.

To detect a Hot to Ground fault, both current carrying wires pass through the core of a sense coil (transformer). When the currents are equal and opposite, there is no output from its multiturn sense voltage winding. When an imbalance occurs, an output signal is produced. When this exceeds a threshold, a circuit breaker inside the GFCI is tripped.

GFCIs for 220 VAC applications need to monitor both Hots as well as the Neutral. The principles are basically the same: the sum of the currents in Hot1 + Hot2 + Neutral should be zero unless a fault exists.

To detect a grounded neutral fault, a separate drive coil is continuously energized and injects a small 120 Hz signal into the current carrying conductors. If a low resistance path exists between N and G downstream of the GFCI, this completes a loop (in conjunction with the normal connection between N and G at the service panel) and enough current flows to again trip the GFCI's internal circuit breaker.

GFCIs use toroidal coils (actually transformers to be more accurate) where the core is shaped like a ring (i.e., toroid or doughnut). These are convenient and efficient for certain applications. For all practical purposes, they are just another kind of transformer. If you look inside a GFCI, you will find a pair of toroidal transformers (one for H-N faults and the other for N-G faults as described above). They look like 1/2" diameter rings with the main current carrying conductors passing once through the center and many fine turns of wire (the sense or drive winding) wound around the toroid.

All in all, quite clever technology. The active component in the Leviton GFCI is a single chip - probably a National Semiconductor LM1851 Ground Fault Interrupter. For more info, check out National's LM1851 Specs.

More on how the GFCI detects a N-G short

To detect a Neutral to Ground fault there is a second transformer placed upstream of the H-G sense transformer (see the illustration of the internal circuitry of the GFCI at: http://www.national.com/pf/LM/LM1851.html). A small drive signal is continuously injected via the 200 T winding which induces equal voltages on the H and N wires passing through its core.

- If N and G are separate downstream (as they should be), no current will be flow in either wire and the GFCI will not trip. (No current will flow in the H wire as a result of this stimulus because the voltage induced on both H and N is equal and cancels.)

- If there is a N-G short downstream, a current will flow through the N wire, to the G wire via the short, and back to the N wire via the normal N-G connection at the service panel. Since there will be NO similar current in the H wire, this represents a current unbalance and will trip the GFCI in the same manner as the usual H-G short.

- Interestingly, this scheme automatically detects a H-H fault as well. This unlikely situation could occur if the Hots from two separate branch circuits were accidentally tied together in a junction box downstream of the GFCI. It works the same way except that the unbalance in current that trips the GFCI flows through the H wire, through the H-H fault, and back around via the Hot busbar at the service panel. Of course if the two Hots are not on the same phase, there may be fireworks as well :-).

GFCIs and safety ground

Despite the fact that a Ground Fault Circuit Interrupter (GFCI) may be installed in a 2 wire circuit, the GFCI does not create a safety ground. In fact, shorting between the Hot and Ground holes in the GFCI outlet will do absolutely nothing if the GFCI is not connected to a grounded circuit (at least for the typical GFCI made by Leviton sold at hardware stores and home centers). The Ground holes are only connected to the green screw on the outside of the GFCI, not to any circuitry inside the GFCI and it will trip only if a fault occurs such that current flows to a true ground. If the original circuit did not have a safety ground, the Ground Holes aren't going anywhere. What this means is that an appliance with a 3 prong plug can develop a short between Hot and the (supposedly) grounded case but the GFCI will not trip until someone touches the case and an earth ground (e.g., water pipe, ground from some other circuit, etc.) at the same time.

Note that even though this is acceptable by the NEC, I do not consider it desirable. Your safety now depends on the proper functioning of the GFCI which is considerable more complex and failure prone than a simple fuse or circuit breaker. If it's not tested periodically, reliability is even lower. Therefore, if at all possible, provide a proper Code compliant ground connection to all outlets feeding appliances with 3 wire plugs.

Where are 3 wire grounded outlets required?

If you move into a house or apartment where some or all of the outlets are the old 2 prong ungrounded type, don't panic. There is no reason to call an electrician at 2:00 AM in the morning to upgrade them all at great expense. (This also applies to 3 prong outlets that don't have their third prong hooked up.)

You don't need grounded outlets for two wire appliances, lamps, etc. They do essentially nothing if the third hole isn't occupied :-). A GFCI will provide much more protection and it is permissible retrofit these into ungrounded wiring.

You should have grounded outlets for the following:

- Computers in order for the line filters and surge suppressors to be most effective. Note that since all the third prongs of your computer system (e.g., PC, monitor, printer) will likely be connected together by the outlet strip, a fault in one unit resulting in its third prong becoming live could result in damage somewhere else without a proper ground. And, no, you shouldn't just cut off all the third prongs to avoid this possibility!

- High-end entertainment gear if it uses 3 prong plugs for similar reasons.

- Microwave ovens. For safety, these really should be on a grounded circuit. (A GFCI will not protect against a fault on the high voltage side of a microwave oven, though this sort of fault is extremely unlikely. And, some microwave oven-GFCI combinations may result in nuisance tripping).

- Large appliances including refrigerators, freezers, clothes washers and dryers, dehumidifiers, window air conditioners, etc.

In most cases, there will only be a few circuits where this is needed and only these need to be upgraded. To what extent the wiring plan of your residence separates lighting type circuits from those with outlets that will be used for 3 wire equipment will determine how easy it is to upgrade only those outlets that are affected. It may be cheaper to just add new branch circuits for specific equipment needs.

However, if you are replacing old worn outlets anyhow, it does make sense to upgrade to 3 prong outlets if they can be properly grounded without pulling a new wire - for example, if the box is already grounded but simply not connected to the old outlet.

In all cases, make sure that the new outlet is properly wired with respect to the ground and H-N polarity. An improperly wired 3 prong outlet may be worse than any 2 prong variety!

Why you should NOT connect G to N

The question often arises: "Why can't I just connect the G to the N if my outlets are only two prong?"

For one reason, consider the 'appliance' below:

```
            +-----------------+
            |                 |        Open Fault
  Hot o---------o-o----/\/\---------+------ X -----o Neutral
            | Switch  Load    |    |
            |  (On)           |----+ Case should be G but is connected to N
            +-----------------+
```

With the appliance 'on', current passes through the internal wiring/motor/etc. of the appliance to the N but this is now connected to the case as well. If the house wiring opens (or even if the plug is loose, it is possible to have line voltage on the case.

The 'appliance' can actually be *all* loads on the circuit upstream of the the Open Fault - all those with a grounded cabinet have it then become live!

Testing installed GFCIs

These tests should be performed periodically to assure that the GFCIs are providing the protection for which they were designed. It is possible for the GFCI's circuitry to go bad or for the contacts to get stuck. The usual recommendation is once a month but more frequently won't hurt.

The built-in tester is designed to actually introduce a small leakage current so its results should be valid. Therefore, testing a single GFCI outlet with an external widget is not really necessary except for peace-of-mind. However, such a device does come in handy for identifying and testing outlets on the same circuit that may be downstream of the GFCI.

An external tester is easy to construct - a 15 K ohm resistor between H and G will provide a 7 mA current. Wire it into a 3 prong plug and label it "GFCI Tester - 7 mA". The GFCI should trip as soon as you plug the tester into a protected outlet. On a GFCI equipped for grounded neutral detection (as most are), shorting the N and G conductors together downstream of the GFCI should also cause it to trip (push buttons for both functions would be a useful enhancement).

Note that such a tester will only work for GFCI protected outlets that are on grounded (3 wire) circuits (unless you add an external ground connection). Thus, just using a commercial tester may falsely indicate that the GFCI is bad when in fact it is simply on an ungrounded outlet (which is allowed by Code in a retrofit situation).

The test button will work whether or not the circuit includes a safety ground because it passes an additional current through the sense coil between Hot and Neutral tapped off the wiring at the line side of the GFCI and therefore doesn't depend on having a safety Ground.

I suppose you can purchase suitable low cost testers as well (but they are subject to the same must-be-grounded restrictions). Try your local home center or electrical supply distributor.

The general procedure for the test is as follows. (This assumes a live GFCI circuit. If there is no power and the RESET button doesn't restore it, testing will need to be done to determine if the problem is in the GFCI, wiring, or a blown fuse/tripped circuit breaker at the service panel.):

- Plug a night light, radio (with a hard on/off switch, not a pushbutton!), or similar low power device into the GFCI outlet and turn it on.

- Press the TEST button or plug in (or activate) your tester -> The outlet should trip within a fraction of a second and the device should go off.

- Press the RESET button -> Power should be restored and the device should come back on.

- Carefully short together N and G with an insulated jumper or the button on your tester -> The outlet should trip.

- Press the RESET button -> Power should be restored and the device should come back on.

- Repeat the above steps for each outlet downstream of the GFCI.

If any of these don't work as expected, the GFCI is defective or the outlet is miswired and there may be no protection.

Reminder: A separate Ground connection must be provided to use a GFCI tester in an ungrounded outlet. Without one, the GFCI's TEST button must be used.

John's comments on the use of GFI breakers

(From: John Grau (affordspam@execpc.com).)

I personally would not feed a subpanel with a GFI breaker. Here are just a few of the reasons:

1. GFI breakers for personnel protection are set to trip at 5 mA (1/1000ths of an Amp). The longer the circuit conductors, the greater the potential for leakage. If you subfeed a panel, you would have the cumulative distances of all circuits connected to that panel to contend with and hope that the breaker would hold.

2. You would not be able to connect any thing to that subpanel that would be a critical load. e.g. freezer, sump pump, well pump, furnace, etc. An unnoticed nuisance trip, could mean that you would come home to a thawed freezer, frozen pipes, flooded basement, etc.

3. Using breakers to achieve GFI protection has 2 downsides: expense, and usually, an inconvenient location to reset the tripped device. A GFI outlet at the point of usage, is usually more convenient to reset, should it trip. Here in Wisconsin, I can buy about 6 GFI outlets for the cost of 1 breaker.

There is no compulsory language in the National Electrical Code the forces an update to current code standards, unless you repair, replace or update the affected component. Not all changes in the 1996 code made sense, and I would not update the wiring in my own home (built in 1995) to current standards.

Phantom voltage measurements of electrical wiring

When making measurements on household wiring, one expects to see one of three voltages: 0, 115 VAC, or 230 VAC (or very similar). However, using a typical multimeter (VOM or DMM) may result in readings that don't make sense. For example, 2 VAC between Neutral and safety Ground or 40 VAC between a Hot wire (with its breaker off) and Neutral or safety Ground.

The most likely reason for these strange readings is that there is E/M (electromagnetic) coupling - capacitive and/or inductive - between wires which run near one another - as inside a Romex(tm) cable. Where one end of a wire is not connected to anything - floating, the wire acts as an antenna and picks up a signal from any adjacent wires which are energized with their 60 (or 50) Hz AC field. There is very little power in these phantom signals but due to the very high input resistance/impedance of your VOM or DMM, it is picked up as a voltage which may approach the line voltage in some cases.

Another possibility is that the you didn't actually walk all the way down to the basement to shut off power completely and the circuit is connected to a high tech switch (such as one with a timer or an automatic dimming or off feature) or a switch with a neon light built in. There will be some leakage through such a switch even if it is supposed to be off - kill power completely and test again.

Putting any sort of load between the wires in question will eliminate the voltage if the cause is E/M coupling. A small light bulb with test probes can be used to confirm this both by serving as a visual indication of significant voltage (enough to light the bulb, if weakly) and to short out the phantom voltage for testing with the multimeter.

There can be other causes of such unexpected voltage readings including incorrect or defective wiring, short circuits in the wiring or an appliance, and voltage drops due to high current in a circuit. However, the E/M coupling explanation is often overlooked when using a multimeter.

I did an experiment using a Radio Shack DMM with a 10 M ohm input impedance. It was set to AC volts and the red lead was plugged into the Hot side of a live outlet:

- Black lead not touching anything: 14 VAC.
- Black lead in contact with unconnected 4 inch metal utility box: 16 VAC.
- Holding INSULATION ONLY of black lead tightly: 30 to 50 VAC.

There may also be resistive leakage in an actual wiring installation but capacitance alone can easily mess up your multimeter readings if you have unconnected conductors! Adding any sort of load like a 25 W bulb in parallel with the multimeter will make the voltage drop nearly to zero if either of these are the cause of the phantom readings.

Checking wiring of a 3-wire outlet

The following assumes a simple duplex outlet, not split or switched. For each of the tests below, check both halves of the outlet.

The easiest thing to do is use an outlet tester. This simple gadget gives a fairly reliable indication using three neon lamps. See the section: Test equipment for details.

Or, using a multimeter set to "AC Volts":

- 115 VAC (nominal, may vary from 110 to 125 VAC and still be considered normal) between Narrow slot (Hot) and wide slot (Neutral).
- 115 VAC between Narrow slot (Hot) and U-hole (Ground).
- Near 0 VAC between Neutral and Ground.

  This is best done with a lamp or other load plugged into the outlet. The load will elminate the phenomenon of "phantom voltage" should one of the wires not be connected. See the section: Phantom voltage measurements of electrical wiring.

Or turn off the breaker for that outlet and remove the cover plate:

- Black wire should be on brass screw or pushed into hole next to brass screw.
- White wire should be on silver screw or pushed into hole next to silver screw.
- Green or bare copper wire should be attached to green screw or box, if metal.

Of course, the wiring could be screwed up at the service panel or an outlet upstream of this one.

Determining wiring of a 2-wire outlet

Connect a wire between one prong of a neon outlet tester and a known ground - cold water pipe if copper throughout, heating system radiator, ground rod, etc.

(Experienced electricians would just hold onto the other prong of the tester rather than actually grounding it. Their body capacitance would provide enough of a return path for the Hot to cause the neon to glow dimly but you didn't hear this from me :-). Yes, they survive without damage and don't even feel anything because the current is a small fraction of a mA. DON'T try this unless you are absolutely sure you know what you are doing!)

With one prong grounded, try the other prong in the suspect outlet:

- The Hot should glow brightly and the Neutral should not light at all. This is the normal situation.

- If neither side glows, the fuse is blown, the circuit breaker is tripped, this is a switched outlet and the switch is off, or there is a wiring problem elsewhere - or your ground isn't really ground.

- If both sides glow and using the tester between the slots results in no glow, then you have an open Neutral and something else on the circuit that is on is allowing enough current to flow to light the neon tester.

- If both sides glow and using the tester between the slots results in an even brighter glow, the outlet is wired for 220 V, a dangerous violation of the NEC Code unless it is actually a 220 V approved outlet. It is unlikely you will ever see this but who knows what bozos worked on your wiring in the past!

Outlet wiring screwed up?

So your $6 outlet tester displays a combination of lights that doesn't make sense or one or more lights is dim. For example, all three lights are on but K and X (see below) are dim.

The three neon bulbs are just between what should be (The first letter is how the light is marked on mine):

- K Hot to Ground (GROUND OK).
- O Hot to Neutral (HOT OK?).
- Neutral to Ground (HOT/NEUTRAL REVERSE - should not light).

I suspect at the very least that your ground is not connected at the service panel. I may run from some/all the outlets but ends somewhere. You are seeing capacitive/inductive pickup between the floating ground and the other wires in the circuit. Your N and H may be reversed as well but this cannot be determined without checking with a load between H/N and a proper ground.

I would recommend:

1. Determining if the ground wire for those 3 prong outlets does indeed go anywhere.

2. Determining if the Hot and Neutral polarity is correct by testing between each of the prongs and a confirmed ground (properly connected 3 prong outlet, service panel, or a cold water pipe in an all metal water system) with a load like a 25 W light bulb. The neon lamps in the tester or a high impedance multimeter can be fooled by capacitance and other leakage paths.

For a computer or other 3 wire appliance, you should really install a proper 3 prong outlet wired correctly. Otherwise, any power line filters and surge suppressors will not have the safety ground (which a GFCI does NOT create). Some UPSs may get away without one but then their surge suppressor and/or line filters will not work correctly.

Some appliances like microwave ovens MUST have a proper safety ground connection for safety. This not only protects you from power line shorts to the case but also a fault which could make the case live from the high voltage of the microwave generator.

220 V outlet reads 0 VAC between slots

> "I have a 220 outlet that I need to plug an AC unit into. The AC unit works fine in another outlet, but not in this specific outlet. I pulled out my handy dandy meter and checked the voltage across the two line slots - the meter read 0.
>
> But when I tried one line and the ground I got 125 V. Similarly, when I tried the other line and the ground I also got 125 V. What's the scoop? Why does the meter, and obviously the AC, think that there isn't 220 V coming in? Any help is greatly appreciated - as this room is stinking hot right now!"

Did it ever work? It sounds like both slots are being fed from the same phase of the power from the service panel. Check with a load like a 100 W light bulb between each slot and ground. This could have happened during the original installation or during renovation.

Another possibility is that there is some other 220 V appliance on the same line with its power switch in the ON position (and not working either) AND one side of the line has a tripped breaker or blown fuse.

Yet another possibility:

(From: David L. Kosenko (davek@informix.com).)

My load center is GE unit. They make both full height and half height breakers. If you use a half height breaker set for a 220 line, you must be careful to install it across the two phases. It is very easy (especially if you don't know about 220) to place the ganged breakers into a single full height slot in the load center, giving you both lines off the same phase line.

Testing for fault in branch circuit

This may trip the breaker or blow a fuse - or trip a GFCI if so protected. The procedure below is specifically for GFCI tripping. You will need a multimeter.

- First, unplug everything from the circuit and see if it still trips. If it now does not trip, one of the appliances was the problem. Try them one at a time to see which is the problem and then check the section for that or a similar appliance elsewhere in this document.

Assuming the circuit is at fault:

- You need to determine whether this is a H-G leakage fault (which is what most people think is the only thing GFCIs test for) or a shorted G-N fault.

- A H-G fault that doesn't trip the normal breaker might be due to damp wiring (an outside outlet box that gets wet or similar) or rodent damage.

- A shorted G-N fault means that G and N are connected somewhere downstream of the GFCI - probably due to incorrect wiring practices or an actual short circuit due to frayed wiring or wires touching - damage during installation or renovation.

Assuming the line is separate from any other wiring:

- With the line disconnected from the service panel (all three wires), first test between each pair of wires with the multimeter on AC to make sure it is truly dead - there should be virtually no voltage. H-G, N-G, and H-N should all be close to 0 (say, less than a volt).

- If this passes, test across the dead line's H and G for leakage on the resistance range. It should be greater than 15 K ohms (it should really be infinity but to trip the GFCI requires around 15 K ohms or less).

- Then, test for resistance between H and G - this too should be infinity.

One of these will show a fault - possibly the N-G test indicating a short or improperly wired outlet since this would not result in any operational problems until a GFCI is installed (though it does represent a safety hazard).

Locating wires inside a wall

There are gadgets you can buy that look like test lights but sense the electric field emitted by the Hot wire. One is called 'Volt Tick' and may be available at your local home center or large hardware or electrical supply store.

It is also possible to inject a signal into the wire and trace it with a sensitive receiver.

However, if you are desperate, here is a quick and easy way that is worth trying (assuming your wiring is unshielded Romex - not BX - and you can power the wire). Everything you need is likely already at your disposal.

Get a cheap light dimmer or a fixture with a light dimmer (like that halogen torchier that is now in the attic due to fire safety concerns) and plug it into an outlet on the circuit you want to trace. Set it about half brightness.

Now, tune a portable AM radio in between stations. If you position the radio near the wire, you should hear a 120 Hz hum - RFI (Radio Frequency Interference) which is the result of the harmonics of the phase controlled waveform (see the section: Dimmer switches and light dimmers. Ironically, the cheaper the dimmer, the more likely this will work well since no RFI filtering is built in.

I have tried this a bit and it does work though it is somewhat quirky. I do not know how sensitive it is or over how large a circuit it is effective. It is somewhat quirky and even normal power may have enough junk on the waveform to hear it in the radio. However, with a partner to flip the dimmer off and on to correlate its position with what you hear, this may be good enough.

(From: author unknown.)

The probe is really simple. All it consists of is a LM386 and a MPF102 JFET from Radio Shack. The MPF102 is connected as a source follower with a 4.7k load resistor from source to ground. The gate has a 10M resistor to ground and a 1M from gate to the probe tip. The drain of course connects to the plus 9 VDC. There is a .1 uF coupling cap between source and the input to the LM386. The LM386 is the standard circuit found in the data sheet. You can put a 5K volume control between the two pins to increase the gain. And of course you have to find a small 1.3 inch or 3 cm speaker to fit the probe. Use a 9 V battery.

The tone generator can be anything that oscillates. You could use a hex inverter in the typical circuit. Or you could use a two transistor astable multivibrator with 2.2k collector load resistors. Whatever you use, make sure the coupling capacitor to the phone line is a 200 V or higher NON POLARIZED capacitor, so it won't make any diff how you connect it up. Remember that this little box takes a lot of beating from stray voltages and stuff, like ringing currents. So it's best to buy this and get one that's safe. I've burnt them out on occasion so I suggest you don't build it but buy it for under $30.

Lights dim when high current load is switched on

Heating appliances space heaters toasters draw a large current when their operating. Appliances with large motors like air conditioners and washing machines draw a very large current momentarily when starting. And, tools like bench grinders and power saws draw a large current until they get up to speed. All of these conditions increase the voltage drop of the wiring in the branch circuit they are on and thus reduces voltage to lights on the same circuit. Normally, this isn't anything to worry about but do make sure your wiring is properly rated for the equipment in use AND that the fuses or circuit breakers are of the correct rating. If the amount of dimming is erratic, it could mean that there are some corroded or loose high resistance connections due to age/use and/or aluminum wiring. These are serious conditions that can result in an electrical fire and would need to be found and repaired. Where lights *brighten* under these conditions, a bad Neutral connection may be the problem. See the next section.

Bad Neutral connections and flickering lights or worse

Residential service comes from a centertapped 110-0-110 V transformer on the utility pole. There are 3 wires into your house - 2 Hot or live wires and the Neutral which is the centertap of the transformer. If the connection between the Neutral bus in your service panel and the pole transformer centertap becomes loose and opens or develops a high resistance, then the actual voltage on either of the Hots with respect to the Neutral bus (which is divided among your branch circuits) will depend on the relative loads on either side much in the way of a voltage divider using resistors. Needless to say, this is an undesirable situation.

Symptoms include excessive flickering of lights (particularly if they get brighter) when large appliances kick in, light bulbs that seem too bright or too dim or burn out frequently, problems with refrigerators or freezer starting due to low voltage, etc. In the worst case, one set of branch circuits can end up with a voltage close to 220 VAC - on your poor 110 V outlets resulting in the destruction of all sorts of appliances and electronics. The opposite side will see a much reduced voltage which may be just as bad for some devices.

It is a simple matter for an electrician to tighten up the connections but this is not for the DIY'er unless you are familiar with electrical wiring and understand the implications of doing anything inside the service panel while it is live! Furthermore, the problem may actually be in the Neutral cable outside your residence and that can only be dealt with by the power company. Since it's exposed to the elements as well as squirrels and such, damage is possible. An electrician will be able to eliminate internal problems, and recommend contacting the power company if necessary.

Here is what can happen if you don't remedy the situation:

(From: Sinbad (sschwartz@moou.edu).)

Speaking from experience, I can tell you that if your ground goes you will have no doubt about.

When I lost mine I was watching TV. The picture tore and then smoke came out of the back of it. I also lost two VCR's, a dryer, a scanner, a microwave, an AM/FM receiver, an amplifier (everything with a remote control since these always have power going to them), a CD player and a scanner, which also smoked.

The incandescent bulbs that were turned on turned blue and then white before they burned out and a couple fluorescent fixtures burned out as the bulbs arced and melted and cracked.

Fortunately, my insurance policy specifies replacement with no deductible, but I still had to run around buying new stuff (except for the dryer, which was repairable.)

Lightning storm trips GFCIs protecting remote outdoor outlets

> "I have several outdoor 110V outlets, protected by GFCI breakers. These circuits nearly always trip when there are nearby lightening strikes. I am satisfied that there is no short circuit caused by water as:
>
> - A lightning storm without rain will still trip the GFCI.
> - Water from the sprinklers does not cause a problem.
> - I can immediately reset the GFCI when it is still raining and it comes back on.
>
> The electrical cables buried underground run for about 600 feet.
>
> Is GFCI tripping caused by electrical storms normal ? Are my GFCI breakers too sensitive ? Is there any way to modify the circuits to avoid this?"

This doesn't surprise me. Long runs of cable will be sensitive to the EM fields created by nearby lightning strikes. Those cables probably have 3 parallel wires: H, N, G. The lightning will induce currents in all three which would normally not be a problem as long as H and N are equal. However, I can see this not being the case since there will be switches in the Hot but not the Neutral so currents could easily unbalance.

These are not power surges as such and surge suppressors will probably not help.

Since it happens with all of your GFCIs, it is not a case of a defective unit. Perhaps there are less sensitive types but then this would reduce the protection they are designed to provide.

GFCI trips when it rains (hard)

Most likely, moisture/water is getting into some portion of the GFCI's protected wiring (at the GFCI or anywhere downstream) and the GFCI is simply doing its job. You will have to trace the wiring through all junction boxes and outlets to determine where the problem is located. Yes, I know this may not be your idea of fun!

Why a GFCI should not be used with major appliances

A Ground Fault Circuit Interrupter is supposed to be a valuable safety device. Why not use them everywhere, even on large appliances with 3 wire plugs?

1. A properly grounded 3 prong outlet provides protection for both people and the appliance should a short circuit develop between a live wire and the cabinet.

2. Highly inductive loads like large motors or even fluorescent lamps or fixtures on the same circuit can cause nuisance tripping of GFCIs which needless to say is not desirable for something like a refrigerator.

Nuisance tripping of GFCIs

When used with highly inductive loads like motors or even fluorescent lamps, GFCIs may occasionally (or more frequently) trip due to the voltage/current spikes at power on/off. While the NEC/UL specifications apparently allow for some time delay in their response to combat this problem, it is not known if all manufacturers of GFCIs incorporate this into their product. However, the very common Leviton GFCI outlet probably does use the National chip (LM1851 Ground Fault Interrupter) referred to below. Also see the section: How does a GFCI work?.

(From: James Phillips (jamarno@juno.com).)

I quit having GFCI trouble after I fixed all the bad wiring connections, and I haven't had trouble at all with GFCIs and my workshop, which I wired myself. GFCI controller chips include a time delay to reduce false tripping. I used to think GFCIs always tripped at 5 to 6 mA, but the UL allows up to a whopping 200 mA if the GFCI stops the current within 30 ms, and 6 mA leakage is allowed to last 6 seconds.

According to National Semiconductor, their GFCI chips will stop a 200 mA fault in 20 ms, a 6mA fault in .5 sec.

Toasters and GFCIs

The following is a reason to use GFCIs on kitchen outlets that may not be obvious:

(From: David Buxton (David.Buxton@tek.com).)

In addition to the usual explanations dealing with safety around water, another reason why kitchen outlets need a GFCI is the toaster. All too often people stick a butter knife in there to dislodge some bread. If the case was grounded there would be short from the element to the case. So toasters are two wire instead of 3-pronged. So, you must have a GFCI for any outlet that might take on a toaster.

Problems with outlets getting hot

With normal loads, electrical outlets should get at most just warm to the touch. A number of factors can result in hot or dangerously hot outlets. Check the following:

- Make sure you have tight fit - spread leaves of prongs out and clean them with fine sandpaper. An old, rarely used outlet will also develop corrosion increasing resistance.

- Make sure the cord itself is in good condition - sometimes the connections at the plug corrode and result in a hot plug independent of the outlet. Replace with suitable high current heater rated cord if this is the case.

- If you have aluminum wiring that hasn't been upgraded (either replaced or terminated with the proper Al/Cu rated wiring devices or pigtails), check it out. Aluminum wiring can definitely be a fire hazard all over - where high current appliances are plugged in as well as any connections (including feed-throughs) upstream.

Reverse polarity outlets - safety and other issues

> "Our new home has reverse polarity in all of the electrical outlets. The house inspector didn't seem to think this was a major problem, and neither did he think it was worth fixing. Can anyone explain how this might matter for us? The best I understand this is that when something is plugged in, even when it's not turned on, there is still a current going through it--is that true at all, or is that normal? Our biggest concern is our computers, and the possibility that our surge protectors won't be effective. If anyone could clear this up, that would be great."

New as in brand new or new for you? If it is a totally new home, the builder should have them fixed and you should not sign off on the house until this is done. While there is no imminent danger, the house inspector was being a bit too casual for my tastes. It is not a big deal as in should stop you from going through with the purchase but it really should be fixed.

As far as current present when the appliance is off, this is not quite true. When properly wired, the power switch is the first thing in the circuit so it cuts off power to all other parts of the internal wiring. With the reversal, it is in the return - the rest of the wiring will be live at all times. Except for servicing, this is really not that big a concern and does not represent any additional electricity usage.

Normally (I assume these are 3 prong grounded outlets) you have the following:

- Hot - the live conductor - the narrow slot.
- Neutral - the return for the current used by the device - the wide slot.
- Ground (or safety ground) - the U shaped slot.

Reverse polarity means that Hot and Neutral are interchanged. (any other variation like an interchange with the ground represents a serious safety hazard and it should be corrected as soon as possible. The outlet should not used until it is).

For most appliances and electronics, this does not really matter. By design, it must not represent a safety hazard. However, there can be issues - as you are concerned - with surge suppressors and susceptibility to interference. In some cases, the metal case of a stereo could be coupled to the Neutral by a small capacitor to bypass radio frequency interference. This will be coupled now to Hot instead. While not a safety hazard, you might feel an almost imperceptible tingle touching such a case.

Surge suppressors may or may not be affected (to the extent that they are ever effective in any case - unplugging the equipment including modem lines and the like during an electrical storm is really the only sure protection but that is another section). It depends on their design. Some handle the 3 wires in an identical manner and interchanging them makes no difference. Others deal differently with the Hot and Neutral in which case you may lose any protection you would otherwise have.

My advice: If you are handy electrically, correct them yourself. If not, get them corrected the next time you have an electrician in for any reason. It is a 5 minute job per outlet unless the wiring is extremely screwed up.

Use a properly wired outlet for your computer to be doubly sure.

It is not an emergency but I consider proper wiring to be very desirable.

Here is another example:

> "I was checking some outlets in my apartment. As I recall, the narrow prong should be hot, i.e., there should be 120 V between it and the wide prong or the ground prong. The wide prong should be neutral, i.e., it should show no voltage relative to the ground prong. Well, it appears that the Neutral and Hot wires are reversed in some outlets. In others, they are correct."

Well, there should be very little voltage although it may not be 0.

Reversed polarity outlets are not unusual even in new construction.

Reversed H and N is not usually dangerous as appliances must be designed so that no user accessible parts are connected to either H or N - even those with polarized plugs. Think of all the times people use such appliances in old unpolarized outlets or with unpolarized extensions cords. (There are exceptions like electric ranges where there may be no separate safety ground conductor but I assume you are talking about branch circuits, not permanently wired-in appliances.)

> "In still others, I get some voltage between ground and either the wide or narrow prong. Ack. Should I worry? Should I do more than worry?"

You should, of course, measure full line voltage between the H and G. The safety ground, G, does not normally carry any current but is at the same or nearly the same potential as N.

The voltage between G and (actual) N if quite low - a couple volts or less - is probably just due to the the voltage drop in the current carrying N wire. Turn off everything on this branch circuit and it should go away. However, there could also be a bad (high resistance connection) somewhere in the N circuit.

If the voltage reads high to either H or N - say, 50 volts - and you are measuring with a high impedance multimeter, this is probably just due to an open ground: a three prong outlet was installed without connecting the ground (in violation of Code unless on a GFCI) and this leakage is just due to inductive/capacitive pickup from other wires. See the section: Phantom voltage measurements of electrical wiring.

Full line voltage on the G conductor relative to an earth ground (like a copper cold water pipe) would represent a serious shock hazard to be corrected as soon as possible - the appliance or outlet should *not* be used until the repair is made. While unlikely, for anyone to screw up this badly, it could happen if someone connected the green or copper wire, or green screw to H instead of G.

In any case, it would be a good idea to correct the H-N reversals and determine if the voltage on the G is an actual problem.

Comments on whole house surge suppressors

These are typically offered your power company:

> "I have a surge suppressor that was put between my meter and the service panel. It's rented from my power company. The advertised product is part of a 'package' that includes plug in surge suppressors. The package price is $4.95/month. I didn't want the plug in suppressors so they said that it would be $2.75/month. Is this a good deal?"

(From: Kirk Kerekes (redgate@oklahoma.net).)

The power company just passes on the warranty of the manufacturer, which is, in turn, merely an insurance policy whose premium in included in the normal retail price of the unit. Basically, the power company is taking a product with a wholesale cost of about $30, and "renting" it to consumers for $40 to $100 a year.

Forever!

Nice work if you can get it.

Note that most homeowner and similar insurance policies *already* cover lightning damage, and that the policy from the surge protector is generally written to only apply to losses not already covered by other insurance. As a result, you are paying for insurance that you will likely *never* be able to make a claim against, even if the device is totally ineffective.

The simplest whole-house protection is to purchase an Intermatic whole house surge protector ($40 from Home Depot or Lowe's) and install it yourself (or pay an electrician to do so -- maybe 15 minutes of work). Then purchase inexpensive ($10 and under) plug-in surge protectors and surge-protected power strips and use them all over the house at sensitive equipment. Note that surge protectors and surge protected power strips protect the _other_ outlets in the house as well as the ones they contain (because the MOV's in inexpensive surge protectors are simply connected in parallel with the power line), so the more of that that you have plugged in, the more effectively protected your home is. Some power strips need to be turned "on" for the MOV's to be connected to the power lines.

You can also buy MOV's and add your own custom protection -- but if you don't already know that, you probably shouldn't be tinkering with such things.

Note that you should only purchase surge protectors that contain a monitor LED to tell you if the protector is still functioning -- MOV's deteriorate when zapped by large surges. This is one reason why I recommend the multiple-power-strip distributed-protection approach -- it is doubtful that all of your surge protectors/power strips will get zorched at once.

Electric tingles or shocks from plumbing

This it not what is meant by a stimulating shower. :-)

Needless to say, any sensation of electricity while using the water indicates a potentially very dangerous situation. (More so, apparently, for cows but that is another story!).

The most likely cause assuming you haven't actually wired the plumbing into the electrical system's Hot bus bar is some variation of bad or lack of connections of the electrical system's ground. What happens is that the unavoidable electrical leakage to the grounds of appliances and computer equipment with 3 prong plugs (from line filter capacitors and such) feeds into the grounding system of your house. If that is bonded to the actual earth ground via the plumbing supply system and that has a bad connection, you can get a voltage between the metal plumbing fixtures and the drain - which is pretty well grounded going into the earth. The reverse is also possible depending if there is plastic pipe at some point in your drain line.

While a tingle is unpleasant, an actual short in an appliance would be quite deadly where such a situation exists.

- Check the main means of grounding for your electrical system. There should be a grounding wire between the main service panel and the ground rod or metal supply pipe. Check the integrity of this and any jumpers that may be present including one bypassing the water meter (if applicable).

- Check for appliances and computer equipment that is grounded via the supply, waste, or radiator pipes (usually against NEC Code but still very commonly done by DIYers and even some electricians). This is especially risky if there is any plastic pipe in the feed or drain lines which isolates the metal pipes making them all one big shocking electrode and attempting to ground these devices is than worse than useless!

- Check for bad connections in the service panel(s) - particularly for the Neutral and Ground busbars. Make sure they are bonded together properly in the main service panel.

Of course, it is also possible to create a situation of electrically live pipes during renovation - by nailing a metal pipe bracket into an electrical wire without realizing it. However, this type of screwup usually takes some effort. :-)

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All About Wire and the AWG (American Wire Gauge) Numbers

Some types of wire

Note: For an understanding of the AWG numbers, you may want to first see the section: American Wire Gauge (AWG) table for annealed copper wire.

A semi-infinite variety of wire and cable is used in modern appliances, electronics, and construction. Here is a quick summary of the buzz words so you will have some idea of what your 12 year old is talking about!

- Solid wire: The current carrying conductor is a single solid piece of metal (usually copper. It may be bare, tinned (solder coated), silver plated, or something else.

  Solid wire may be used for general hookup inside appliances and electronics, and building (and higher power wiring) but not for cords that need to be flexible and flexed repeatedly.

- Stranded wire: The current carrying conductor consists of multiple strands of copper or tinned copper (though other metals may be found in some cases). The individual strands are NOT insulated from one-another. The wire gauge is determined by the total cross sectional area (which may be a bit greater than the specified AWG number due to discrete number of strands). See the section: What about stranded wire?.

  Stranded wire is used for general hookup, building wiring, etc. It is easier to position than solid wire (but tends not to stay put) and more robust when flexed repeatedly. Cordsets always use finely stranded wire but despite this, may develop problems due to flexing after long use.

- Magnet wire: This is a solid copper (or sometimes aluminum or silver) conductor insulated with a very thin layer of varnish or high-tech plastic. This coating must be removed either chemically, by heating in a flame, or fine sandpaper, before the wire can be connected to anything.

  Magnet wire is used where a large number of turns of wire must be packed as tightly as possible in a limited space - transformers, motors, relays, solenoids, etc.

  The very thin insulation is susceptible to nicks and other damage.

- Litz wire: This is similar to stranded wire EXCEPT that the strands are individually insulated from each other (like multiple pieces of magnet wire).

  Litz wire is used in high frequency transformers to reduce losses (including the skin effect which results in current only traveling near the surface of the wire - using multiple insulated strands increases its effective surface area).

Like magnet wire, the insulation needs to be removed from all strands before making connections.

- Tinsel wire: A very thin, metallic conductor is wound around a flexible cloth or plastic core.

  Tinsel wire is found in telephone and headphone cords since it can be made extremely flexible.

  Repair is difficult (but not impossible) since it very fine and the conductor must be unraveled from the core for soldering. The area of the repair must be carefully insulated and will be less robust than the rest of the cord.

- Shielded wire: An insulated central conductor is surrounded by a metal braid and/or foil shield.

  Shielded wire is used for low level audio and video, and other analog or digital signals where external interference needs to be minimized.

- Coaxial cable: This is similar to shielded wire but may be more robust and have a specified impedance for transmitting signals over long distances.

- Zip cord: This is 2 or 3 (or sometimes more) conductor cable where the plastic insulation is scored so that the individual wires can be easily separated for attachment to the plug or socket.

- 14/2, 12/3, etc.: These are the abbreviations used for building (electrical) wire like Romex (which is one name brand) and for round or zip-type cordsetwire. The conductor material is usually copper.

  Note: Some houses during the '50s and '60s were constructed with aluminum wiring which has since been found to result in significantly increased risk of fire and other problems. For more information, see the references listed in the section: Safe electrical wiring. However, aluminum wiring is safe if installed according to very specific guidelines (and is used extensively in power transmission and distribution - probably for your main connection to the utility - due to its light weight and low cost).

  The first number is the AWG wire gauge.

  The second number is the number of insulated conductors (excluding any bare safety ground if present). For example:

  - A 14/2 Romex cable has white and black insulated solid #14 AWG current carrying conductors and a bare safety ground (some older similar types of cable had no safety ground, however).

  - A 16/3 cordset has white, black and green insulated stranded #16 AWG wires (or, overseas, blue, brown, and green or green with yellow stripe).

So, where did AWG come from?

Nearly everyone who has done any sort of wiring probably knows that the AWG or American Wire Gauge number refers to the size of the wire somehow. But how?

(From: Frank (fwpe@hotcoco.infi.net).)

According to the 'Standard Handbook for Electrical Engineers' (Fink and Beaty) the 'gauge' you referenced to is 'American Wire Gauge' or AWG and also known as Brown & Sharp gauge.

According to above handbook, the AWG designation corresponds to the number of steps by which the wire is drawn. Say the 18 AWG is smaller than 10 AWG and is therefore drawn more times than the 10 AWG to obtain the smaller cross sectional area. The AWG numbers were not chosen arbitrary but follows a mathematical formulation devised by J. R. Brown in 1857!

For the marginally mathematically inclined

Each increase of 3 in the gauge halves the cross sectional area. Each reduction by 3 doubles it. So, 2 AWG 14 wires is like one AWG 11.

It seems that everyone has their own pet formula for this (though I prefer to just check the chart, below!).

(From: Tom Bruhns (tomb@lsid.hp.com).)

As I understand it, AWG is defined to be a geometric progression with AWG 0000 defined to be 460 mils diameter and 36 gauge defined to be 5.000 mils diameter. This leads directly to the formula:

```
Diameter(mils) = 5 * 92^((36-AWG)/39)
```

That is, 460 mils is 92 times 5 mils, and the exponent accounts for 39 steps of AWG number starting at 36 gauge.

(From: David Knaack (dknaack@rdtech.com).)

You can get a fairly accurate wire diameter by using the equation:

```
Diameter(inches) = 0.3252 * e^(-0.116 * AWG)
```

where 'e' is the base of the natural logarithms, 2.728182....

I don't know where it came from, but it is handy (more so if you can do natural base exponentials in your head).

In its simplest form, the cross sectional area is:

```
A(circular mils) = 2^((50 - AWG) / 3)
```

Here's a Web site that has a program to calculate most of the useful specifications based on the AWG number, diameter, or cross-sectional area:

- Mogami Wire Gauge Calculator.

They also have a bunch of other useful CAD programs at:

- Mogami Wire and Cable Related CAD Programs.

American Wire Gauge (AWG) table for annealed copper wire

(Similar tables exist for other types of wire, e.g., aluminum.)

(Table provided by: Peter Boniewicz (peterbon@mail.atr.bydgoszcz.pl).)

Wire Table for AWG 0000 to 40, with diam in mils, circular mils, square microinches, ohms per foot, ft per lb, etc.

AWG gauge	Dia in mils	Circ. Mils	Square MicroIn	Ohms per 1000 ft	lbs per 1000 ft	Feet/ Pound	Feet/ Ohm	Ohms/ Pound
0000	460.0	211600	166200	0.04901	640.5	1.561	20400	0.00007652
000	409.6	167800	131800	0.06180	507.9	1.968	16180	0.0001217
00	364.8	133100	104500	0.07793	402.8	2.482	12830	0.0001935
0	324.9	105500	82890	0.09827	319.5	3.130	10180	0.0003076
1	289.3	83690	65730	0.1239	253.3	3.947	8070	0.0004891
2	257.6	66370	52130	0.1563	200.9	4.977	6400	0.0007778
3	229.4	52640	41340	0.1970	159.3	6.276	5075	0.001237
4	204.3	41740	32780	0.2485	126.4	7.914	4025	0.001966
5	181.9	33100	26000	0.3133	100.2	9.980	3192	0.003127
6	162.0	26250	20620	0.3951	79.46	12.58	2531	0.004972
7	144.3	20820	16350	0.4982	63.02	15.87	2007	0.007905
8	128.5	16510	12970	0.6282	49.98	20.01	1592	0.01257
9	114.4	13090	10280	0.7921	39.63	25.23	1262	0.01999
10	101.9	10380	8155	0.9989	31.43	31.82	1001	0.03178
11	90.74	8234	6467	1.260	24.92	40.12	794	0.05053
12	80.81	6530	5129	1.588	19.77	50.59	629.6	0.08035
13	71.96	5178	4067	2.003	15.68	63.80	499.3	0.1278
14	64.08	4107	3225	2.525	12.43	80.44	396.0	0.2032
15	57.07	3257	2558	3.184	9.858	101.4	314.0	0.3230
16	50.82	2583	2028	4.016	7.818	127.9	249.0	0.5136
17	45.26	2048	1609	5.064	6.200	161.3	197.5	0.8167
18	40.30	1624	1276	6.385	4.917	203.4	156.6	1.299
19	35.89	1288	1012	8.051	3.899	256.5	124.2	2.065
20	31.96	1022	802.3	10.15	3.092	323.4	98.50	3.283
21	28.46	810.1	636.3	12.80	2.452	407.8	78.11	5.221
22	25.35	642.4	504.6	16.14	1.945	514.2	61.95	8.301
23	22.57	509.5	400.2	20.36	1.542	648.4	49.13	13.20
24	20.10	404.0	317.3	25.67	1.223	817.7	38.96	20.99
25	17.90	320.4	251.7	32.37	0.9699	1031.0	30.90	33.37
26	15.94	254.1	199.6	40.81	0.7692	1300	24.50	53.06

27	14.20	201.5	158.3	51.47	0.6100	1639	19.43	84.37
28	12.64	159.8	125.5	64.90	0.4837	2067	15.41	134.2
29	11.26	126.7	99.53	81.83	0.3836	2607	12.22	213.3
30	10.03	100.5	78.94	103.2	0.3042	3287	9.691	339.2
31	8.928	79.70	62.60	130.1	0.2413	4145	7.685	539.3
32	7.950	63.21	49.64	164.1	0.1913	5227	6.095	857.6
33	7.080	50.13	39.37	206.9	0.1517	6591	4.833	1364
34	6.305	39.75	31.22	260.9	0.1203	8310	3.833	2168
35	5.615	31.52	24.76	329.0	0.09542	10480	3.040	3448
36	5.000	25.00	19.64	414.8	0.07568	13210	2.411	5482
37	4.453	19.83	15.57	523.1	0.06001	16660	1.912	8717
38	3.965	15.72	12.35	659.6	0.04759	21010	1.516	13860
39	3.531	12.47	9.793	831.8	0.03774	26500	1.202	22040
40	3.145	9.888	7.766	1049.0	0.02993	33410	0.9534	35040
41	2.808	7.860	6.175	1319	0.02379	42020	0.758	55440
42	2.500	6.235	4.896	1663	0.01887	53000	0.601	88160
43	2.226	4.944	3.883	2098	0.01497	66820	0.476	140160
44	1.982	3.903	3.087	2638	0.01189	84040	0.379	221760
45	1.766	3.117	2.448	3326	0.00943	106000	0.300	352640
46	1.572	2.472	1.841	4196	0.00748	133640	0.238	560640

Note: Values for AWG #41 to #46 extrapolated from AWG #35 to #40 based on wire gauge formula.

Ohms per 1000 ft, ft per Ohm, Ohms per lb, all taken at 20 degC (68 degF). Sizes assume bare wire - insulation is extra. For hookup and similar wire, this is easy to determine. For magnet wire, the additional diameter will be a fraction of mil (0.001 inch) up to several mils depending on the wire gauge and type. When in doubt, use a micrometer to compare the original wire and the wire with insulation removed using a non-mechanical (e.g., chemical) stripper.

Apparently, you can buy wire down (up?) to size #60 - less than .000350 inches in diameter! Check out MWS Wire Industries if you are really curious about fine wire.)

What about stranded wire?

(From: Calvin Henry-Cotnam (cal@cate.ryerson.ca).)

In addition to the cross-section area, there are a few other factors. First off, a stranded wire effectively has more surface area than a solid wire of the same gauge, but much of this surface is "inside" the wire.

I checked out the label of a spool of #18 stranded wire and found it was comprised of 16 strands of #30 wire. Given the info above that each reduction of 3 in the gauge, then #18 has a cross-section area that is 16 times greater than #30 -- so it *appears* to translate exactly.

Looking through a catalog for wire, I found that this more-or-less holds true, though the occasional wire might have an extra strand or two. Here is what I quickly found -- there are many more, but this is a sample:

```
 Overall gauge      Typical stranded wires made up of:
--------------------------------------------------------------
    #32                  7 x #40
    #30                  7 x #38
    #28                  7 x #36
    #26                  7 x #34
    #24                  7 x #32    19 x #36
    #22                  7 x #30    19 x #34
    #20                  7 x #28    10 x #30    19 x #32
    #18                 16 x #30
    #16                 19 x #29    26 x #30
    #14                 41 x #30
    #12                 65 x #30
    #10                 65 x #28
     #8                 84 x #27
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Items of Interest

Editor's note: Not all of these actually apply to small appliances but may be of use nonetheless.

Determining electricity usage

So, where does all the electricity (or money, same thing) go?

You could put a watt-hour meter on every appliance in your house but that is probably not needed to estimate the expected electricity usage.

Check the nameplate on heating appliances or those with large motors. They will give the wattage. Multiple these by hours used and the result is W-hours (or kW-hours) worst case. Appliances that cycle like refrigerators and space heaters with thermostats will actually use less than this, however.

Multiple light bulb wattages by hours used to get the W-hours for them.

Things like radios, clocks, small stereos, etc., are insignificant.

Add up all the numbers :-).

It would be unusual for an appliance to suddenly increase significantly in its use of electricity though this could happen if, for example, the door on a freezer or refrigerator is left ajar or has a deteriorated seal.

How your electric (kW-hour) meter works

While there have been a variety of technologies used to measure the amount of electric power used by residential and industrial customers, the most common is probably the one that uses a rotating aluminum disk to operate a clockwork mechanism with a visible readout in kW-hours.

The implementation is quite clever - and often misunderstood. This type of meter is designed to read true power (for residential customers, at least) and operates as follows:

There is both a current electromagnet (which passes the user load current) and a voltage electromagnet (connected across the AC line). The pole pieces of these electromagnets are mounted in close proximity to the aluminum disk and close to one-another. When the voltage and current are in phase, their magnetic fields are roughly 90 degrees out of phase. Why? Because the load current is in-phase with the AC voltage but the current in the voltage electromagnet lags by 90 degrees since its winding acts like an inductor.

This results in a net torque on the disc which is proportional to voltage times current. The disk acts like the rotor of an induction motor and rotates, operating the dials. A permanent magnet also acts on the disk and acts to limit the rotation due to induced eddy-currents - its restraining force is proportional to speed. Rotation rate is therefore proportional to the instantaneous power being consumed with a direct readout in kW-hours.

Where reactive power is involved and the voltage and current are out of phase, the peak current will be higher (for the same real power) but the phase angle will change resulting in reduced torque. These effects will tend to cancel so the rotation rate will be essentially unchanged. Therefore, adding capacitors or inductors to change the power factor in a house or apartment (either to legitimately improve power factor or to cheat the power company) will have little effect on the measured power usage. Note: Power factor is equal to: cos(phase angle between voltage and current).

That's why it is called a kW-hour meter and not a VA-hour meter :-).

(Note that large industrial customers ARE charged for reactive power since that extra current DOES stress generating and transmission facilities thus requiring excess capacity so this does not apply in that case.)

It is quite possible that under extremely low power factor conditions, accuracy may be compromised due to friction and materials non-linearities but over the range of power factors generally encountered, these should be quite accurate.

Taking equipment overseas (or vice-versa)

When does it make sense to take an appliance or piece of electronic equipment to a country where the electric power and possibly other standards differ?

For anything other than a simple heating appliance (see below) that uses a lot of power, my advise would be to sell them and buy new when you get there. For example, to power a microwave oven would require a 2kVA step down (U.S. to Europe) transformer. This would weigh about 50 pounds and likely cost almost as much as a new oven.

There are several considerations:

1. AC voltage - in the U.S. this is nominally 115 VAC but in actuality may vary from around 110 to 125 VAC depending on where you are located. Many European countries use 220 VAC while voltages as low as 90 or 100 VAC or as high as 240 VAC (or higher?) are found elsewhere.

2. Power line frequency - in the U.S. this is 60 Hz. The accuracy, particularly over the long term, is excellent (actually, for all intents and purposes, perfect) - better than most quartz clocks. In many foreign countries, 50 Hz power is used. However, the stability of foreign power is a lot less assured.

3. TV standards - The NTSC 525L/60F system is used in the U.S. but other countries use various versions of PAL, SECAM, and even NTSC. PAL with 625L/50F is common in many European countries.

4. FM (and other) radio station channel frequencies and other broadcast parameters differ.

5. Phone line connectors and other aspects of telephone equipment may differ (not to mention reliability in general but that is another issue).

6. Of course, all the plugs are different and every country seems to think that their design is best.

For example, going to a country with 220 VAC 50 Hz power from the U.S.:

For electronic equipment like CD players and such, you will need a small step down transformer and then the only consideration power-wise is the frequency. In most cases the equipment should be fine - the power transformers will be running a little closer to saturation but it is likely they are designed with enough margin to handle this. Not too much electronic equipment uses the line frequency as a reference for anything anymore (i.e., cassette deck motors are DC).

Of course, your line operated clock will run slow, the radio stations are tuned to different frequencies, TV is incompatible, phone equipment may have problems, etc.

Some equipment like PCs and monitors may have jumpers or have universal autoselecting power supplies - you would have to check your equipment or with the manufacturer(s). Laptop computer, portable printer, and camcorder AC adapter/chargers are often of this type. They are switching power supplies that will automatically run on anywhere from 90-240 VAC, 50-400 Hz (and probably DC as well).

Warning: those inexpensive power converters sold for international travel that weigh almost nothing and claim to handle over a kilowatt are not intended and will not work with (meaning they will damage or destroy) many electronic devices. They use diodes and/or thyristors and do not cut the voltage in half, only the heating effect. The peak voltage may still approach that for 220 VAC resulting in way too much voltage on the input and nasty problems with transformer core saturation. For a waffle iron they may be ok but not a microwave oven or stereo system. I also have serious doubts about their overall long term reliability and fire safety aspects of these inexpensive devices..

For small low power appliances, a compact 50 W transformer will work fine but would be rather inconvenient to move from appliance to appliance or outlet to outlet. Where an AC adapter is used, 220 V versions are probably available to power the appliance directly.

As noted, the transformer required for a high power heating appliance is likely to cost more than the appliance so unless one of the inexpensive converters (see above) is used, this may not pay.

Note that if you plan to be moving between countries with different standards, it may pay to invest in appliances specifically designed for multisystem operation. However, there are all sorts of definitions of 'multisystem' - not all will handle what you need so the specifications must be checked carefully and even then, marketing departments sometimes get in the way of truth in advertising!

For additional information, see the document: International Power and Standards Conversion.

Controlling an inductive load with a triac

Thyristor based controllers need to be designed with inductive loads in mind or else they may not work correctly or may be damaged when used to control a motor or even a transformer or large relay.

There are a couple of issues:

1. Will it switch correctly? Assuming it uses a Triac to do the switching, the inductive nature of the load may prevent the current from ever turning off. Once it goes on the first time, it stays on.

2. Inductive kickback. Inductive loads do not like to be switched off suddenly and generate a voltage spike as a result of the rapid change in current. This may damage the Triac resulting the load staying on through the next millennium.

3. Heating. Due to the inductive load, this will be slightly greater for the switch but I wouldn't expect it to be a major issue. However, some derating would be advised. Don't try to switch a load anywhere near the rated maximum for a resistive load.

Where feasible, adding a light bulb in parallel with the load will decrease the effect of the inductance. There is no way of knowing whether it will be effective without analyzing the design or trying it.

Using a relay controlled by the Triac to then switch the inductive load may work but keep in mind that a relay coil is also an inductive load - a much smaller one to be sure - but nonetheless, not totally immune to these effects.

Dan's notes on low voltage outdoor lighting

(From: Dan Hicks (danhicks@millcomm.com).)

Most major brands of 12V lights are "sort of" interchangeable. (Occasionally you have trouble getting the wire from one brand to connect with the fixtures of another brand, but with a little fudging it can usually be done.) So look for the brand/model that gives you most of the lights you want in the styles you want, then augment with add-ons from other brands. Be aware of the current limit of transformers, though -- some kits have small transformers not sized for add-ons, while others have quite a bit of excess capacity. I've got a (mostly) Toro system I'm semi-satisfied with, though the built-in photocell system has failed twice. (I'm going to install a separate photocell & timer and just set the transformer to "On".)

Effects of brownouts and blackouts on electronic equipment and appliances

Brownouts down to 100 V, maybe even 90 volts should not affect electronic equipment. It is possible that there is a no-man's land in between 0 and 90 volts (just an estimate) where strange things may happen. Whether this will cause permanent damage I cannot say. The surge, spikes, and overvoltage possibly associated with repeated brownouts or blackouts can damage electronics, however.

Induction motors - the type in most large appliances - will run hotter and may be more prone to failure at reduced line voltage. This is because they are essentially constant speed motors and for a fixed load, constant power input. Decrease the voltage and the current will increase to compensate resulting in increased heating. Similar problems occur with electronic equipment using switching power supplies including TVs, some VCRs, PCs and many peripherals. At reduced line voltage, failure is quite possible. If possible, this type of equipment should not be used during brownout periods.

Grounding of computer equipment

While electronic equipment with 3 prong plugs will generally operate properly without an earth ground (you know, using those 3-2 prong adapters without attaching the ground wire/lug), there are 3 reasons why this is a bad idea:

1. Safety. The metal cases of computer equipment should be grounded so that it will trip a breaker or GFCI should an internal power supply short occur.

   The result can be a serious risk of shock that will go undetected until the wrong set of circumstances occur.

2. Line noise suppression. There are RLC filters in the power supplies of computer and peripheral equipment which bypass power supply noise to ground. Without a proper ground, these are largely ineffective.

   The result may be an increased number of crashes and lockups or just plain erratic weird behavior.

3. Effectiveness of surge suppressors. There are surge suppression components inside PC power supplies and surge suppression outlet strips. Without a proper ground, H-G and N-G surge protection devices are not effective.

   The result may be increased hard failures due to line spikes and overvoltage events.

Removing gummed labels (or other dried or sticky gunk)

My order of attack: water, alcohol, WD40, Windex, then stronger stuff like ammonia, acetone, degreaser, flux-off, carburetor cleaner, lacquer thinner, gasoline. WARNING: most of these are flammable and harmful to your health - use only in a well ventilated areas away from open flames. Test that they are safe for plastics and painted surfaces by trying some in an inconspicuous location first.

(From: Paul Grohe (grohe@galaxy.nsc.com).)

I use "Desolv-it", one of those citrus oil (orange) based grease and "get's-the-kids-gum-out-of-your-carpet" cleaners (These are usually touted as "environmentally friendly" or "natural" cleaners).

Spray it right on the label and let it soak into the paper for a minute or two, then the sticker slips right off (it also seems to do well on tobacco and kitchen grease residue).

The only problem is you have to remove the oily residue left by it. I just use Windex (a window cleaner) to remove the residue, as I usually have to clean the rest of the unit anyways.

(From: Bob Parnass, AJ9S (parnass@radioman.ih.att.com).)

I spray the label with WD40 and let it soak in for several minutes. This usually dissolves the glue without damaging the paint and I can remove the label using my fingernail.

Preventing radio frequency interference from whacking out appliances

This probably applies to many of the new high tech appliances including touch lamps, smart irons and coffeemakers, etc.

(From: James Leahy (jleahy@norwich.net).)

My lamps were flashing each time I transmitted on 2 meters. HF transmissions don't seem to cause any trouble. (that just knocks the neighbor's TV out, har de har). Believe it or not, a simple snap-on toroidal choke with the lamp cord wrapped as many turns possible near the plug end cured it. Didn't want to bother with the several type of filter circuits one could build to fix the problem. It may be a simple fix for others with similar 2-way interference problems. One can get these chokes at Radio Shack among other sources.

Yard lights cycling and maintenance humor

(From: John Rowe (johnrowe@lightresource.com).)

The new maintenance man at one of our customers, a rather large apartment complex in Minneapolis, had purchased from us a case of 200 watt incandescents. He returned to our office about a week later with the lamps, complaining that they 'flashed' and that the residents were really upset that these lights (used outside) were not letting them sleep.

Under the 'customer is right' rule, I replaced them immediately, no questions asked. Of course I tested the 'bad' ones and found no defects.

When he returned with the new batch and the same complaint, he was really upset, because the residents were now complaining to the management company (his employer) about the situation.

I sat him down and asked him about the application. He explained that they were being used in 16" white poly pole lights, along all the footpaths around the complex.

I asked how they were switched, and he replied that they used to be on timers but that after complaints that the lights were on during the daylight hours, he had purchased, from his local hardware store, screw-in photocells. The type into which the bulb screws. These were then, inside the globes with the bulbs.

Of course the reflection within the poly globe was enough to prompt the photocell to switch the circuit off and cycle the lights all night.

It took him a minute or two to comprehend his error. I was able to recommend an electrician to install more appropriate photocells. He remained a good customer for several more years after this incident.

My amusement comes from the picture I have in my mind of the residents of this rather up-scale apartment complex looking out of their windows to see all the walkway security lights going on and off all night, and wondering what the heck was going on! I imagine it was quite a sight.

Will a hard-wired appliance save energy over a plugged in variety?

The resistance of the connection may be slightly lower - .05 versus .1 ohm, for example. Other than the reduced amount of power lost in this wiring, there is otherwise no functional difference.

With fancy expensive test equipment you might be able to detect it but not in normal use. The savings of a hard wired appliance would be quite small even for a high wattage device like a space heater.

However, the hard wired connection will be more reliable and should not deteriorate over time whereas a plug and outlet can corrode and the spring force decreases with multiple plugins and outs. The added resistance will increase the losses. So, in this regard, directly connecting the device into the house wiring is better.

Note that if the cord and/or plug gets hot in use, this is a loss (though for a space heater, the heat is just coming from the cord/plug instead of the elements inside) - and a possible fire hazard as well and should be checked out. Sometimes, all it takes to remedy such a problem is to expand the metal strips of the prongs of the plug so it makes better contact.

A short history of heat

(From: Bill (bill394@juno.com).)

In the beginning we had but rocks and wood, not an efficient safe or practical way to heat your home. This system was refined and did do a fair job, as long as you didn't mind cold spots or care about your safety.

Then we got more creative and used coal and then oil. Oil was a far safer and a better controlled system. Then came gas now that's the fuel, the fuel of choice for most. It's also the one we are here to explain.

The older systems were really very simple. You had a small pilot light which was always on. No safety, it just was lit, and we hoped it stayed lit. When the thermostat called for heat we opened a solenoid (electric valve) and allowed gas to flow in and hopefully get lit by the pilot light. If the pilot had gone out the theory was that the majority of the gas would go up the chimney and vent to the outside. This simple system, used for years did a fair job. It lacked many features we take for granted today.

With the coming of more technology people started thinking more of safety and expected more from there equipment. A device commonly known as a thermocouple was a great start in the direction of safety. It is a union of dissimilar metals that when heated generates electricity. Now we had a way to stop gas flow if our pilot went out. By putting a solenoid in the pilot gas line we could use a thermocouple to keep it powered open by the heat of the pilot. Thus if our pilot went out the thermocouple would cool and stop producing power to hold the solenoid open, gas flow would be interrupted. Power from this control was also required prior to the main valve opening, this making uncontrolled gas flows a thing of the past.

With the coming of the R.E.A. (Rural Electric Authority) power to every home became a reality. We now could introduce a new concept, blowers. The fan motor made forced air heat a reality. Now even the most distant room could be heated and even temperatures became a real happening.

The addition of electricity allowed for the addition of safety controls which resulted in greatly reducing the fiscal size of a furnace. We now had the means to control running temperatures using the fan - turning it on and off by the temperature and the on and off valve of the fire. Should by chance the fan not start, the furnace would over heat and a high temperature switch would turn the fire off. No melt down! very safe.

We all know that something simple that works well can't be left alone. Man just has to make it more labor complex. Soon came the addition of some actually neat ideas. First being the addition of humidity, in cold climates a must, that also lowers your heat bill. The ability to run the fan just to stir air, not add heat or cool. Then the electronic air cleaner. This one if you have allergy is a must. I don't have one so can't tell if it is on or off. BUT my son can tell in a matter of hours if its off.

And let's not forget the best of all air conditioning! In my world a must. All of these additions were working steps towards our modern furnace.

The older burners were called ribbon (they sat in the combustion chamber) and did a good job until we started going for higher efficiency. Then a major problem arrived, with colder heat exchangers came condensation. This caused the mild steel burners to rust and the size of the openings to get smaller, making for a poor air to fuel ratio and just a terrible dirty burn, lots of soot. The good news is stainless steel burners did solve this, how ever it's an expensive fix.

Now remember what we said about something that worked? You got it! new style burners, not all bad though. With the high efficiency furnaces comes a colder stack temperature (fumes to chimney). They are cold enough that they possibly would not raise without a little help. So a venter (blower) motor is used to draw the fumes out of the heat exchanger and up the chimney. This made possible a new style burner. It is in reality a far better burner then the previous style. We call it, in shot. This burner is self adjusting for it's air mixture and is positioned out side of the heat exchanger. It is more like the fire from a torch. The fire is now sucked in to the heat exchanger by the draft of the venter. keep in mind the burner sits out in mid air. In most modern furnaces the heat exchanger is basically a piece of pipe with a burner on one end and a venter on the other.

Knowing that good things get better, next we worked over the controls. Rather then using temperature to turn on the fan we use a solid state timer. This controls all fan functions. Remember the pilot light? It's gone. We now use either a hot surface igniter or if your lucky a spark. The hot surface is much like the filament of a light bulb. It upon demand gets very hot and is used as the source for ignition, unfortunately like a light bulb it burns out. Again remember the thermal couple? Yes it to is gone. We now use a micro processor and electronically sense if the fire is lit.

On most modern furnaces the sequence of operation is as follows:

1. The thermostat call for heat. It starts only the venter.

2. The venter comes to speed and if the chimney is not blocked and intake air is present it will draw a vacuum on the heat exchanger. This is sensed by a vacuum switch, it now will turn on our timer.

3. The timer lets the ignition come on and after a delay the gas valve opens and if all is well we finally get FIRE!

4. A rod in the fire passes an extremely small current through the fire to ground. If the microprocessor accepts the signal the fire will remain on.

5. Our timer will soon turn on the blower.

When the thermostat no longer calls for heat:

Venter stops. Vacuum is lost. Fire is turned off. Blower will run till timer tells it to stop. You still have the old style over temperature switches. All of this has made new furnaces extremely small, efficient and safe. Do they require more maintenance? YES. If someone tells you different, they tell less then the truth! But I will gladly pay the cost to have my family safe and comfortable.

About those automatic toilets

I bet you will probably never have to repair one of these but I also bet that you were curious as to how they work. :) In addition to what is said below, I should add that only the initial push to open or close the valve comes from the solenoid. Most of thw work is done by a clever hydraulic amplifier which uses water pressure as the power source.

(From: Hauser Christoph (chhauser@bluewin.ch).)

The automatic toilets are active infrared devices. This means, you have a IR transmitter and an IR receiver basically. More sophisticated systems use more emitters and receivers or a PSD to get a triangulation. Some systems are battery-operated with lithium 2CR5, CR-P2 or simply with four AA-cells.

Usually, the infrared system is activated every second up to every 4 seconds. If the receiver sees a response, the sampling is higher. There also several time delays included. The systems detects persons or objects in the range of 10 to 100 cm (4 to 40").

The valve for the flush is a bistable solenoid device. With a short pulse you open the valve and with another and opposite polarity you close it. It's possible to reach about 200,000 flushes with batteries and a life-cycle of 4 years. Often PIC's (Programmable Interface Controllers - one chip micros) are used, because they have a low stand-by consumption.

You wonder, why I know this? It's my job to develop these devices!

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Service Information

Wiring diagrams

Many larger appliances like washing machines and microwave ovens have a wiring diagram or connection diagram pasted inside the cover. However, this is rare for small appliances.

In most cases, wiring is trivial and five minutes with your Mark I Eyeball(s) and a pencil and paper (remember those? If not, use your PC and a schematic capture software package) will result a complete schematic. There may still be some uncertainties with respect to motor, transformer, or switch wiring but testing with an ohmmeter or continuity checker should eventually prevail.

Removing screw with stripped head

Even if a Phillips head screw head is severely damaged, it is sometimes possible to free it just by applying enough pressure while turning with a properly shaped screwdriver. This can only be attempted if it is possible to press hard without risk of breaking or damaging anything.

Other more drastic measures:

1. Drill it out - the same way you would remove a rivet - with a sharp twist drill bit on slow speed. If necessary, use a metal or plastic sleeve to guide the drill bit.

2. Use a Dremel tool with a disk cutter or fine hacksaw blade to cut a slot in the head and then use a straight blade screwdriver to remove it.

3. Take a pair of sharp diagonal cutters and grip between the center and one edge or the entire head. Or, grab the head with a pair of miniature locking pliers (Vice-Grips(tm).)

4. Drill a hole in the head and use a screw extractor (E-Zout(tm).)

Take care to avoid excessive mechanical shock to delicate equipment and avoid allowing metal particles to fall into the interior of the appliance.

Fil's tips on improvised parts repair

(From: Filip "I'll buy a vowel" Gieszczykiewicz (filipg@repairfaq.org).)

Whenever I'm stuck with some "Unprofitable" with a broken part, I see if I can duplicate the functionality of the part. My raw materials include:

- 5 minute 2-part epoxy (under $8 from a RC hobby store).
- 30 minute 2-part epoxy (under $8 from a RC hobby store).
- Wire: copper, steel, SS, "piano", spring, etc.
- Springs (a box of 1000s from hamfests, stripped monsters).
- Plastic stock: all types (you will learn which glue well).
- Plastic build up kit: two parts - foul smelling polymer and "dust".
- Aluminum stock: from thin foil to .080" to .5".
- Brain: regular edition. :-)

As long as you know what the part does (you need not HAVE it... as long as you can see where it goes in, what it moves, what activates it, etc).

If it's something intricate, my parts bin door is NEVER closed.. and it gives it's "body" to science :-)

If you have part of the old plastic lever, it's usually easy to build up the broken off part. I like to heat up a segment of piano wire and insert it into the remaining part in such a way as to hit the most "meat" of the part. Then, using either epoxy or plastic build up material, I form something that does the job.

Overall, I have about a 75% "plastic broken part" repair ratio. After a while, you will be able to judge if it's doable. "lever"s are usually easy... sliding assemblies are a pain in the @ss...

Fixing stripped plastic threaded holes

(From: Gordon S. Hlavenka (cgordon@worldnet.att.net).)

Simply set the screw on top of the hole, and press LIGHTLY on it with the tip of your soldering iron. The iron will heat the screw, which then slides into the post. After everything cools, you can take the screw out normally and the threads are as good as new! If the post is badly stripped, you may want to stuff the hole with extra plastic shaved from some non-critical area to provide additional material.

You have to be careful not to overheat, or push too hard. But it works very well.

Interchangeability of components

The question often arises: If I cannot obtain an exact replacement or if I have another appliance carcass gathering dust, or I just have some extra parts left over from a previous project, can I substitute a part that is not a precise match? Sometimes, this is simply desired to confirm a diagnosis and avoid the risk of ordering an expensive replacement and/or having to wait until it arrives.

For safety related items, the answer is generally NO - an exact replacement part is needed to maintain the specifications within acceptable limits with respect to line isolation (shock prevention) and to minimize fire hazards. However, these components are not very common in small appliances.

For other components, whether a not quite identical substitute will work reliably or at all depends on many factors. Some designs are so carefully optimized for a particular part's specifications that an identical replacement is the way to return performance to factory new levels. With appliances in particular, may parts which perform common functions - like thermostats - utilize custom mounting arrangements which precluded easy substitution even if the electrical and thermal characteristics are an exact match.

Here are some guidelines:

1. Fuses - exact same current rating and at least equal voltage rating. I have often soldered a normal 3AG size fuse onto a smaller blown 20 mm long fuse as a substitute. Also, they should be the same type - slow blow only if originally specified. A fuse with a faster response time may be used but it may blow when no faults actually exist.

2. Thermal fuses and thermal cutouts - exact same temperature and current rating (if stated). Physical size may also be important when these are buried in motor or transformer windings. Also see the document: Notes on the Troubleshooting and Repair of AC Adapters, Power Supplies, and Battery Packs.

3. Thermostats - temperature range must be compatible (or slightly wider may be acceptable). Electrical current and voltage ratings must meet or exceed original. With some devices, hysteresis - the tendency of a thermostat that has switched to stay that way until the temperature changes by a few degrees - may be an issue. For example, electric heaters use a thermostat which has a typical hysteresis of 3-5 degrees F. However, heating appliances like waffle irons and slow cookers may depend on the thermal mass of the castings and use a thermostat with very little hysteresis.

4. Resistors, capacitors, inductors, diodes, switches, trimpots, lamps and LEDs, and other common parts - except for those specifically marked as safety-critical - substitution as long as the replacement part fits and specifications are met should be fine.

5. Rectifiers - use types of equal or greater current and PRV ratings. A bad bridge rectifier can be replaced with 4 individual diodes. However, high efficiency and/or fast recovery types are used in parts of electronic ballasts and other switching power supplies.

6. Transistors and thyristors (except power supply choppers) - substitutes will generally work as long as their specifications meet or exceed those of the original. For testing, it is usually ok to use types that do not quite meet all of these as long as the breakdown voltage and maximum current specifications are not exceeded. However, performance may not be quite as good. For power types, make sure to use a heatsink.

7. Motors - small PM motors may often be substituted if they fit physically. Make sure you install for the correct direction of rotation (determined by polarity). For universal and induction motors, substitution may be possible but power input, speed, horsepower, direction of rotation, and mounting need to be compatible.

8. Sensor switches - some of these are common types but many seem to be uniquely designed for each appliance.

9. Power transformers - in some cases, these may be sufficiently similar that a substitute will work. However, make sure you test for compatible output voltages to avoid damage to the regulator(s) and rest of the circuitry. Transformer current ratings as well as the current requirements of the equipment are often unknown, however.

10. Belts or other rubber parts - a close match may be good enough at least to confirm a problem or to use until the replacements arrives.

11. Mechanical parts like screws, flat and split washers, C- and E-clips, and springs - these can often be salvaged from another unit.

The following are usually custom parts and substitution of something from your junk box is unlikely to be successful even for testing: SMPS (power supply) transformers, microcontrollers, other custom programmed chips, display modules, and entire power supplies unless identical.

Appliance repair books

Your local large public or university library should have a variety of books on appliance repair and general troubleshooting techniques.

Here are a few titles for both small and large appliance repair:

1. Chilton's Guide to Small Appliance Repair and Maintenance
   Gene B. Williams
   Chilton Book Company, 1986
   Radnor, PA 19089
   ISBN 0-8019-7718-5

2. Chilton's Guide to Large Appliance Repair and Maintenance
   Gene B. Williams
   Chilton Book Company, 1986
   Radnor, PA 19089

ISBN 0-8019-7687-1

3. Major Appliances, Operation, Maintenance, Troubleshooting and Repair
Billy C. Langley
Regents/Prentice Hall, A Division of Simon and Schuster, 1993
Englewood Cliffs, NJ 07632
ISBN 0-13-544834-4

4. Major Home Appliances, A Common Sense Repair Manual
Darell L. Rains
TAB Books, Inc., 1987
Blue Ridge Summit, PA 17214
ISBN 0-8306-0747-1 (Paperback: ISBN 0-8306-0747-2)

5. Home Appliance Servicing
Edwin P. Anderson
Theodore Audel & Co., A Division of Howard W. SAMS & Company, Inc., 1969
2647 Waterfront Parkway, East Drive
Indianapolis, IN 46214
Telephone: 1-800-428-7267

6. Handbook of Small Appliance Troubleshooting and Repair
David L. Heisserman
Prentice-Hall, Inc. 1974
Englewood Cliffs, NJ 07632
ISBN 0-13-381749-0

7. Fix It Yourself - Power Tools and Equipment
Time-Life Books, Alexandria, VA
ISBN 0-8094-6268-0, ISBN 0-8094-6269-9 (lib. bdg.)

8. Readers Digest Fix-It-Yourself Manual
The Readers Digest Association, 1996
Pleasantville, New York/Montreal
ISBN 0-89577-871-8

Overall, this is an excellent book which I would not hesitate to recommend as long as one understands its shortcomings. The coverage of both small and large appliances, tools, and common yard equipment, as well as a variety of other categories of household repair (furniture, plumbing, etc.) is quite comprehensive.

It is very well illustrated with hundreds upon hundreds of easy to understand exploded diagrams. In fact, that is probably its most significant feature. Where the equipment is similar to yours, it is possible to use the pictures almost exclusively for understanding its construction, operation, and disassembly/reassembly procedures.

The discussion of each type of more complex equipment provides one or more troubleshooting charts. Each entry includes the level of difficulty and identifies any needed test equipment (e.g., multimeter) for dealing with that problem or repair.

However, this book is at best an introduction and once-over. Much of the material is presented based on one or two models of a particular type of devices while sort of implying that all the rest are similar. In all fairness, very often this is sufficient as most models of simpler differ only in details. However, for all but the most general repairs on the more complex appliances, a book with more specific information would be highly desirable before actually tackling the repair.

One significant shortcoming is that there are NO wiring diagrams of any kind for any of the appliances. Their approach seens to be to just check parts for failure. While this will be successful in many cases. a wiring diagram would be useful when explaining appliance operation and would help in logical troubleshooting to localize the problem.

Although there is a chapter on home electronics - audio, video, computer, security systems, etc. - don't expect anything useful beyond very general information and simple repairs like replacing belts and looking for bad connections. While it isn't surprising that the treatment of this complex equipment is superficial at best in a book of this type, in some cases it is as though the editing was based on a page limit rather than including a more complete summary but with fewer details. For example, the only repair on a CD player beyond belts and lens cleaning is to test and replace the tray loading motor (one particular model). Unfortunately, some of the specific information is not entirely accurate either and may be misleading and expensive. The safety instructions for the electronics (as well as microwave ovens) is also a bit lacking considering some of the suggestions for troubleshooting and parts replacement.

Some errata: Testing of microwave oven HV diodes (good ones will test bad), HV discharging of TVs and monitors always (not needed) and possibly to wrong place (should be to picture tube ground, not chassis ground) but no mention of power supply capacitor discharging, not specific enough on 'good' and 'bad' resistance readings for various parts like motors.

9. All About Lamps - Construction, Repair, Restoration
   Frank W. Coggins
   Tab Books, 1992
   Blue Ridge Summit, PA 17214
   ISBN 0-8306-0258-5 (hardback), 0-8306-0358-1 (paperback)

10. How to Repair and Care for Home Appliances
    Arthor Darack and the Staff of Consumer Group, Inc.
    Prentice-Hall, Inc. 1983
    Englewood Cliffs, NJ 07632
    ISBN 0-13-430835-2 (hardcover), ISBN 0-13-430827-1 (paperback)

11. Popular Mechanics Home Appliance Repair Manual
    Hearst Books, NY, 1981
    ISBN 0-910990-75-1

12. Microsoft Home (CDROM)
    Based on the Readers Digest Complete Do-It-Yourself Guide
    The Readers Digest Association, 1991
    Microsoft, 1996
    ISBN 0-57231-259-9

    This isn't the Fix-It-Yourself Manual but I expect that is coming on CDROM if it is not out already. However, there is some information including nice diagrams relating to door chimes, telephone wiring, incandescent and fluorescent lighting fixtures, electrical switches, and heating and air conditioning systems (in addition to everything else you ever wanted to know about how your house works, tools and tool skills, materials and techniques, and home repair and maintenance).

Manufacturer support

Major manufacturers may provide a variety of types of support for their products including technical assistance, parts sourcing, unadvertised repair or replacement beyond the expiration of the warranty, upgrade or replacement to fix known defects whether covered by official recalls or not, etc.

I have on several occasions been pleasantly surprised to find that some companies really do stand behind their products and all it took was a phone call or short letter. One only hears of the horror stories!

(From: lizard3 (lizard3@ix.netcom.com).)

Sears sells schematics and plans of all their appliances. This includes a breakout of the entire machine with each part number. They have a toll-free number to call. All you need is the model number and a credit card. We have used their washing machine schematic a couple of times to replace some very minor parts.

Parts suppliers

Common parts like cordsets, plugs, wire, and some light bulbs can be found a larger hardware stores, home centers, or electrical supply houses. Small electronic components like resistors and capacitors, can be found at any electronics distributor - including even Radio Shack in a pinch.

The original manufacturer of the appliance is often the best source for unusual or custom parts. Many are quite willing to sell to the consumer directly. Check for an 800 number and have complete information on model and a part number if possible. However, their prices may be high - possibly rendering a repair uneconomical.

There are numerous appliance repair centers that may be able to obtain parts at lower cost - check your Yellow Pages. Their prices may be less than half of those of the original manufacturer.

The following is a good source for consumer electronics replacement parts, especially for VCRs, TVs, and other audio and video equipment but they also carry a variety of common electronic components and appliance parts like switches, range elements, defrost timers, light bulbs, and belts

- MCM Electronics, 1-800-543-4330, http://www.mcmelectronics.com/.

  VCR parts, Japanese semiconductors, tools, test equipment, audio, consumer electronics including microwave oven parts and electric range elements, etc.

- Global Micro Parts, 1-800-325-8488, http://www.allapplianceparts.com/.

  They specialize in microwave oven parts, but also carry some other major appliance parts.

Also see the documents: "Troubleshooting of Consumer Electronic Equipment" and "Electronics Mail Order List" for additional parts sources.

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-- end V2.66 --

Notes on the Troubleshooting and Repair of AC Adapters, Power Supplies, and Battery Packs

- and -
Other Related Information
Version 1.12

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

AC adapters, transformers, and even batteries, are critical safety components. Replacement with an improperly rated or incompatible device can result in damage or destruction of the powered equipment as well as the risk of shock or electrocution in certain cases.

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

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Introduction

Scope of this Document

This collection of information deals with the troubleshooting, repair, and use (normal or unconventional) of AC (wall) adapters, transformers, equipment power supplies (non-switching type), and batteries used in portable electronic devices and power tools.

- AC adapters (may also be called: wall adapters, power packs, or wall warts) are those boxes hanging on the end of the power cords of many modern consumer electronic devices. Their output may be a single AC or DC voltage, or several, with or without regulation. Most of those outputting AC are simple transformers and with the addition of a diode or bridge and filter capacitor for DC. (Often, people refer to all types of AC adapters including those outputting DC as 'transformers' but this is not really correct.) Others (those that are compact and weigh almost nothing) may be sophisticated switchmode power supplies. In most cases, the output will be totally isolated from the power line for safety. However, some that are designed for applications like battery chargers may **not** be line isolated and should not therefore be used for any other purposes.

- Transformers in this context refer to the actual magnetic components which may be found in AC adapters or equipment power supplies.

- Equipment power supplies are those portions of the equipment that provide various (usually DC) voltages for its operation. Note that in this document, non-switchmode types are discussed. For switchmode power supply information, see the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies.

- Batteries are found in all sorts of portable equipment nowadays. The discussions in this document related directly to problems and repair. This is not intended as a comprehensive battery "FAQ".

Note: This document replaces the chapters relating to these topics in the documents "Notes on the Troubleshooting and Repair of Small Household Appliances and Power Tools" and "....Audio Equipment and Other Miscellaneous Stuff".

Where another document is referenced, it is assumed to be at this site. If the link doesn't work, find the document of the same name at the Sci.Electronics.Repair FAQ or one of its mirror sites.

SAFETY

For the common transformer based AC adapter, there is no danger anywhere inside the device once unplugged. For the switchmode variety, see the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies for information beyond what is covered in this document.

Any internal overcurrent fuses or thermal fuses represent essential safety features of an AC adapter. These must **not** be removed except during testing. Where a fuse is found to be blown, use only an exact replacement. I really don't recommend running a repaired cobbled together AC adapter unattended in any case since even the sealed case provides some additional amount of fire protection. Inexpensive replacements are generally available.

For power supplies inside equipment, the same basic precautions apply but access and repair are generally much more easily accomplished.

The only real danger from an unplugged heavy iron transformer would be accidentally dropping it on your foot. :(

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General AC Adapter Information

AC Adapter Basics

It seems that the world now revolves around AC Adapters or 'Wall Warts' as they tend to be called. There are several basic types. Despite the fact that the plugs to the equipment may be identical THESE CAN GENERALLY NOT BE INTERCHANGED. The type (AC or DC), voltage, current capacity, and polarity are all critical to proper operation of the equipment. Use of an improper adapter or even just reverse polarity can permanently damage or destroy the device. Most equipment is protected against stupidity to a greater or lessor degree but don't count on it.

The most common problems are due to failure of the output cable due to flexing at either the adapter or output plug end. See section: AC Adapter Testing.

1. AC Transformer. All wall warts are often called transformers. However, only if the output is stated to be 'AC' does the device consist of only a (stepdown) transformer. These adapters typically put out anywhere from 3 to 20 VAC or more at 50 mA to 3 A or more. The most common range from 6 to 15 VAC at less than 1 A. The regulation is typically very poor so that an adapter rated at 12 VAC may put out 15 VAC with no load and drop to less than 12 VAC at rated load. However, some may actually output up to *two times* the rated voltage *or more* with a light load. To gain agency approval, the transformer needs to be protected internally so that there is no fire hazard even if the output is shorted. There may be a fuse or thermal fuse internally located (and inaccessible).

   If the output tested inside the adapter (assuming that you can get it open without total destruction - it is secured with screws and is not glued or you are skilled with a hacksaw - measures 0 or very low with no load but plugged into a live outlet, either the transformer has failed or the internal fuse had blown. In either case, it is probably easier to just buy a new adapter but sometimes these can be repaired. Occasionally, it will be as simple as a bad connection inside the adapter. Check the fine wires connected to the AC plug as well as the output connections. There may be a thermal fuse buried under the outer layers of the transformer which may have blown. These can be replaced but locating one may prove quite a challenge. Also see the section: Comments on Importance of Thermal Fuses and Protectors.

2. DC Power Pack. In addition to a step down transformer, these include at the very least a rectifier and filter capacitor. There may be additional regulation but most often there is none. Thus, while the output is DC, the powered equipment will almost always include an electronic regulation.

   As above, you may find bad connections or a blown fuse or thermal fuse inside the adapter but the most common problems are with the cable.

3. Switching Power Supply. These are complete low power AC-DC converters using a high frequency inverter. Most common applications are laptop computers and camcorders. The output(s) will be fairly well regulated and these will often accept universal power - 90-250 V AC or DC.

   Again, cable problems predominate but failures of the switching power supply components are also possible. If the output is dead and you have eliminated the cable as a possible problem or the output is cycling on and off at approximately a 1 second rate, then some part of the switching power supply may be bad. In the first case, it could be a blown fuse, bad startup resistor, shorted/open semiconductors, bad controller, or other components. If the output is cycling, it could be a shorted diode or capacitor, or a bad controller. See the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies for more info, especially on safety while servicing these units.

Also see the chapter on "Equipment Power Supplies" in the document: Notes on the Troubleshooting and Repair of Audio Equipment and Other Miscellaneous Stuff.

About AC Adapter Ratings

The following mainly applies to AC adapters using transformers. Those based on switchmode power supplies adapters have tended to be well designed with decent regulation and realistic ratings. Of course, they are generally also much more expensive!

There is no standard for rating AC adapters. When a particular adapter is listed as, say, 12 V, 1 A max, there's a good chance the output will average 12 V when outputting 1 A but what it does at lower currents is not known. In fact, lightly loaded, the output voltage may be more than double its nameplate rating! This could be disastrous where a piece of equipment is plugged into it that doesn't expect such a high voltage. The rating also doesn't say anything about the ripple (for DC models) - it could be almost anything.

The lifetime of an AC adapter (particularly those outputting DC) when run at or near its nameplate rating may be very short. Why? Because they often use low temperature (cheap!) components that can't take the heat. For AC output models, the transformer itself may fail (or at least the thermal fuse). For DC models, the electrolytic capacitor(s) may go bad very quickly. The likely result will be that the output voltage will disappear entirely (AC models) or drop in value with greatly increased ripple (DC models).

Where the adapter is used with its intended equipment, one can presume the manufacturer did the proper testing to assure compatibility and adequate life (though this isn't always the case!). However, where it is used in some other application, the life of the adapter and the equipment may be much shorter than expected, possibly failing almost immediately.

Protect Yourself from "Unknown AC Adapter Syndrome"

Apparently, manufacturers of equipment powered by AC adapters have discovered that they can improve their bottom line by *not* printing the AC adapter ratings on the device itself, and possibly not even in the user manual. I don't know whether this is actually done for liability reasons (so you aren't tempted to actually use an AC adapter other than their own exorbitantly priced replacement) or just to same 3 microcents on printing ink but the net result is that the owner has no idea what adapter in that drawer that collects adapters is the correct one. They could at least specify a particular model adapter if they don't think the average consumer has an intelligence greater than a carrot.

For example, I own 2 U.S. Robotics modems. One uses a 9 VAC adapter; the other uses a 20 VAC adapter. The power jacks are identical and totally unmarked. Guess what happens if I guess wrong? With too little voltage, the modem may appear to work but be unreliable. With too much voltage, the smoke will very likely be released instantly. :(

To save yourself a lot of hassle and possible damaged equipment, put a label on each AC adapter powered device you own with the voltage, current, AC or DC (with polarity), and model number of the adapter (make one up if nothing is obvious and put it on the device and adapter). Then, if you misplace the adapter, you'll know what to look for and if it is nowhere to be found, will have enough information to purchase a replacement.

Why do AC Adapters Usually Use Heavy Transformers?

The main reasons are safety and cost.

Line isolation is essential for safety with respect to electrical shock - no part accessible to the user must be connected to either side of the power line. A regular transformer provides this automatically. While combinations of passive components can reduce the risk of shock, nothing quite matches the virtually fail-safe nature of a simple transformer between the power line and the low voltage circuitry. To achieve similar isolation without a line transformer generally requires a switchmode power supply which actually contains a small high frequency transformer to provide the isolation. Until recently, such systems were much more expensive than a simple iron transformer but that is changing and many modern devices do now use a wall adapter based on this approach. These can be recognized by their light weight, DC (probably regulated) output, and the required warnings NOT to cut them off and replace them with an ordinary plug! I wonder how many people have ignored the warnings when their equipment stopped working and replaced that fat "plug"? What a scenario for disaster!

Compact AC Adapters

These use switchmode power supply technology and can therefore be quite small and light weight. In addition to the applications noted below, they are turning up on a variety of other high tech gadgets from shavers to Personal Digital Assistants.

WARNING: DON'T attempt to disassemble or repair one of these unless you are familiar with the safety and troubleshooting information for larger switchmode power supplies - they can be quite deadly. See the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies.

(From: Mike Schuster (schuster@panix.com).)

For some reason I've been fascinated by tiny wall wart AC adaptors that use switch mode power supplies, since they're light and can supply more current than similar linear power cubes.

One type that keeps catching my eye is used a lot for "AC travel charger" accessories for cellular phones. These things connect via a cable to the bottom of a cell phone, much like the cigarette-lighter "charger/saver" accessories, only these are driven by house current.

The typical wart is a small rectangular box, about the size of two 9V transistor batteries side by side, manufactured in China or Taiwan. The wall side is distinguished by the fact that the AC prongs line up with the long axis of the box, rather than the other way around as with most wall cubes. This makes it possible to put them side by side on an AC power strip. The opposite face contains a tri-mode LED which may display red, green, or orange under conditions I've yet to figure out.

Recently I noticed one of these thingies in K-Mart as part of a modular power system for cell phones. There are several models of cigarette lighter cords, however the actual 12VDC car plug in _interchangeable_ and connected to the cable using a 4-pin modular telephone handset jack. Each model comes with a cable constructed to mate with the phone it's sold for.

Next to these on the pegboard is a variant of the wall wart being discussed, also having a 4-pin handset socket, and sold as an accessory to the DC cords. Instead of using the cigarette lighter plug, you connect the cable to the wall wart and create a new device which uses house current. So I picked up the wall wart and started to play.

It's marked as being capable of 5-15 VDC at 750 mA. Playing with the 4 output pins; one is ground, two are tied together and supply 14.35 VDC open circuit, and can deliver about 1.5 amps. The other reads about 13 volts between it and the ground. Unpowered there is a small leakage between the ground and the "13 volt" pin.

Looking inside, there are two 8-pin DIPs on the PC board; both having identifiers sanded off. One is near the transformer end and the other is near the DC output end. All of the DC side output traces lead, directly or indirectly, to the second IC.

My guess is that the "13 volt" pin is really used to program the output voltage between ground and the other two pins that are tied together. The cable sold for any specific phone has some passive components inside that will cause the second IC to produce the required output voltage. Am I warm?

I'd like to try programming this myself ... any ideas? Resistors?

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AC Adapter Troubleshooting and Repair

AC Adapter Testing

AC adapters that are not the switching type (1) and (2), above, can easily be tested with a VOM or DMM. The voltage you measure (AC or DC) will probably be 10-25% higher than the label specification. If you get no reading, wiggle, squeeze, squish, and otherwise abuse the cord both at the wall wart end and at the device end. You may be able to get it to make momentary contact and confirm that the adapter itself is functioning.

The most common problem is one or both conductors breaking internally at one of the ends due to continuous bending and stretching.

Make sure the outlet is live - check with a lamp.

Make sure any voltage selector switch is set to the correct position. Move it back and forth a couple of times to make sure the contacts are clean.

If the voltage readings check out for now, then wiggle the cord as above in any case to make sure the internal wiring is intact - it may be intermittent.

Although it is possible for the adapter to fail in peculiar ways, a satisfactory voltage test should indicate that the adapter is functioning correctly.

It's also possible that the power jack on the device itself is damaged from use or abuse. If possible, confirm proper operation with a **COMPATIBLE** adapter. With battery operated devices, there is usually a set of contacts that should close when the adapter is removed to connect the internal battery to the circuitry. If these don't operate properly, the device may not work off batteries (they may appear to not be charged), the AC adapter, or both. Check the jack for obvious signs of damage (cracked, loose, etc.). A squirt of contact cleaner into the jack may clear up intermittent contact problems not due to actual damage.

Pocket Wall Adapter Tester/Polarity Checker

This handy low cost device can be built into an old ball point pen case or something similar to provide a convenient indication of wall adapter type, operation, and polarity:

```
            Probe(+) o-----/\/\-----+----|>|----+---o Probe(-)
                         1K, 1/2 W  | Green LED |
                                    +----|<|----+
                                       Red LED
```

- The green LED will light up if the polarity of an adapter with a DC output agrees with the probe markings.
- The red LED will light up if the polarity of an adapter with a DC output is opposite of the probe markings.
- Both LEDs will light up if your adapter puts out AC rather than DC.
- The LED brightness can provide a rough indication of the output voltage.

Getting Inside an AC Adapter

Manufacturers come up with all sorts of creative ways of making access a challenge:

- Some are secured with screws - possibly with strange heads. If this is the case, disassembly is possible without damage, at least in principle. However, you may need to find or improvise for the special tool.
- Some are fully potted and impossible to open without dynamite. Forget it, move on with your life. :) These will feel solid and there will be no 'give' when pressing the sides.

For those that are glued:

- A hacksaw or thin file can be used to carefully cut along the glue line just deep enough so that the two halves can be popped apart. Make sure you don't rip into internal components! Gently whacking a large knife with a soft mallet may be a bit more persuasive. :)
- A vise can be used to squeeze on diagonally opposing corners which will hopefully pop the case open along the glue line (or somewhere!).

After the repair, the two halves (or pieces!) can be glued back together using something like Duco Cement or windshield sealer.

AC Adapter Repair

Although the cost of a new adapter is usually modest, repair is often so easy that it makes sense in any case.

The most common problem (and the only one we will deal with here) is the case of a broken wire internal to the cable at either the wall wart or device end due to excessive flexing of the cable.

Usually, the point of the break is just at the end of the rubber cable guard. If you flex the cable, you will probably see that it bends more easily here than elsewhere due to the broken inner conductor. If you are reasonably dextrous, you can cut the cable at this point, strip the wires back far enough to get to the good copper, and solder the ends together. Insulate completely with several layers of electrical tape. Make sure you do not interchange the two wires for DC output adapters! (They are usually marked somehow either with a stripe on the insulator, a thread inside with one of the conductors, or copper and silver colored conductors. Before you cut, make a note of the proper hookup just to be sure. Verify polarity after the repair with a voltmeter.

The same procedure can be followed if the break is at the device plug end but you may be able to buy a replacement plug which has solder or screw terminals rather than attempting to salvage the old one.

Once the repair is complete, test for correct voltage and polarity before connecting the powered equipment.

This repair may not be pretty, but it will work fine, is safe, and will last a long time if done carefully.

If the adapter can be opened - it is assembled with screws rather than being glued together - then you can run the good part of the cable inside and solder directly to the internal terminals. Again, verify the polarity before you plug in your expensive equipment.

WARNING: If this is a switching power supply type of adapter, there are dangerous voltages present inside in addition to the actual line connections. Do not touch any parts of the internal circuitry when plugged in and make sure the large filter capacitor is discharged (test with a voltmeter) before touching or doing any work on the circuit board. For more info on switching power supply repair, refer to the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies.

If it is a normal adapter, then the only danger when open are direct connections to the AC plug. Stay clear when it is plugged in.

AC Adapter Substitution and Equipment Damage

Those voltage and current ratings are there for a reason. You may get away with a lower voltage or current adapter without permanent damage but using a higher voltage adapter is playing Russian Roulette. Even using an adapter from a different device - even with similar ratings, may be risky because there is no real standard. A 12 V adapter from one manufacturer may put out 12 V at all times whereas one from another manufacturer may put out 20 V or more when unloaded.

A variety of types of protection are often incorporated into adapter powered equipment. Sometimes these actually will save the day. Unfortunately, designers cannot anticipate all the creative techniques people use to prove they really do not have a clue of what they are doing.

The worst seems to be where an attempt is made to operate portable devices off of an automotive electrical system. Fireworks are often the result, see below and the section on: "Automotive power".

If you tried an incorrect adapter and the device now does not work there are several possibilities (assuming the adapter survived and this is not the problem):

1. An internal fuse or IC protector blew. This would be the easiest to repair.

2. A protection diode sacrificed itself. This is usually reverse biased across the input and is supposed to short out the adapter if the polarity is reversed. However, it may have failed shorted particularly if you used a high current adapter (or automotive power).

3. Some really expensive hard to obtain parts blew up. Unfortunately, this outcome is all too common.

Some devices are designed in such a way that they will survive almost anything. A series diode would protect against reverse polarity. Alternatively, a large parallel diode with upstream current limiting resistor or PTC thermistor, and fuses, fusable resistors, or IC protectors would cut off current before the parallel diode or circuit board traces have time to vaporize. A crowbar circuit (zener to trigger an SCR) could be used to protect against reasonable overvoltage.

I inherited a Sony Discman from a guy who thought he would save a few bucks and make an adapter cord to use it in his car. Not only was the 12-15 volts from the car battery too high but he got it backwards! Blew the DC-DC converter transistor in two despite the built in reverse voltage protection and fried the microcontroller. Needless to say, the player was a loss but the cigarette lighter fuse was happy as a clam!

Moral: those voltage, current, and polarity ratings marked on portable equipment are there for a reason. Voltage rating should not be exceeded, though using a slightly lower voltage adapter will probably cause no harm though performance may suffer. The current rating of the adapter should be at least equal to the printed rating. The polarity, of course, must be correct. If connected backwards with a current limited adapter, there may be no immediate damage depending on the design of the protective circuits. But don't take chances - double check that the polarities match - with a voltmeter if necessary - before you plug it in! Note that even some identically marked adapters put out widely different open circuit voltages. If the unloaded voltage reading is more than 25-30% higher than the marked value, I would be cautious about using the adapter without confirmation that it is acceptable for your equipment. Needless to say, if you experience any strange or unexpected behavior with a new adapter, if any part gets unusually warm, or if there is any unusual odor, unplug it immediately and attempt to identify the cause of the problem.

Or, a more dramatic result of the same principles:

(From: Don Parker (tazman@yournet.com).)

A guy brought a Johnson Messenger CB to my shop a few decades back. He had been told it would run on 12 VDC *and* 115 VAC - so he tried it! I never saw so many little leads sticking up from any PCB since - that once were capacitors and top hat transistors. There was enough fluff from the caps to have the chassis rated at least R-10 :->).

Power Reversal - Better Pray

> "That's right, I reversed power and ground on a Sony XR-6000 AM/FM cassette car stereo. (12V negative ground).

> The little fellow made a stinky smell, so I assume that at least one component is cooked."

If it had not been turned on before you discovered your error, the damage may have been limited to the display and some filter caps. Then again...

The problem is that an auto battery has a very high current capacity and any fuses respond too slowly to be of much value in a situation such as this. Any capacitors and solid state components on the 12 V bus at the time power was applied are likely fried - well done.

> "Is there any hope of my repairing it? (This assumes I show more ability than I did when installing it.) Which part(s) are likely damaged?"

(From: Onat Ahmet (onat@turbine.kuee.kyoto-u.ac.jp).)

Well, based on that last statement ;-)

- **Bad:** car batteries can provide amps and amps of current (much worse than reverse connecting a wall adapter for example.)

- **Good:** The stinking might be due to a component getting too hot and vaporizing the solder paste/preserver/dust on it, but not actually giving up the ghost.

  I would find and check any fuses, or components directly in-line with or parallel to the power lines (the latter might include the IC's unfortunately...)

- **Good:** There might have been a protecting diode somewhere (but why did it stink then (^_^)

- **Neutral:** Did you disassemble it to see if there were any blackened areas/components? Smell from a close distance; I can often locate a burnt component that way even after a long time.

If not, join the happy crowd, and gut the good old stereo for parts!

Determining Voltage and Polarity of AC Adapter Powered Devices

This is often required when the original adapter is lost or misplaced or isn't labeled so you are not sure if it is the correct one for your device. It's amazing how many things like modems and phone answering machines don't list the voltage and polarity on the case - it's not like the extra printing would cost anything! While I would stop short of calling this a conspiracy, there does appear to be an industry-wide practice of leaving out key information to encourage replacement of the equipment rather than the much less costly and much less profitable repair or replacement of only the wall adapter. Information on voltage, current, and AC or DC polarity, is often missing on the equipment itself. And, absolutely totally incompatible wall adapters having similar plugs can be attached with the possible result being instant destruction of the device. This even applies to equipment from the same manufacturer! At least wall sockets are standardized - wall adapters are not.

If you are simply replacing a broken adapter with a universal type, check the label on the old one - they almost always provide this information. There are three issues: AC versus DC, the voltage, and polarity. Unfortunately, fully determining these requirements experimentally can be non-trivial. While many devices have built in protection for reverse polarity (which would probably also include putting AC into a device requiring DC), others do not and may be damaged or may at least blow an internal fuse. Few devices protect against extreme overvoltage.

If you have a multimeter, there are also some tests you can perform without opening the device but they are not foolproof. Here are some general guidelines. The more of these you can confirm, the greater the confidence of avoiding disaster.

1. The best way would be to find the information without serious testing. It may be readily available:

    - Examine the device for labels, either embossed near the power jack or on the rear or underneath such as:

      ```
      DC 5V ----     AC 12 V ~
            ____             _
      ```

    - If there is a voltage listed but no indication of AC/DC, 6 V or less is likely to be DC (and may require decent regulation; higher voltages could be either AC or DC (probably filtered but unregulated though not always).

    - A symmetric (non-polarized) jack means it is supposed to operate on AC.

    - If the device has a metal case or you can get to the metal shields on connectors, check for continuity to the power jack. This probably is the negative input (though no guarantee - some manufacturers do really strange things!).

    - Check your user manual!

    - Contact the manufacturer or their Web site.

2. The next best way would be to open it up and trace enough of the power circuitry to identify components which have obvious voltage ratings and polarities like electrolytic capacitors. There may even be labeling on the circuit board.

    - There will almost always be at least one electrolytic cap very near the power input.

    - If there is nothing between it and the power jack, then polarity will be that of the cap and you will have an upper bound on voltage (but the actual safe operating voltage will probably be considerably less).

    - If there is a diode in series with the cap, then the voltage and polarity will be as above (except for the 0.7 or so V diode drop) and the device is probably designed to operate on DC (and possibly AC but there may not be enough filtering).

    - If there is a bridge rectifier or multiple rectifier diodes between the input and any DC loads, it is probably designed to operate on AC.

- If the device also has a battery compartment and the battery powers the device the same way as the adapter (possibly with one connection going through a diode or an interlock on the power jack), then the AC adapter polarity and voltage will be the same (+/- 0.7 V or so) as the battery. However, some devices use totally different means of powering themselves with battery and AC operation!

3. If you have a multimeter for which you know the polarity of its output on the ohms ranges (VOMs may be reversed from the probes; DMMs are often the same - this can be determined by testing a diode or with another meter), then test on the low ohms range first in one direction, than the other. This is like applying a very low safe voltage to the device:

    - Open in one direction and a charging cap (resistance starts low and increases relatively slowly) indicates a series diode (protection or a rectifier). The probe polarity where the cap is charging is the correct one. (Note: once the internal caps charge up, reversing the leads again may result in an apparent open reading.)

    - A diode drop in one direction and charging cap in the other indicates a parallel protection diode. Again, the slowly charging direction is correct.

    - Symmetric behavior may indicate it is supposed to use AC. However, this could just mean that a filter cap is directly across the input and DC is required.

Anything else will probably require you do (1) or (2). And, except for manufacturer supplied information, even these are no guarantee of anything!

Once AC versus DC and polarity (if relevant) are determined, start low on voltage to see at what point the device behaves normally. Depending on design, this may be quite low compared to the recommended input voltage or very near it - no way to really know. Devices with motors and solenoids may appear to operate at relatively low voltage but fail to do the proper mechanical things reliably if at all. RF devices capable of transmitting may behave similarly when asked to transmit. Devices with more constant power requirements may operate happily at these reduced voltages. However, depending on the type of power supplies they use, running at a low voltage may also be stressful (e.g., where DC-DC converters are involved).

NOTE: Some devices with microcontrollers and/or logic will require a fast power turn-on so it may be necessary to switch off and then on for each input voltage you try for proper reset.

Again, determining the requirements from the manufacturer is best!

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AC Adapter Modifications or Enhancements

Using AC Adapters in Series for Multiple Voltages

Where a bipolar DC power supply is needed, it is possible to create this with a pair of DC output adapters in series. Each adapter must have voltage and current ratings adequate for your application. They can be used with or without external regulators (see the section: Adding an IC Regulator to a Wall Adapter or Battery. Since they are fully isolated from the AC line and each other, they can be tied together with any desired polarity and common point.

The only cautions are that if one of them is unpowered for any reason (it falls out of the AC outlet!) or the current rating of one of the adapters is exceeded, then current may be forced through the other one in the wrong direction possibly damaging its electrolytic capacitors or other components. To prevent this possibility, place a rectifier like a 1N4002 (this is 1 A, use a larger one if your adapters are really huge) in REVERSE across each output. This will bypass current safely around the internal circuitry.

The idea of using multiple adapters can be extended to even more outputs but this is left as an exercise for the student.

Using AC Adapters in Series for Higher or Lower Voltage

Wall adapters are totally isolated from everything (except possibly for a very high value resistor to one side of the AC line which for this purpose can be ignored) so using one set of wires as a common for the series connection won't blow anything.

However, obtaining an AC adapter with the proper ratings for long term use would be a good idea.

There are two cases:

1. DC output. It's probably not recommended and only the sum case (higher voltage output) is generally possible but will work (at least for testing purposes) as long as neither current rating is exceeded and both units are powered. (Else, you could end up with the wrong polarity on one of the unit's electrolytic capacitors.)

2. AC output. There should be no problem as long as the current rating of neither adapter is exceeded. Unless they are identical units, you will probably have to experiment with the phasing to get the sum or difference of the voltages WITHOUT the equipment attached!

   WARNING: If one of the adapters is not plugged in, high voltage (possibly even more than the normal line voltage) may appear on its exposed prongs due to the AC from the other adapters present on its output (being stepped up going the wrong way through the transformer). The voltage and available current may be enough to be dangerous in some cases.

   CAUTION: For the difference case, if one of the units isn't powered, you may get a HIGHER voltage than expected at the output of the series combination which may let the smoke out of your equipment. :(

Replacing Batteries With an AC Adapter

While most appliances that run off of internal batteries also include a socket for an wall adapter, this is not always the case. Just because there is no hole to plug one in doesn't necessarily mean that you cannot use one.

The type we are considering in this discussion are plug-in wall adapter that output a DC voltage (not AC transformers). This would be stated on the nameplate.

The first major consideration is voltage. This needs to be matched to the needs of the equipment. However, what you provide may also need to be well regulated for several reasons as the manufacturer may have saved on the cost of the circuitry by assuming the use of batteries:

- The maximum voltage supplied by a battery is well defined. For example, 4 AA cells provide just over 6 V when new. The design of the device may assume that this voltage is never exceeded and include no internal regulator. Overheating or failure may result immediately or down the road with a wall adapter which supplies more voltage than its nameplate rating (as most do especially when lightly loaded).

- Most wall adapters do not include much filtering. With audio equipment, this may mean that there will be unacceptable levels of hum if used direct. There are exceptions. However, there is no way of telling without actually testing the adapter under load.

- The load on the power source (batteries or adapter) may vary quite a bit depending on what the device is doing. Fresh batteries can provide quite a bit of current without their voltage drooping that much. This is not always the case with wall adapters and the performance of the equipment may suffer.

Thus, the typical universal adapter found at Radio Shack and others may not work satisfactorily. No-load voltage can be much higher than the voltage at full load - which in itself may be greater than the marked voltage. Adding an external regulator to a somewhat higher voltage wall adapter is best. See the section: Adding an IC Regulator to a Wall Adapter or Battery.

The other major consideration is current. The rating of the was adapter must be at least equal to the *maximum* current - mA or A - drawn by the device in any mode which lasts more than a fraction of a second. The best way to determine this is to measure it using fresh batteries and checking all modes. Add a safety factor of 10 to 25 percent to your maximum reading and use this when selecting an adapter.

For shock and fire safety, any wall adapter you use should be isolated and have UL approval.

- Isolation means that there is a transformer in the adapter to protect you and your equipment from direct connection to the power line. Most of the inexpensive types consist of nothing more than a transformer (and for DC types), rectifier and filter capacitor. However, if what you have weighs almost nothing and is in a tiny case, it may be meant for a specific purpose like a battery chargers or rechargeable device where human contact is not possible and may not include line isolation. But, if there is a low voltage plug with exposed contacts and/or the powered equipment has exposed shields or other parts, the compact light-weight types are actually miniaturized switchmode power supplies which are functionally equivalent to the heavier, bulkier adapters and do provide line isolation.

- UL (Underwriters Lab) approval means that the adapter has been tested to destruction and it is unlikely that a fire would result from any reasonable internal fault like a short circuit or external fault like a prolonged overload condition.

To wire it in, you can obtain a socket like those used on appliances with external adapter inputs - from something that is lying in your junk-box or a distributor like MCM Electronics. Use one with an automatic disconnect (3 terminals) if possible. Then, you can retain the optional use of the battery. Cut the wire to the battery for the side that will be the outer ring of the adapter plug and wire it in series with the disconnect (make sure the disconnected terminal goes to the battery and the other terminal goes to the equipment). The common (center) terminal goes to other side of the battery, adapter, and equipment as shown in the example below. In this wiring diagram, it is assumed that the ring is + and the center is -. Your adapter could be wired either way. Don't get it backwards!

```
                   +--+
                 X V  | (Inserting plug breaks connection at X)
Battery (+) o-------  |
Adapter (+) o---------+------------------o Equipment (Ring, +)
                       \_______
                                o===+
Battery/                            |
Adapter (-) o-----------------------+----o Equipment (Center, -)
```

WARNING: if you do not use an automatic disconnect socket, remove the battery holder or otherwise disable it - accidentally using the wall adapter with the batteries installed could result in leakage or even an explosion!

A possibly simpler alternative is to fashion a 'module' the size and shape of the battery or battery pack with screw contacts at the same locations and connect your external power supply to it. For example, a couple of pieces of wooden dowel rod about 2-1/4" long taped together with wood screws in the appropriate ends would substitute for a pair of side-by-side AA batteries. Then, you don't need to modify the Walkman or whatever at all (or at most just file a slot for the wire to exit the battery door).

Converting an AC Output Wall Adapter to DC

Where a modest source of DC is required for an appliance or other device, it may be possible to add a rectifier and filter capacitor (and possibly a regulator as well) to a wall adapter with an AC output. While many wall adapter output DC, some - modems and some phone answering machines, for example - are just transformers and output low voltage AC.

To convert such an adapter to DC requires the use of:

- Bridge rectifier - turns AC into pulsating DC.
- Filter capacitor - smooths the output reducing its ripple.
- Regulator - produces a nearly constant output voltage.

Depending on your needs, you may find a suitable wall adapter in your junk box (maybe from that 2400 baud modem that was all the rage a couple of years ago!).

The basic circuit is shown below:

```
         Bridge Rectifier   Filter Capacitor

 AC o-----+----|>|-------+---------+-----o DC (+)
         ~|              |+        |
In from   +----|<|----+  |       +_|_   Out to powered device
AC wall               |  |      C ___   or voltage regulator
Adapter   +----|>|----|--+       - |
          |           |            |
```

```
     AC o-----+----|<|----+-----------+-----o DC (-)
              ~                 -
```

Considerations:

- An AC input of Vin VRMS will result in a peak output of approximately 1.4 Vin - 1.4 V. The first factor of 1.4 results from the fact that the peak value of a sinusoid (the power line waveform) is 1.414 (sqrt(2)) times the RMS value. The second factor of 1.4 is due to the two diodes that are in series as part of the bridge rectifier. The fact that they are both about 1.4 is a total coincidence.

  Therefore, you will need to find an AC wall adapter that produces an output voltage which will result in something close to what you need. However, this may be a bit more difficult than it sounds since the nameplate rating of many wall adapters is not an accurate indication of what they actually produce especially when lightly loaded. Measuring the output is best.

- Select the filter capacitor to be at least 10,000 uF per 1000 mA of output current with a voltage rating of at least 2 x Vin. This rule of thumb will result in a ripple of less than 1 V p-p which will be acceptable for many devices or where a voltage regulator is used (but may be inadequate for some audio devices resulting in some 120 Hz hum. Use a larger or additional capacitor or a regulator in such a case.

- Suitable components can be purchased at any electronics distributor as well as Radio Shack. The bridge rectifier comes as a single unit or you can put one together from 1N400x diodes (the x can be anything from 1 to 7 for these low voltage applications). Observe the polarity for the filter capacitor!

The following examples illustrate some of the possibilities.

- Example 1: A typical modem power pack is rated at 12 VAC but actually produces around 14 VAC at modest load (say half the nameplate current rating). This will result in about 17 to 18 VDC at the output of the rectifier and filter capacitor.

- Example 2: A cordless VAC battery charger adapter might produce 6 VAC. This would result in 6 to 7 VDC at the output of the rectifier and filter capacitor.

Limiting your load to the VA ratings of the transformer should keep it from overheating. Whether you will get a decently smooth output will depend on how much filtering you have AND on the peak current available from the transformer to recharge the filter capacitors on each half-cycle. A high quality transformer (e.g. something from a manufacturer like Stancor or Thorderson that is designed with much more copper) will be much much better in this respect. A wall adapter is likely to have limited peak current and significant droop.

Adding an IC regulator to either of these would permit an output of up to about 2.5 V less than the filtered DC voltage.

Adding an IC Regulator to a Wall Adapter or Battery

For many applications, it is desirable to have a well regulated source of DC power. This may be the case when running equipment from batteries as well as from a wall adapter that outputs a DC voltage or the enhanced adapter described in the section: Converting an AC Output Wall Adapter to DC.

The following is a very basic introduction to the construction of a circuit with appropriate modifications will work for outputs in the range of about 1.25 to 35 V and currents up 1 A. This can also be used as the basis for a small general purpose power supply for use with electronics experiments.

For an arbitrary voltage between about 1.2 and 35 V what you want is an IC called an 'adjustable voltage regulator'. LM317 is one example - Radio Shack should have it along with a schematic. The LM317 looks like a power transistor but is a complete regulator on a chip.

Where the output needs to be a common value like +5 V or -12 V, ICs called 'fixed voltage regulators' are available which are preprogrammed for these. Typical ICs have designations of 78xx (positive output) and 79xx (negative output).

For example:

```
         Positive                    Negative
     Voltage Regulator           Voltage Regulator
   -----------------------     -----------------------
       7805      +5 V              7905      -5 V
       7809      +9 V              7909      -9 V
       7812     +12 V              7912     -12 V
       7815     +15 V              7915     -15 V
```

and so forth. Where these will suffice, the circuit below can be simplified by eliminating the resistors and tying the third terminal to ground. Note: pinouts differ between positive and negative types - check the datasheet!

Here is a sample circuit using the LM317:

```
                  I +-------+ O
    Vin (+) o-----+---| LM317 |---+--------------+-----o Vout (+)
                  |   +-------+   |              |
                  |       | A     /              |
                  |       |       \ R1 = 240     |
                  |       |       /              |                ___
                 _|_ C1   |       |            +_|_ C2      |_O_|  LM317
                 ___ .01  +-------+             ___ 1 uF    |   |  1 - Adjust
                  |  uF   |                    - |          |___|  2 - Output
                  |       \                      |           |||   3 - Input
                  |       / R2                   |           123
                  |       \                      |
                  |       |                      |
    Vin(-) o------+-------+----------------------+-----o Vout (-)
```

Note: Not all voltage regulator ICs use this pinout. If you are not using an LM317, double check its pinout - as well as all the other specifications.

For the LM317:

1. R2 = (192 x Vout) - 240, where R2 in ohms, Vout is in volts and must be at between 1.2 V and 35 V.

2. Vin should be at least 2.5V greater than Vout. Select a wall adapter with a voltage at least 2.5 V greater than your regulated output at full load.

   However, note that a typical adapter's voltage may vary quite a bit depending on manufacturer and load. You will have to select one that isn't too much greater than what you really want since this will add unnecessary wasted power in the device and additional heat dissipation.

3. Maximum output current is 1 A. Your adapter must be capable of supplying the maximum current safely and without its voltage drooping below the requirement in (2) above.

4. Additional filter capacitance (across C1) on the adapter's output may help (or be required) to reduce its ripple and thus the swing of its input. This may allow you to use an adapter with a lower output voltage and reduce the power dissipation in the regulator as well.

   Using 10,000 uF per *amp* of output current will result in less than 1 V p-p ripple on the input to the regulator. As long as the input is always greater than your desired output voltage plus 2.5 V, the regulator will totally remove this ripple resulting in a constant DC output independent of line voltage and load current fluctuations. (For you purists, the regulator isn't quite perfect but is good enough for most applications.)

   Make sure you select a capacitor with a voltage rating at least 25% greater than the adapter's *unloaded* peak output voltage and observe the polarity!

   Note: wall adapters designed as battery chargers may not have any filter capacitors so this will definitely be needed with this type. Quick check: If the voltage on the adapter's output drops to zero as soon as it is pulled from the wall - even with no load - it does not have a filter capacitor.

5. The tab of the LM317 is connected to the center pin - keep this in mind because the chip will have to be on a heat sink if it will be dissipating more than a watt or so. P = (Vout - Vin) * Iout.

6. There are other considerations - check the datasheet for the LM317 particularly if you are running near the limits of 35 V and/or 1 A.

More information on this topic can be found in the document: Various Schematics and Diagrams.

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Equipment Power Supplies

Types of Power Supplies

See the document: Safety Guidelines for High Voltage and/or Line Powered Equipment before tackling any power supply problems!

If your equipment uses an AC adapter (wall wart), see the sections on those devices.

The power supplies built in to consumer electronic equipment are usually one of three types or a hybrid combination of these (There are no doubt others):

1. Power transformer with linear regulator using 78/79XX ICs or discrete components. The power transformer will be large and very near the AC line cord.

2. Power transformer with hybrid regulator like STK5481 or any of its cousins - multioutput with some outputs switched by power on. If it has one of these, check ECG, SK, or NTE, or post to sci.electronics.repair and someone can probably provide the pinout. Again, the power transformer will be large and very near the AC line cord.

3. Small switching power supply. Most common problems: shorted semiconductors, bad capacitors, open fusable resistors. In this case there is usually no large power transformer near the line input but a smaller transformer amidships. This is rare in audio equipment as the switching noise is difficult to keep out of the audio circuits. These are more often found found in some VCRs, TVs, monitors, fax machines, and printers.

Some comments for each type:

1. Troubleshooting is quite straightforward as the components are readily identified and it is easy to trace through from the power transformer, bridge or centertapped full wave rectifiers, regulators, caps, etc.

2. Failures of one or more of the outputs of these hybrid regulators are very common. Use ECG/STK/NTE cross reference to identify the correct output voltages. Test with power switch in both positions. Any discrepancy indicates likely problem. While an excessive load dragging down a voltage is possible, the regulator is the first suspect. Replacement cost is usually under $10.

3. Switching supplies. These are tougher to diagnose, but it is possible without service literature by tracing the circuit and checking for bad semiconductors with an ohmmeter. Common problems - dried up capacitors, shorted semiconductors, and bad solder joints. See the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies for more detailed information.

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Power Supply Troubleshooting

Totally Dead Power Supply (Non-Switching Type)

Don't overlook the possibility of bad solder connections or even a bad line cord or plug. Maybe Fido was hungry.

First, make sure the outlet is live - try a lamp. Even a neon circuit tester is not a 100% guarantee - the outlet may have a high resistance marginal connection.

Check for blown fuses near the line cord input. With the unit unplugged, test for continuity from the AC plug to the fuse, on/off switch and power transformer. With the power switch in the 'on' position, testing across the AC plug should result in a resistance of 1 to 100 ohms depending on the size of the equipment:

- Small AC adapter - 100 to 500 ohms.
- Large AC adapter - 10 to 100 ohms.
- VCR - 15 to 30 ohms.
- Cassette deck or CD player - 25 to 100 ohms.
- Stereo receiver or amplifier - .5 to 10 ohms.

If the fuse blew and the readings are too low, the transformer primary may be partially or totally shorted. If the resistance is infinite even directly across the primary of the power transformer, it may be open or there may be an open thermal fuse underneath the outer layer of insulation wrapping. Also see the section: Comments on Importance of Thermal Fuses and Protectors.

If the fuse blew but resistance is reasonable, try a new fuse of the proper ratings. If this blows instantly, there is still a fault in the power supply or one of its loads. See the section: About Fuses, IC Protectors, and Circuit Breakers.

If these check out, then the problem is likely on the secondary side. One or more outputs may be low or missing due to bad regulator components. A secondary winding could be open though is is less common than primary side failure as the wire (in transistorized equipment at least) is much thicker.

Low or Missing Power Supply Outputs (Non-Switching Type)

Once the line input and primary circuits have been found to be good (or at have continuity and a resistance that is reasonable, the problems is most likely in the secondary side - fuses, rectifiers, filter capacitors, regulator components, bad connections, excess load due to electronic problems elsewhere.

Depending on the type of equipment, there may be a single output of several outputs from the power supply. A failure of one of these can result in multiple systems problems depending on what parts of the equipment use what supply.

Check for bad fuses in the secondary circuits - test with an ohmmeter. (I once even found an intermittent fuse!) Try a new fuse of the same ratings. If this one blows immediately, there is a fault in the power supply or one of its loads. See the section: About Fuses, IC Protectors, and Circuit Breakers. The use of a series current limiting resistor - a low wattage light bulb, for example - may be useful to allow you to make measurements without undo risk of damage and an unlimited supply of fuses.

Locate the large electrolytic filter capacitor(s). These will probably be near the power transformer connections to the circuit board with the power supply components. Test for voltage across each of these with power on. If they are in pairs, this may be a dual polarity supply (+/-, very common in audio equipment). Sometimes, two or more capacitors are simply used to provide a higher uF rating. If you find no voltage on one of these capacitors, trace back to determine if the problem is a rectifier diode, bad connection, or bad secondary winding on the power transformer (the latter is somewhat uncommon as the wire is relatively thick, however).

Dried up electrolytic capacitors will result in excessive ripple leading to hum or reduced headroom in audio outputs and possible regulation problems as well. Test with a scope or multimeter on its AC scale (but not all multimeters have DC blocking capacitors on its AC input and these readings may be confused by the DC level). If ripple is excessive - as a guideline if it is more than 10 to 20% of the DC level - then substitute or jumper across with a good capacitor of similar uF rating and at least the same voltage rating.

If you find voltages that are lower than expected, this could be due to bad filter capacitors, an open diode or connection (one side of a full wave rectifier circuit), or excessive load which may be either in the regulator(s), if any, or driven circuitry.

Disconnect the output of the power supply from its load. If the voltage jumps up dramatically (or the fuse now survives or the series light bulb now goes out or glows dimly), then a short or excess load is likely.

If the behavior does not change substantially, the problem may be in the regulator(s). Transistors, zener diodes, resistors, and other discrete components, and IC regulators like LM317s or 7809s can be tested with an ohmmeter or by substitution. The most common failures are shorts for semiconductors, opens for resistors, and no or low output for ICs.

Where the supply uses a hybrid regulator like an STK5481, confirming proper input and then testing each output is usually sufficient to identify a failure. A defective hybrid regulator will likely provide no or very low output on one or more outputs. Confirm by disconnecting the load. Test with any on/off (logic) control in both states.

Uninterruptible Power Supplies (UPSs) and Power Inverters

CAUTION: reread safety guidelines as portions of these devices can be nasty.

Note: inexpensive UPSs and inverters generate a squarewave output so don't be surprised at how ugly the waveform appears if you look at it on a scope. This is probably normal. More sophisticated and expensive units may use a modified sinewave - actually a 3 or 5 level discrete approximation to a sinewave (instead of a 2 level squarewave). The highest quality units will generate a true sinewave using high frequency bipolar pulse width modulation. Don't expect to find this in a $100 K-Mart special, however.

A UPS incorporates a battery charger, lead-acid (usually) storage battery, DC-AC inverter, and control and bypass circuitry.

Note that if finding a UPS that provides surge protection is an important consideration, look for one that runs the output off of the battery at all times rather than bypassing the inverter during normal operation. The battery will act as a nearly perfect filter in so far as short term line voltage variations, spikes, and noise, are concerned.

A DC-AC power inverter used to run line powered equipment from an automotive battery or other low voltage source is similar to the internal inverter in a UPS.

For a unit that appears dead (and the power has not been off for more than its rated holdup time and the outlet is live), first, check for a blown fuse - external or internal. Perhaps, someone was attempting to run their microwave oven off of the UPS or inverter!

(See the section on: "Fuse post mortems" to identify likely failure mode.)

If you find one - and it is blown due to a short circuit - then there are likely internal problems like shorted components. However, if it is blown due to a modest overload, the powered equipment may simply be of too high a wattage for the UPS or inverter - or it may be defective.

Failures of a UPS can be due to:

1. Battery charging circuit - if the battery does not appear to be charging even after an extended time, measure across the battery with the unit both unplugged and plugged in. The voltage should jump up some amount with power on - when it is supposed to be charging. Disconnect the battery and try again if there is no action - the battery may be shorted totally. Check for blown fuses, smoked parts, and bad connections.

2. Battery - deteriorated or abused lead acid batteries are very common. If the battery will not charge or hold a charge, battery problems are likely. A UPS (or any kind of lead-acid battery powered equipment) that lies idle for a long time (say a year or two) without power to top off the battery will likely result in a dead - not salvageable - battery due to sulfation. Symptoms will be: voltage on battery climbs to more than 2.5 V per cell when first put on charge and even after a long charging period, the battery has essentially no capacity. If the battery voltage is at its nominal value - even when the inverter should be running from it (and there is no or low output), then there is a problem in the inverter or its connections or there is excess load.

3. Inverter - troubleshooting is similar to that required for a switchmode power supply. Common problems: shorted power semiconductors, open fusable resistors, dried up electrolytic capacitors, and bad connections. See the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies. A visual inspection may reveal parts that have exploded or lost their smoke.

4. Line bypass circuit (if used) - check for problems in the controller or its standby power supply, or power switchover components, and bad connections.

Here is some additional information on the basics and troubleshooting of uninterruptable power supplies. Note that the following is from someone with a 230 VAC perspective so some aspects of the line circuitry may not apply to U.S.A. models.

(From: Lex Cunningham (lextron@iinet.net.au).)

UPSs come in all shapes and sizes, from 300 VA units for PCs to 3 phase units rated into the hundreds of kVA for use in industrial applications. The most common type readers of the repair newsgroup will come across will be single phase units with ratings up to 3 kVA. These mainly see use in domestic and commercial applications to provide protection for a single PC, a small network of PCs, or a server.

Types of UPS:

There are basically two types of UPS. With the standby type, the input voltage is switched to the output under normal conditions and the control electronics monitor the incoming line. Should the incoming line fail altogether, fall below a set voltage, or rise above a set voltage, the inverter is powered up to support the load. When the line returns to normal, the inverter is turned off and the line is switched back to support the load. The marketing people use some odd terms for the standby type such as Line Interactive. What this means is that the UPS has Automatic Voltage Regulation of the output voltage. This is achieved by using boost and buck windings on the transformer. These windings are switched as necessary to maintain a relatively constant output voltage, even though the input voltage may be high or low.

The on-line type of UPS uses a dual conversion technique to deliver power to the load. The incoming line is converted to DC and then converted back to AC. The inverter runs continuously, hence the term on-line. These have the advantage of removing all of the line noise and no changeover delay. When the incoming line fails, a DC to DC converter is powered up to provide the DC rail required for the DC to AC inverter.

Power Conversion Techniques:

The standby UPS has two sub classes to describe the method of converting the battery supply to AC. The cheapest method is called quasi sine wave which uses pulse width modulation at the line frequency (50/60 Hz) to maintain the inverter output voltage. The output is basically a square wave of variable duty-cycle depending on the load. This square wave is applied to a transformer to obtain the required output voltage. To a switch mode power supply, the wave shape is not all that important.

The more expensive method is known as true sine wave. Pulse width modulation at 15 to 20 kHz is used to reconstruct a sine wave. This type of UPS is used in situations where square waves would cause overheating of electric motors. These are more complex than quasi sine wave units, and hence come at a higher price.

The on-line UPS uses high frequency PWM techniques and provides a sine wave output. The difference from the standby sine wave type is that the modern on-line inverter works directly at the line output voltage, rather than through a step up transformer.

Safety Considerations:

It can not be stressed enough that all UPS's are potential death traps. The line voltage in any country is lethal. Any voltage higher than around 50 V is considered hazardous.

DC Safety:

UPS's using a single 12 V battery can cause injury. The batteries used can supply large currents if short circuited. It is easy to lose a finger if a ring shorts the battery supply. The risk is that the ring becomes hot, causing cauterisation of the blood vessels. With no blood supply, the only solution is amputation.

The other risks of shorted batteries is the potential for the battery case to split open releasing electrolyte, and flying molten metal.

The DC supply of units in the 2 to 3 kVA range from 48 to 96 V. The 96 V units float the battery bank at 110 V, which will electrocute.

On-line units work at high voltages. In Australia, the nominal line voltage is 240 VAC which when rectified, results in power rails of plus and minus 350 VDC. That is a total of some 700 V.

AC Safety:

When working on UPS's, the use of an earth leakage circuit breaker/residual current detector, or whatever they are known as in your part of the world, has to be considered mandatory.

Other Safety:

Some manufacturers, for cost reasons, do not use line monitoring transformers. Instead, high value resistors are used to divide the line voltage to a value suitable for the control electronics. This results in a machine that is technically totally live. Keep a watch out for these ones and test before touching.

Be aware that the ground clip of an oscilloscope probe is earth. Depending on wiring rules, earth may be bonded to neutral at the main switch/fuse panel. This is true in Australia. Use an oscilloscope with differential inputs designed for the job. A suitable alternative is an add on differential input unit in conjunction with a standard scope. The design presented in Elektor Electronics around 1994 works very well and with a bandwidth of 15 MHz, nothing will be missed.

Battery Changing Procedures:

There are a couple of types of UPS that have a strict battery change procedure. Failure to follow correct procedure results in the destruction of the UPS. Both types come from Lantech of Taiwan. This is not to say that only Lantech machines behave in this way. The ALi range from the mid 90's require the battery to be disconnected, and the reservoir capacitors on the main board discharged using a 220 ohm, 5 W resistor. Before reconnecting the battery, the unit must be plugged into the line to precharge the capacitors. Failure to discharge or precharge the capacitors causes destruction of the inverter output devices. This procedure is noted on a sticker inside the unit.

The current AI-UPS range requires reservoir capacitor precharging using a 1K ohm, 1 W resistor between the battery and the main board, however it is good practice to do the discharge part as well. This procedure is only noted on 19 inch rack mount units. There is no warning on stand alone machines.

Common UPS Faults

- **UPS shuts down in backup mode:**

  The most common fault ever seen is sulphated batteries. The constant charging causes the electrolyte to dry out and the lead plates to become lead sulphate. This results in a battery that has a greatly reduced capacity resulting in the UPS shutting down on line failure. To determine a poor battery, check for swelling of the battery case, or do a load test while monitoring the battery voltage. If the battery voltage falls rapidly to below 12 volts, then it is faulty. Also, if the battery charges rapidly from below 12 volts to 13.8 volts, it is faulty. Always replace all batteries in a bank, or the new one(s) will fail quickly.

- **UPS will not start:**

  Most UPS's will not start unless there is sufficient input voltage. Assuming the fuse is not blown or circuit breaker is good, check the input cutout relay. The coils have been known to burn out.

  Even with an input voltage, the UPS will not start if the battery is flat. This can be caused by battery age, a faulty charger, or running the UPS until low voltage shutdown. If possible program the UPS to shut down at 30% remaining capacity as this increases the life of the battery and ensures there is sufficient power to restart when the line is restored.

  The Best Power (Sola in Oz) range of machines will go into fault mode at power up if an internal fault is detected. Two of the causes are flat batteries or the output relay not switching over. The 510 range has a problem with the output relay not switching over. This is caused by an electrolytic in the battery charger circuit failing. This is associated with the auxiliary winding on the transformer. The capacitor fails leaving the relay with insufficient voltage to switch, the microprocessor detects no output voltage and enters fault mode. Replacing the capacitor with a bipolar type capable of handling the high frequency ripple currents solves the problem.

Some UPS's will not work from their front panel controls as they have been programmed into a certain mode to suit shutdown software. This requires the use of a programming utility from the manufacturer to reprogram the unit.

- **UPS stays in backup mode:**

  Check the line monitoring transformer windings. In units without transformers, check the RF chokes and resistors. This particularly applies to Lantech units.

- **Other faults:**

  All faults can be traced using standard fault finding techniques. If the fault simply can not be found, take the unit to your friendly UPS service tech for an opinion. You will be charged for the work, but then the technician likes to eat as well!

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Protection Devices

About Fuses, IC Protectors, and Circuit Breakers

The purpose of fuses and circuit breakers is to protect both the wiring from heating and possible fire due to a short circuit or severe overload and to prevent damage to the equipment due to excess current resulting from a failed component or improper use (i.e., excess volume to loudspeakers).

Fuses use a fine wire or strip (called the element) made from a metal which has enough resistance (more than for copper usually) to be heated by current flow and which melts at a relatively low well defined temperature. When the rated current is exceeded, this element heats up enough to melt (or vaporize). How quickly this happens depends on the extent of the overload and the type of fuse.

Fuses found in consumer electronic equipment are usually cartridge type consisting of a glass (or sometimes ceramic) body and metal end caps. The most common sizes are 1-1/4" mm x 1/4" or 20 mm x 5 mm. Some of these have wire leads to the end caps and are directly soldered to the circuit board but most snap into a fuse holder or fuse clips. Miniature types include: Pico(tm) fuses that look like green 1/4 W resistors or other miniature cylindrical or square varieties, little clear plastic buttons, etc. Typical circuit board markings are F or PR.

IC protectors are just miniature fuses specifically designed to have a very rapid response to prevent damage to sensitive solid state components including intergrated circuits and transistors. These usually are often in TO92 plastic cases but with only 2 leads or little rectangular cases about .1" W x .3" L x .2" H. Test just like a fuse. These may be designated ICP, PR, or F.

Circuit breakers may be thermal, magnetic, or a combination of the two. Small (push button) circuit breakers for electronic equipment are most often thermal - metal heats up due to current flow and breaks the circuit when its temperature exceeds a set value. The mechanism is often the bending action of a bimetal strip or disc - similar to the operation of a thermostat. Flip type circuit breakers are normally magnetic. An electro- magnet pulls on a lever held from tripping by a calibrated spring. These are not usually common in consumer equipment (but are used at the electrical service panel).

At just over the rated current, it may take minutes to break the circuit. At 10 times rated current, the fuse may blow or circuit breaker may open in milliseconds.

The response time of a 'normal' or 'rapid action' fuse or circuit breaker depends on the instantaneous value of the overcurrent.

A 'slow blow' or 'delayed action' fuse or circuit breaker allows instantaneous overload (such as normal motor starting) but will interrupt the circuit quickly for significant extended overloads or short circuits. A large thermal mass delays the temperature rise so that momentary overloads are ignored. The magnetic type breaker adds a viscous damping fluid to slow down the movement of the tripping mechanism.

Fuse Post Mortems

Quite a bit can be inferred from the appearance of a blown fuse if the inside is visible as is the case with a glass cartridge type. One advantage to the use of fuses is that this diagnostic information is often available!

A fuse which has an element that looks intact but tests open may have just become tired with age. Even if the fuse does not blow, continuous cycling at currents approaching its rating or instantaneous overloads results in repeated heating and cooling of the fuse element. It is quite common for the fuse to eventually fail when no actual fault is present.

A fuse where the element is broken in a single or multiple locations blew due to an overload. The current was probably more than twice the fuse's rating but not a dead short.

A fuse with a blackened or silvered discoloration on the glass where the entire element is likely vaporized blew due to a short circuit.

This information can be of use in directly further troubleshooting.

Fuse or Circuit Breaker Replacement

As noted, sometimes a fuse will blow for no good reason. Replace fuse, end of story. In this situation, or after the problem is found, what are the rules of safe fuse replacement? It is inconvenient, to say the least, to have to wait a week until the proper fuse arrives or to venture out to Radio Shack in the middle of the night.

Even with circuit breakers, a short circuit may so damage the contacts or totally melt the device that replacement will be needed.

Four parameters characterizes a fuse or circuit breaker:

1. Current rating - this should not be exceeded (you have heard about not putting pennies in fuse boxes, right?)

(The one exception to this rule is if all other testing fails to reveal which component caused the fuse to blow in the first place. Then, and only then, putting a larger fuse in or jumpering across the fuse **just for testing** will allow the faulty component to identify itself by smoking or blowing its top!) A smaller current rating can safely be used but depending on how close the original rating was to the actual current, this may blow immediately.

2. Voltage rating - this is the maximum safe working voltage of the circuit (including any inductive spikes) which the device will safety interrupt. It is safe to use a replacement with equal or high voltage rating.

3. Type - normal, fast blow, slow blow, etc. It is safe to substitute a fuse or circuit breaker with a faster response characteristic but there may be consistent or occasional failure mostly during power-on. The opposite should be avoided as it risks damage to the equipment as semiconductors tend to die quite quickly.

4. Mounting - it is usually quite easy to obtain an identical replacement.

   However, as long as the other specifications are met, soldering a normal 1-1/4" (3AG) fuse across a 20 mm fuse is perfectly fine, for example. Sometimes a fuse will have wire leads and be soldered directly onto the circuit board. However, your own wires can be carefully soldered to the much more common cartridge type to create a suitable replacement.

Comments on Importance of Thermal Fuses and Protectors

Like a normal fuse or circuit breaker, a thermal fuse or thermal protector provides a critical safety function. Therefore, it is extremely ill advised to just short it out if it fails. Some designs even make this option extra tempting by providing an easy way to bypass even one buried inside a power transformer - using an additional, normally unused terminal.

For testing, it is perfectly acceptable to temporarily short out the device to see if the equipment then operates normally without overheating. However, while these fuses do sometimes just fail on their own, most likely, there was another cause. If you know what it was - you were trying to charge a shorted battery pack, using your window fan to mix cement, or something was shorted externally, then the fuse served its protective function and the equipment is fine. IT SHOULD BE REPLACED WITH THE SAME TYPE or the entire transformer, motor, or whatever it was in should be replaced! This is especially critical for unattended devices. Otherwise, especially with unattended devices, you have a situation where if the overload occurred again or something else failed, the equipment could overheat to the point of causing a fire - and your insurance company may refuse to cover the claim if they find that a change was made to the circuit. And even for portable devices like blow dryers and portable power tools, aside from personal safety should the device malfunction, the thermal protector is there to prevent damage to the equipment itself - don't leave it out!

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Transformers

Common Types of Transformers

A transformer consists of a laminated iron or ferrite core and 2 or more insulated windings that are most often not connected to each other directly. If one set of windings is used as the input for AC power or an audio signal (the 'primary' winding), the voltage appearing on each of the other windings (the 'secondary' winding(s)) will be related by the ratio of the number of turns on each of the windings. However, you don't get something for nothing: The current is related by the inverse of this ratio so the power doesn't change (except due to unavoidable losses).

Transformers are used in nearly every type of electronic equipment both for power and signals, and throughout the electrical distribution network to optimize the voltage/current used on each leg of the journey from the power plant to the user.

The types we are interested in with respect to household appliances, power tools, and consumer electronic equipment are most often use to convert the AC line voltage to some other value, lower or higher:

1. Low voltage power transformer are found in AC wall adapters and electronic equipment as part of their power supplies to generate 1 or more DC voltages to run the device, recharge its batteries, etc. Their outputs are typically between 2 and 48 VAC but almost any other value is possible.

2. High voltage power transformers are found in microwave ovens, old TVs and audio equipment based on vacuum tubes, oil burner ignitions, and some neon signs. Their output can go as high as 15 kV or more.

3. Flyback (or LOPT), inverter, and other more specialized transformers are driven by a high frequency oscillator or chopper in various equipment like TVs and monitors (HV, LV, and other power supplies), PCs and some of their peripherals, electronic flash units. Note that these will NOT operate from the AC line directly and are therefore useless unless driven by a proper electronic circuit.

There are also a couple of other common types of AC line operated transformers used in servicing:

4. Isolation transformers are wound 1:1 so that the output voltage is the same as the input voltage. However, with no direct connection between windings, equipment can be tested with less risk of shock.

5. Variable transformers (or "Variac") allow the output voltage to be adjusted between 0 and full (or slightly above) line voltage which is useful for testing purposes where the behavior of a piece of equipment is being determined.

See the document: Troubleshooting of Consumer Electronic Equipment for more information on these types of transformers.

Testing a Power Transformer

Here are some simple tests to perform where you want to determine if a used (or new) power transformer with known specifications is actually good:

1. Look for obvious signs of distress. Smell it to determine if there is any indication of previous overheating, burning, etc.

2. Plug it in and check for output voltages to be reasonably close (probably somewhat high) to what you expect.

3. Leave it on for awhile. It may get anywhere from just detectable to moderately warm but not to hot to touch and it shouldn't melt down, smoke, or blow up. Needless to say, if it does any of the latter, the tests are concluded!

4. Find a suitable load based on: R = V/I from the specifications and make sure it can supply the current without overheating. The voltage should also not drop excessively between no and full load (but this depends on the design, quality of constructions, whether you got it at Radio Shack :-), etc.

Identifying the Connections on an Unknown Power Transformer

Start with a good multimeter - DMM on the lowest ohms scale or VOM on the X1 resistance range. (You will need to be able to measure down to .1 ohms for many of these.) This will permit you to map the windings.

First, identify all connections that have continuity between them. Except for the possible case of a water soaked transformer with excessive leakage, any reading less than infinity on the meter is an indication of a connection. The typical values will be between something very close to 0 ohms and 100 ohms.

Each group of connected terminals represents one winding. The highest reading for each group will be between the ends of the winding; others will be lower. With a few measurements and some logical thinking, you will be able to label the arrangement ends and taps of each winding.

Once you do this, applying a low voltage AC input (from another power transformer driven by a Variac) will enable you to determine voltage ratios. Then, you may be able to make some educated guesses as to the primary and secondary. Often, primary and secondary windings will exit from opposite sides of the transformer.

For typical power transformers, there will be two primary wires but international power transformers may have multiple taps as well as a pair or primary windings (possibly with multiple taps) for switching between 110/115/120 VAC and 220/230/240 VAC operation. Typical color codes for the primary winding(s) will be black or black with various color stripes. Almost any colors can be used for secondary windings. Stripes may indicate center tap connections but not always.

Note: for safety, use the Variac and another isolated transformer for this.

Here is a more specific example:

> "I recently purchased at a local electronics surplus store at 35volt center tap 2A transformer for a model railroad throttle (power supply). The secondary wires are red-red/yellow-red and I understand how to hook up the secondary in order to get two 17.5 volt sources. My dilemma is the primary. There are SIX black wires (black, black/red, black/blue, black/green, black/yellow, black/grey). Two of the wires were already stripped and I hooked these up to 115 VAC but no voltage on the secondary side. Does anyone have any ideas? I don't know the manufacturer, the transformer is in an enclosed case (no open windings). I also don't know if it has multiple primaries that must be connected or if it has five taps for different input voltages. Any ideas????"

Of course, I assume you did measure on the AC scale on the secondary! :-) Sorry, have to confirm the basics. My natural assumption would also be that the striped wires were the ones you needed.

Here is a suggestion:

1. Use an ohmmeter to determine which sets of primary wires are connected. The resistances will be very low but you should also be able to determine which are just taps as the resistance between them will be very low.

2. Since you already know what the secondary should be, power the secondary from a low voltage AC source like another transformer. Then measure across each pair of primary wires. You should be able to determine which are the main wires and which are the taps.

Using a combination of the above procedures should enable you to pretty fully determine what is going on. I suspect that you have a pair of primary windings that can be connected either series (for 220) or parallel (110) and a tap but who knows. Do the tests. If in doubt, don't just connect it to 110 - you could end up with a melt-down. Post your findings.

Determining Unknown Connections on International Power Transformers

Most likely, you can figure this out if you can identify the input connections.

There will be two primary windings (resistance between the two will be infinite). Each of these may also have additional taps to accommodate various slight variations in input voltage. For example, there may be taps for 110/220, 115/230, 120/240, etc.

For the U.S. (110 VAC), the two primary windings will be wired in parallel. For overseas (220 VAC) operation, they will be wired in series. When switching from one to the other make sure you get the phases of the two windings correct - otherwise you will have a short circuit! You can test for this when you apply power - leave one end of one winding disconnected and measure between these two points - there should be close to zero voltage present if the phase is correct. If the voltage is significant, reverse one of the windings and then confirm.

A multimeter on the lowest resistance scale should permit you to determine the internal arrangement of any taps on the primaries and which sets of secondary terminals are connected to each winding. This will probably need to be a DMM as many VOMs do not have low enough resistance ranges.

It is best to test with a Variac so you can bring up the voltage gradually and catch your mistakes before anything smokes.

You can then power it from a low voltage AC source, say 10 VAC from your Variac or even an AC wall adapter, to be safe and make your secondary measurements. Then scale all these voltage readings appropriately.

Determining Power (VA) Ratings of Unknown Transformers

For a transformer with a single output winding, measuring temperature rise isn't a bad way to go. Since you don't know what an acceptable temperature is for the transformer, a conservative approach is to load it - increase the current gradually - until it runs warm to the touch after an extended period (say an hour) of time.

Where multiple output windings are involved, this is more difficult since the safe currents from each are unknown.

(From: Greg Szekeres (szekeres@pitt.edu).)

Generally, the VA rating of individual secondary taps can be measured. While measuring the no load voltage, start to load the winding until the voltage drops 10%, stop measure the voltage and measure or compute the current. 10% would be a very safe value. A cheap transformer may compute the VA rating with a 20% drop. 15% is considered good. You will have to play around with it to make sure everything is OK with no overheating, etc.

(From: James Meyer (jimbob@acpub.duke.edu).)

With the open circuit voltage of the individual windings, and their DC resistance, you can make a very reasonable assumption as to the relative amounts of power available at each winding.

Set up something like a spread-sheet model and adjust the output current to make the losses equal in each secondary. The major factor in any winding's safe power capability is wire size since the volts per turn and therefore the winding's length is fixed for any particular output voltage.

Determining the Ratings of a Fried Power Transformer

A power transformer can die in a number of ways. The following are the most common:

- Primary open. This usually is the result of a power surge but could also be a short on the output leading to overheating.

  Since the primary is open, the transformer is totally lifeless.

  First, confirm that the transformer is indeed beyond redemption. Some have thermal or normal fuses under the outer layer of insulating tape or paper.

- Short in primary or secondary. This may have been the result of overheating or just due to poor manufacturing but for whatever reason, two wires are touching. One or more outputs may be dead and even those that provide some voltage may be low.

  The transformer may now blow the equipment fuse and even if it does not, probably overheats very quickly.

  First, make sure that it isn't a problem in the equipment being powered. Disconnect all outputs of the transformer and confirm that it still has nearly the same symptoms.

There are several approaches to analyzing the blown transformer and/or identifying what is needed as a replacement:

- If you have the time and patience and the transformer is not totally sealed in Epoxy or varnish, disassembling it and counting the number of turns of wire for each of the windings may be the surest approach. This isn't as bad as it sounds. The total time required from start to dumping the remains in the trash will likely be less than 20 minutes for a small power transformer.

  Remove the case and frame (if any) and separate and discard the (iron) core. The insulating tape or paper can then be pealed off revealing each of the windings. The secondaries will be the outer ones. The primary will be the last - closest to the center. As you unwind the wires, count the number of full turns around the form or bobbin.

By counting turns, you will know the precise (open circuit) voltages of each of the outputs. Even if the primary is a melted charred mass, enough of the wire will likely be intact to permit a fairly accurate count. Don't worry, an error of a few turns between friends won't matter.

Measuring the wire size will help to determine the relative amount of current each of the outputs was able to supply. The overall ratings of the transformer are probably more reliably found from the wattage listed on the equipment nameplate.

If you cannot do this for whatever reason, some educated guesswork will be required. Each of the outputs will likely drive either a half wave (one diode), full wave (2 diodes if it has a centertap), or bridge (module or 4 diodes). For the bridge, there might be a centertap as well to provide both a positive and negative output.

- You can sometimes estimate the voltage needed by looking at the components in the power supply - filter cap voltage ratings and regulators.
- The capacitor voltage ratings will give you an upper bound - they are probably going to be at least 25 to 50 percent above the PEAK of the input voltage.
- Where there are regulators, their type and ratings and/or the circuit itself may reveal what the expected output will be and thus the required input voltage to the regulators. For example, if there is a 7805 regulator chip, you will know that its input must be greater than about 7.5 V (valleys of the ripple) to produce a solid 5 V output.
- If there are no regulators, then the ICs, relays, motors, whatever, that are powered may have voltage and current ratings indicating what power supply is expected (min-max).

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Transformer Troubleshooting and Repair

Transformer Fault Diagnosis

Some power transformers include a thermal fuse under the outer layers of insulation. In many cases, an overload will result in a thermal fuse opening and if you can get at it, replacement will restore the transformer to health. Also see the section: Comments on Importance of Thermal Fuses and Protectors.

Where an open thermal fuse is not the problem, aside from bad solder or crimp connections where the wire leads or terminals connect to the transformer windings, anything else will require unwrapping one or more of the windings to locate an open or short. Where a total melt-down has occurred and the result is a charred hunk of copper and iron, even more drastic measures would be required.

In principle, it would be possible to totally rebuild a faulty transformer. All that is needed is to determine the number of turns, direction, layer distribution and order for each winding. Suitable magnet (sometimes called motor wire) is readily available.

However, unless you really know what you are doing and obtain the proper insulating material and varnish, long term reliability and safety are unknown. Therefore, I would definitely recommend obtaining a proper commercial replacement if at all possible.

See the section: Rewinding Power Transformers.

However, DIY transformer construction is nothing new:

(From: Robert Blum (rfblum@worldnet.att.net).)

I have a book from the Government Printing Office . The title is: "Information for the Amateur Designer of Transformers for 25 to 60 cycle circuits" by Herbert B. Brooks. It was issued June 14, 1935 so I do not know if it is still in print. At the time I got it it cost $.10.

(From: Mark Zenier (mzenier@netcom.com).)

"Practical Transformer Design Handbook" by Eric Lowdon. Trouble is, last I checked it's out of print. Published by both Sams and Tab Professional Books.

(From: Paul Giancaterino (PAULYGS@prodigy.net).)

I found a decent article on the subject in Radio Electronics, May 1983. The article explains the basics, including how to figure what amps your transformer can handle and how to size the wiring.

Rewinding Power Transformers

Here is some information and recommendations from people who have successfully repaired power transformers that have self destructed:

(From: colin@rowec.screaming.net.)

DISCLAIMER: There is a safety aspect of mains transformers. Use this information entirely at your own risk.

I have wound and re wound several transformers. When I was first into Electronics (at about 12), I rewound a line output transformer of a colour TV. I reused the wire but I had to re insulate it by suspending it all around the garage and painting it with a special paint I had found. I would never do this again or suggest anyone else do it like this either! but it outlasted the tube.

Since then as an electronics engineer I have wound many SMPS transformers and rewound some working mains transformers to get different voltages.

If you do wind a transformer yourself you need a lot of patience and to be able to keep count of the number of turns (not as easy as it sounds) and strong fingers.

However, the mains transformers that I have come across that have blown up have been beyond repair. This is because the plastic former or bobbin usually melts with the heat that is generated by the fault current that flows when the insulation on the windings gives up. I would not attempt to try and wind a small mains transformer without the coil former as it would be too difficult to SAFELY keep the windings insulated from each other and get the required amount of wire to fit.

If the windings are severely shorted it would seem as though your transformer has suffered this fate. You would definitely have to replace all the windings.

There is of course the problem of finding out what voltage/current the windings were in the first place.

If the machine is only used at one input voltage you may be able to get away with one primary winding (where there were two before - a slight simplification but the wire will need to be slightly thicker - lower by 3 AWG numbers).

Apart from obtaining a direct replacement the best bet would be to find a transformer that has outputs that are the right voltages and sufficient current. This may be tricky and it may not fit inside the case. there are many places that sell of the shelf transformers. maybe you would need two transformers to get the right combination of voltages.

If you are very luck you might get just what you want from a junk shop. or from a piece of junk equipment.

However if you are determined to try to wind a transformer there are several possibilities.

The most critical aspect of winding a mains transformer is the primary winding as the wire used is incredibly fine on small transformers and is easily damaged or even broken and good insulation is of the utmost importance. Also there is a heck of a lot wire and it becomes impracticable unless you are prepared to set up some sort of rig. I would suggest that you consider the alternatives to winding this yourself which are :-

- Buy a kit. Maplin in the UK do these in various sizes. the primary winding comes ready wound, you just need the wire for the secondarys. It comes with the information needed to calculate the number of turns and diameter of wire to use from the voltage and current you need.

- Rewind a healthy transformer. I have done this several times. It is imperative to dismantle the transformer without damaging the primary winding insulation in any way. This is most difficult to do. Normally the 'E' and 'I' laminations are tightly packed into the bobbin and the first one to get out gets really bent up. It is unlikely that you you would be able to do this successfully on a your first try. If it is sealed with a lacquer or worse a hard setting sealant then it is almost impossible. once you have removed the laminations you have to get at the windings you are going to replace. sometimes a two piece plastic cover clips over the bobbin.

You must of course use a transformer that is big enough and has the correct primary voltage. given that the original failed and hand made transformers are never as compact as manufactured ones it would be best to use the biggest transformer that you can possible get to fit. For safety sake only use a modern transformer that is in good condition.

You may well be able to use one or more of the existing windings but you must bear in mind that each winding takes up an amount of space proportional to its current X voltage.

To work out the number of turns and size of wire in the windings you need to know the turns per volt of the new transformer. this can be found by counting one of the secondary windings and dividing by its rated voltage. The number of turns you need is this number times the voltage you want. The size of wire is determined by the current rating. use the wire with the same area per amp as the existing winding. The ends of the windings must be terminated properly. Use enameled copper wire. the enamel might need to be scraped of to enable soldering unless it is the self fluxing type and you have a very hot soldering iron. usually there are tags to solder the ends to.

Also, if it is in something like a tape recorder it most probably needs shielding.

It is up to you to ensure that the finished transformer is safe. The best way to test the insulation is to test with a high voltage (a few kV) between primary and secondary and then between the core and each winding and check there is no leakage current. with mains applied check that there is correct voltages at the outputs. check that the transformer does not get too hot. All transformers get hot, some too hot to touch, but if after several hours its so hot that you skin sticks to it when you touch it it wont last very long !!

There are various places to get the EC wire and junk transformers, a search on the internet would be a good place to start.

(From: Bill Rothanburg (william.rothanburg@worldnet.att.net).)

I've done this. It was more of an intellectual challenge, rather than something practical, but it can be done. Some requirements:

- A transformer which can be easily disassembled. If the transformer is saturated with varnish, expect problems.
- A lot of patience.
- A very good memory.
- A lot of patience.
- Reasonably good mechanical skills.

I had a relatively easy transformer to work with - single primary, dual secondaries. The windings had not been saturated with varnish, so I was able to unwind them COUNTING THE TURNS. Did I mention that this required a great deal of patience? I was able to determine the wire gauge from the old windings.

The transformer had overheated to the point the plastic bobbin was garbage. I was able to fabricate a replacement using fish paper and lots of varnish.

To assist in rewinding I built a "tool" to help - Actually a crank through a piece of wood. The bobbin was held in place by a couple of nuts and spacers. The actual rewinding was the easiest part of the process.

If I were to try this again, I would definitely use a thermal protector in the transformer.

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Batteries and Battery Packs

Battery Technology

The desire for portable power seems to be increasing exponentially with the proliferation of notebook and palmtop computers, electronic organizers, PDAs, cellular phones and faxes, pagers, pocket cameras, camcorders and audio cassette recorders, boomboxes - the list is endless.

Two of the hottest areas in engineering these days are in developing higher capacity battery technologies (electrochemical systems) for rechargeable equipment and in the implementation of smart power management (optimal charging and high efficiency power conversion) for portable devices. Lithium and Nickel Metal Hydride are among the more recent additions to the inventory of popular battery technologies. A variety of ICs are now available to implement rapid charging techniques while preserving battery life. Low cost DC-DC converter designs are capable of generating whatever voltages are required by the equipment at over 90% efficiency

However, most of the devices you are likely to encounter still use pretty basic battery technologies - most commonly throwaway Alkaline and Lithium followed by rechargeable Nickel Cadmium or Lead-Acid. The charging circuits are often very simple and don't really do the best job but it is adequate for many applications.

For more detailed information on all aspects of battery technology, see the articles at:

- Sci.Electronics Battery FAQs

Many major battery manufacturers have extensive technical information on their Web sites, though not all of it may be unbiased.

There is more on batteries than you ever dreamed of ever needing. The sections below represent just a brief introduction.

Battery Basics

A battery is, strictly speaking, made up of a number of individual cells (most often wired in series to provide multiples of the basic cell voltage for the battery technology - 1.2, 1.5, 2.0, or 3.0 V are most common). However, the term is popularly used even for single cells.

Four types of batteries are typically used in consumer electronic equipment:

1. Alkaline - consisting of one or more primary cells with a nominal terminal voltage of 1.5 V. Examples are AAA, AA, C, D, N, 9V ('transistor'), lantern batteries (6V or more), etc. There are many other available sizes including miniature button cells for specialty applications like clocks, watches, calculators, and cameras. In general recharging of alkaline batteries is not practical due to their chemistry and construction. Exceptions which work (if not entirely consistently as of this writing) are the rechargeable Alkalines (e.g., 'Renewals'). Advantages of alkalines are high capacity and long shelf life. These now dominate the primary battery marketplace largely replacing the original carbon-zinc and heavy duty types. Note that under most conditions, it not necessary to store alkaline batteries in the 'fridge to obtain maximum shelf life.

2. Lithium - these primary cells have a much higher capacity than alkalines. The terminal voltage is around 3

volts per cell. These are often used in cameras where their high cost is offset by the convenience of long life and compact size. Lithium batteries in common sizes like 9V are beginning to appear. In general, I would not recommend the use of lithiums for use in applications where a device can be accidentally left on - particularly with kids' toys. Your batteries will be drained overnight whether a cheap carbon zinc or a costly lithium. However, for smoke alarms, the lithium 9V battery (assuming they hold up to their longevity claims) is ideal as a 5-10 year service life without attention can be expected.

3. Nickel Cadmium (NiCd) - these are the most common type of rechargeable battery technology use in small electronic devices. They are available in all the poplar sizes. However, their terminal voltage is only 1.2 V per cell compared to 1.5 V per cell for alkalines (unloaded). This is not the whole story, however, as NiCds terminal voltage holds up better under load and as they are discharged. Manufacturers claim 500-1000 charge-discharge cycles but expect to achieve these optimistic ratings only under certain types of applications. In particular it is usually recommended that NiCds should not be discharged below about 1 V per cell and should not be left in a discharged state for too long. Overcharging is also an enemy of NiCds and will reduce their ultimate life. An electric shaver is an example of a device that will approach this cycle life as it is used until the battery starts to poop out and then immediately put on charge. If a device is used and then neglected (like a seldom used printing calculator), don't be surprised to find that the NiCd battery will not charge or will not hold a charge next time the calculator is used.

4. Lead Acid - similar to the type used in your automobile but generally specially designed in a sealed package which cannot leak acid under most conditions. These come in a wide variety of capacities but not in standard sizes like AA or D. They are used in some camcorders, flashlights, CD players, security systems, emergency lighting, and many other applications. Nominal terminal voltage is 2.0 V per cell. These batteries definitely do not like to be left in a discharged condition (even more so than NiCds) and will quickly become unusable if left that way for any length of time.

Battery Chargers

The (energy storage) capacity, C, of a battery is measured in ampere hours denoted a A-h (or mA-h for smaller types). The charging rate is normally expressed as a fraction of C - e.g., .5 C or C/2.

In most cases, trickle charging at a slow rate - C/100 to C/20 - is easier on batteries. Where this is convenient, you will likely see better performance and longer life. Such an approach should be less expensive in the long run even if it means having extra cells or packs on hand to pop in when the others are being charged. Fast charging is hard on batteries - it generates heat and gasses and the chemical reactions may be less uniform.

Each type of battery requires a different type of charging technique.

1. NiCd batteries are charged with a controlled (usually constant) current. Fast charge may be performed at as high as a .5-1C rate for the types of batteries in portable tools and laptop computers. (C here is the amp-hour capacity of the battery. A .5C charge rate for a 2 amp hour battery pack would use a current equal to 1 A, for example.) Trickle charge at a 1/20-1/10C rate. Sophisticated charges will use a variety of techniques to sense end-of-charge. Inexpensive chargers (and the type in many cheap consumer electronics devices) simply trickle charge at a constant current.

   Rapid chargers for portable tools, laptop computers, and camcorders, do at least sense the temperature rise which is one indication of having reached full charge but this is far from totally reliable and some damage is probably unavoidable as some cells reach full charge before others due to slight unavoidable differences in capacity. Better charging techniques depend on sensing the slight voltage drop that occurs when full charge is reached but even this can be deceptive. The best power management techniques use a combination of sensing and precise control of charge to each cell, knowledge about the battery's characteristics, and state of charge.

While slow charging is better for NiCds, long term trickle charging is generally not recommended.

Problems with simple NiCd battery chargers are usually pretty easy to find - bad transformer, rectifiers, capacitors, possibly a regulator. Where temperature sensing is used, the sensor in the battery pack may be defective and there may be problems in the control circuits as well. However, more sophisticated power management systems controlled by microprocessors or custom ICs and may be impossible to troubleshoot for anything beyond obviously bad parts or bad connections.

2. Lead acid batteries are charged with a current limited but voltage cutoff technique. Although the terminal voltage of a lead-acid battery is 2.00 V per cell nominal, it may actually reach more than 2.5 V per cell while charging. For an automotive battery, 15 V is still within the normal range of voltages to be found on the battery terminals when the engine (and alternator) are running.

   A simple charger for a lead-acid battery is simply a stepped down rectified AC source with some resistance to provide current limiting. The current will naturally taper off as the battery voltage approaches the peaks of the charging waveform. This is how inexpensive automotive battery chargers are constructed. For small sealed lead-acid batteries, an IC regulator may be used to provide current limited constant voltage charging. A 1 A (max) charger for a 12 V battery may use an LM317, 3 resistors, and two capacitors, running off of a 15 V or greater input supply.

   Trickle chargers for lead-acid batteries are usually constant voltage and current tapers off as the battery reaches full charge. Therefore, leaving the battery under constant charge is acceptable and will maintain it at the desired state of full charge.

   Problems with lead-acid battery chargers are usually pretty easy to diagnose due to the simplicity of most designs.

Dave's Comments on Building Charger for Small Lead-Acid Batteries

The following applies to the sort of lead-acid batteries found in some camcorders and other portable equipment:

(From: Dave Martindale (davem@cs.ubc.ca).)

The simple way is to build a power supply that outputs 13.8 volts regulated, with a current limit of 0.5 A. 13.8 V can be left connected to the battery forever without damage - this is called a float charge. The 0.5 A current limit protects the battery from drawing too much current and overheating if it's been deeply discharged. This sort of charger will get the battery back up to 80% charge within a few hours, so it's fine for most uses.

However, when designing it, make sure the charger doesn't self-destruct if the input voltage goes away (due to AC power failure) while still connected to the battery. With a standard series regulator, when the input power fails the whole battery voltage gets applied to the base- emitter junction of the output transistor in reverse. Many transistors are only specified to withstand about 6 V reverse base-emitter voltage, so with this design your charger will be toast at the first power failure.

If you want higher-performance charging, there are special charge controller chips that provide 3 or more charge phases. They are:

- Constant current charge at maximum safe current (see battery spec sheet) until the voltage rises to about 14.5 V.
- Constant voltage charge at 14.5 V until the current drops to a fraction of the initial current limit.
- Float charge at 13.65 V after that.

By using the 14.5 V instead of 13.8 V for the initial charge voltage, this type of charger gets the battery back up to 90% charged in considerably less time. But if you only care about charging overnight, you don't need the extra complexity.

On the other hand, NiCd batteries can safely be charged in less than an hour with suitable electronics. Lead-acid simply can't be recharged that fast.

Substituting NiCds for Alkalines

First note that rechargeable batteries are NOT suitable for safety critical applications like smoke detectors unless they are used only as emergency power fail backup (the smoke detector is also plugged into the AC line) and are on continuous trickle charge). NiCds self discharge (with no load) at a rate which will cause them to go dead in a month or two.

For many toys and games, portable phones, tape players and CD players, and boomboxes, TVs, palmtop computers, and other battery gobbling gadgets, it may be possible to substitute rechargeable batteries for disposable primary batteries. However, NiCds have a lower terminal voltage - 1.2V vs. 1.5V - and some devices will just not be happy. In particular, tape players may not work well due to this reduced voltage not being able to power the motor at a constant correct speed. Manufacturers may specifically warn against their use. Flashlights will not be as bright unless the light bulb is also replaced with a lower voltage type. Other equipment may perform poorly or fail to operate entirely on NiCds. When in doubt, check your instruction manual. And, there is a slight, but non-zero chance that some equipment may actually be damaged. This might occur if its design assumed something about the internal resistance of the batteris; the resistance is much lower for NiCds than Alkalines.

Can a Large Electrolytic Capacitor be Substituted for a NiCd?

The quick answer is: probably not. The charger very likely assumes that the NiCds will limit voltage. The circuits found in many common appliances just use a voltage source significantly higher than the terminal voltage of the battery pack through a current limiting resistor. If you replace the NiCd with a capacitor and the voltage will end up much higher than expected with unknown consequences. For more sophisticated chargers, the results might be even more unpredictable.

Furthermore, even a SuperCap cannot begin to compare to a small NiCd for capacity. A 5.5 V 1 F (that's Farad) capacitor holds about 15 W-s of energy which is roughly equivalent to a 5 V battery of 3 A-s capacity - less than 1 mA-h. A very tiny NiCd pack is 100 mA-h or two orders of magnitude larger.

Determining the Actual Capacity of a NiCd Battery Pack

When a battery pack is not performing up to expectations or is not marked in terms of capacity, here are some comments on experimentally determining the A-h rating.

When laying eggs, start with a chicken. Actually, you have to estimate the capacity so that charge and discharge rates can be approximated. However, this is usually easy to do with a factor of 2 either way just be size:

Size of cells	Capacity range, A-h
AAA	.2 - .4
AA	.4 - 1
C	1 - 2
D	1 - 5
Cordless phone	.1 - .3
Camcorder	1 - 3+
Laptop computer	1 - 5+

First, you must charge the battery fully. For a battery that does not appear to have full capacity, this may be the only problem. Your charger may be cutting off prematurely due to a fault in the charger and not the battery. This could be due to dirty or corroded contacts on the charger or battery, bad connections, faulty temperature sensor or other end-of-charge control circuitry. Monitoring the current during charge to determine if the battery is getting roughly the correct A-h to charge it fully would be a desirable first step. Figure about 1.2 to 1.5 times the A-h of the battery capacity to bring it to full charge.

Then discharge at approximately a C/20 - C/10 rate until the cell voltages drops to about 1 V (don't discharge until flat or damage may occur). Capacity is calculated as average current x elapsed time since the current for a NiCd will be fairly constant until very near the end.

NiCd Batteries and the Infamous 'Memory Effect'

Whether the NiCd 'memory effect' is fact or fiction seems to depend on one's point of view and anecdotal evidence. What most people think is due to the memory effect is more accurately described as voltage depression - reduced voltage (and therefore, reduced power and capacity) during use.

(The next section is from: Bob Myers (myers@fc.hp.com) and are based on a GE technical note on NiCd batteries.)

The following are the most common causes of application problems wrongly attributed to 'memory':

1. Cutoff voltage too high - basically, since NiCds have such a flat voltage vs. discharge characteristic, using voltage sensing to determine when the battery is nearly empty can be tricky; an improper setting coupled with a slight voltage depression can cause many products to call a battery "dead" even when nearly the full capacity remains usable (albeit at a slightly reduced voltage).

2. High temperature conditions - NiCds suffer under high-temp conditions; such environments reduce both the charge that will be accepted by the cells when charging, and the voltage across the battery when charged (and the latter, of course, ties back into the above problem).

3. Voltage depression due to long-term overcharge - Self-explanatory. NiCds can drop 0.1-0.15 V/cell if

exposed to a long-term (i.e., a period of months) overcharge. Such an overcharge is not unheard-of in consumer gear, especially if the user gets in the habit of leaving the unit in a charger of simplistic design (but which was intended to provide enough current for a relatively rapid charge). As a precaution, I do NOT leave any of my NiCd gear on a charger longer than the recommended time UNLESS the charger is specifically designed for long-term "trickle charging", and explicitly identified as such by the manufacturer.

4. There are a number of other possible causes listed in a "miscellaneous" category; these include -

   - Operation below 0 degrees C.
   - High discharge rates (above 5C) if not specifically designed for such use.
   - Inadequate charging time or a defective charger.
   - One or more defective or worn-out cells. They do not last forever.

   To close with a quote from the GE note:

   > "To recap, we can say that true 'memory' is exceedingly rare. When we see poor battery performance attributed to 'memory', it is almost always certain to be a correctable application problem. Of the problems noted above, Voltage Depression is the one most often mistaken for 'memory'.....

   This information should dispel many of the myths that exaggerate the idea of a 'memory' phenomenon."

Memory Effect in NiMH Batteries?

The party line is that Nickel-Metal-Hydride batteries do not have any memory effect. Perhaps, perhaps not. See HiMH Batteries, Memory, and Thermal Runaway for one person's test results and other information.

Care and Feeding of NiCds

Here are six guidelines to follow which will hopefully avoid voltage depression or the memory effect or whatever:

(Portions of the following guidelines are from the NiCd FAQ written by: Ken A. Nishimura (KO6AF))

1. DON'T deliberately discharge the batteries to avoid memory. You risk reverse charging one or more cell which is a sure way of killing them.

2. DO let the cells discharge to 1.0V/cell on occasion through normal use.

3. DON'T leave the cells on trickle charge for long times, unless voltage depression can be tolerated.

4. DO protect the cells from high temperature both in charging and storage.

5. DON'T overcharge the cells. Use a good charging technique. With most inexpensive equipment, the charging circuits are not intelligent and will not terminate properly - only charge for as long as recommended in the user manual.

6. DO choose cells wisely. Sponge/foam plates will not tolerate high charge/discharge currents as well as

sintered plate. Of course, it is rare that this choice exists.

Author's note: I refuse to get involved in the flame wars with respect to NiCd battery myths and legends --- sam.

Why There Will Never Actually be Closure on This Topic

(From: Mark Kinsler (kinsler@froggy.frognet.net).)

All of which tends to support my basic operating theory about the charging of nickel-cadmium batteries:

1. Man is born in sin and must somehow arrange for the salvation of his immortal soul.

2. All nickel-cadmium batteries must be recharged.

3. There is no proper method of performing either task (1) or task (2) to the satisfaction of anyone.

Nickel Cadmium Versus Nickel-Metal-Hydride in a Nutshell

NiCds are inexpensive, reliable, and easy to charge, but may suffer from voltage depression (what people call the memory effect) from repeated shallow discharge cycles.

NiMHs have slightly higher capacity and no memory effect but have higher initial cost and are more sensitive to overcharging. Must be used with compatible charger.

Randy's Notes on First Aid for NiCd Battery Packs

CAUTION: Opening these battery packs will of course void any warranty but you knew that. Also, make notes of exactly how the cells and anything else inside is arranged. Improper reassembly can result in damage to equipment and/or risk of overheating should cells short inside the pack due to lack of or misplaced insulation. Under no circumstances should all thermal switches be removed - not only are they a safety device to prevent excessive temperatures but may also be part of the charging circuit. So, if they are removed, your next charge may be your last! I'd highly recommend that all of them be replaced (from another pack as a last resort) and installed in exactly the same positions they were originally.

(From: Randolph Miller (randolph.miller2@verizon.net).)

Many "name brand" camcorder and other similar battery packs contain two or even 3 thermal switches (those rectangular, un-identifiable, wired between the cells). They contain a bimetal strip operating a set of contacts which open at a preset temperature. Often only one of these will fail, resulting in a $40 NiCad that won't charge. Since these little suckers are pricey if ya kind find them, a safe and cheap fix, is to test the thermal switches for continuity (they should be closed at room temp) and remove the defective one. If needed move the other, or at least one, to the mid-point of the cells series. If a battery pack has 8 separate cells, (i.e.: a 9.6 V VHS-C camera pack) the thermal switch should be wired between the 4th and 5th, and as far away from the charging contacts as possible. The extra switches were added as a safety factor but since the average one is designed to open at 87°C, there is no fire hazard so long as the pack is re-sealed after working on it.

A quick fix for a NiCad pack left on the dashboard. Since good ol' solar power can heat a battery pack to the point where the thermal protection can open (and even warp a case) you can be stuck at the soccer game with what seems like dead batteries. The trick is to drop the temp below 87°C. Wrap the battery in plastic so the contacts won't get wet, and stick it in the cooler with the kids lunch and your six-pack. A few minutes and the thermistor should close. letting the batter work normally. Also, if the cord is long enough, never recharge a NiCad inside the car. Place the battery and charger under the car, in the shade, so it doesn't heat quickly and will get a full charge.

Identifying Technology of Unmarked Battery Packs

Since the nominal (rated) voltages for the common battery technologies differ, it is often possible to identify which type is inside a pack by the total output voltage:

- NiCd packs will be a multiple of 1.2 V.
- Lead-acid packs will be a multiple of 2.0 V.
- Alkaline packs will be a multiple of 1.5.

Note that these are open circuit voltages and may be very slightly higher when fully charged or new.

Therefore, it is generally easy to tell what kind of technology is inside a pack even if the type is not marked as long as the voltage is marked. Of course, there are some - like 6 V that will be ambiguous.

Powering LEDs with Batteries

LEDs look like diodes with a high forward voltage drop. Above the that voltage, the incremental resistance is very low and without current limiting, the current would be critically dependent on the exact voltage of the power source. Most of the time, they are spec'd at a particular maximum current and need some means to limit the current to that value based on the input voltage. Some devices may depend on the internal resistance of the batteries to provide the current limiting - this is a poor approach and depends greatly on the type and capacity of the batteries being used. Most common is just a resistor but this provides no regulation and poor efficiency. Better designs (used in LED flashlights) will use a DC to pulse inverter with regulation achieving constant light output regardless of battery state-of-charge and high efficiency. LEDs can usually withstand short high current pulses and this allows the circuit to be designed with low losses.

The specifications for LEDs you see in electronics distributor's catalogs may look the same as those for incandescent lamps but they are not. Incandescent lamps provide their own current limiting; LEDs do not. It's possible to luck out and happen to have a given LED work without current limiting with a particular set of batteries but it hardly an acceptable design approach. Slight variations in battery parameters will result in gross changes in light intensity and possible shortening of life or outright destruction of the LED.

- Back to AC Adapters and Power Supplies Table of Contents.

Battery Problem Troubleshooting and Repair

Problems with Battery Operated Equipment

For primary batteries like Alkalines, first try a fresh set. For NiCds, test across the battery pack after charging overnight (or as recommended by the manufacturer of the equipment). The voltage should be 1.2 x n V where n is the number of cells in the pack. If it is much lower - off by a multiple of 1.2 V, one or more cells is shorted and will need to be replaced or you can attempt zapping it to restore the shorted cells. See the section: Zapping NiCds to Clear Shorted Cells. Attempt at your own risk!

If the voltage drops when the device is turned on or the batteries are installed - and the batteries are known to be good - then an overload may be pulling the voltage down.

Assuming the battery is putting out the proper voltage, then a number of causes are possible:

1. Corroded contacts or bad connections in the battery holder.
2. Bad connections or broken wires inside the device.
3. Faulty regulator in the internal power supply circuits. Test semiconductors and IC regulators.
4. Faulty DC-DC inverter components. Test semiconductors and other components.
5. Defective on/off switch (!!) or logic problem in power control.
6. Other problems in the internal circuitry.

NiCd Battery Pack Will Not Hold a Charge

This applies if the pack appears to charge normally and the terminal voltage immediately after charging is at least 1.2 x n where n is the number of cells in the pack but after a couple of days, the terminal voltage has dropped drastically. For example, a 12 V pack reads only 6 V 48 hours after charging without being used.

What is most likely happening is that several of the NiCd cells have high leakage current and drain themselves quite rapidly. If they are bad enough, then a substantial fraction of the charging current itself is being wasted so that even right after charging, their capacity is less than expected. However, in many cases, the pack will deliver close to rated capacity if used immediately after charging.

If the pack is old and unused or abused (especially, it seems, if it is a fast recharge type of pack), this is quite possible. The cause is the growth of fine metallic whiskers called dendrites that partially shorts the cell(s). If severe enough, a dead short is created and no charge at all is possible.

Sometimes this can be repaired temporarily at least by 'zapping' using a large charged capacitor to blow out the whiskers or dendrites that are causing the leakage (on a cell-by-cell basis) but my success on these types of larger or high charge rate packs such as used in laptop computers or camcorders has been less than spectacular. See the section: Zapping NiCds to Clear Shorted Cells.

What is This Thing in my NiCd Battery Pack?

In addition to the NiCd cells, you will often find one or more small parts that are generally unrecognizable. Normally, you won't see these until you have a problem and, ignoring all warnings, open the pack.

If it is a little rectangular silver or plastic box in series with one of the positive or negative terminals of the pack, it is probably a thermostat and is there to shut down the charging or discharging if the temperature of the pack rises too high. (The manufacturer name "Klixon" would be a dead giveaway to identity. Izuzu also makes these things.) If it tests open at room temperature, it is bad. With care, you can safely substitute a low value resistor or auto tail light bulb and see if the original problem goes away or at least the behavior changes. However, if there is a dead short somewhere, that device may have sacrificed its life to protect your equipment or charger and going beyond this (like shorting it out entirely) should be done with extreme care. These may be either mechanical (bimetal strip/contacts) or solid state (Polyfuse(tm) - increases resistance with overcurrent).

If it looks like a small diode or resistor, it could be a temperature sensing thermistor which is used by the charger to determine that the cells are heating which in its simple minded way means the cells are being overcharged and it is should quit charging them. You can try using a resistor in place of the thermistor to see if the charger will now cooperate. Try a variety of values while monitoring the current or charge indicators. However, the problem may actually be in the charger controller and not the thermistor. The best approach is to try another pack.

It could be any of a number of other possible components but they all serve a protective and/or charge related function.

Of course, the part may be bad due to a fault in the charger not shutting down or not properly limiting the current as well.

Zapping NiCds to Clear Shorted Cells

Nickel-Cadmium batteries that have shorted cells can sometimes be rejuvenated - at least temporarily - by a procedure affectionately called 'zapping'.

The cause of these bad NiCd cells is the formation of conductive filaments called whiskers or dendrites that pierce the separator and short the positive and negative electrodes of the cell. The result is either a cell that will not take a charge at all or which self discharges in a very short time. A high current pulse can sometimes vaporize the filament and clear the short.

The result may be reliable particularly if the battery is under constant charge (float service) and/or is never discharged fully. Since there are still holes in the separator, repeated shorts are quite likely especially if the battery is discharged fully which seems to promote filament formation,

I have used zapping with long term reliability (with the restrictions identified above) on NiCds for shavers, Dustbusters, portable phones, and calculators.

WARNING: There is some danger in the following procedures as heat is generated. The cell may explode! Take appropriate precautions and don't overdo it. If the first few attempts do not work, dump the battery pack.

Attempt sapping at your own risk!!!

You will need a DC power supply and a large capacitor - one of those 70,000 uF 40 V types used for filtering in multimegawatt geek type automotive audio systems, for example. A smaller capacitor can be tried as well.

Alternatively, a you can use a 50 to 100 A 5 volt power supply that doesn't mind (or is protected against) being overloaded or shorted.

Some people recommend the use of a car battery for NiCd zapping. DO NOT be tempted - there is nearly unlimited current available and you could end with a disaster including the possible destruction of that battery, your NiCd, you, and anything else that is in the vicinity.

OK, you have read the warnings:

Remove the battery pack from the equipment. Gain access to the shorted cell(s) by removing the outer covering or case of the battery pack and test the individual cells with a multimeter. Since you likely tried charging the pack, the good cells will be around 1.2 V and the shorted cells will be exactly 0 V. You must perform the zapping directly across each shorted cell for best results.

Connect a pair of heavy duty clip leads - #12 wire would be fine - directly across the first shorted cell. Clip your multimeter across the cell as well to monitor the operation. Put it on a high enough scale such that the full voltage of your power supply or capacitor won't cause any damage to the multimeter.

Wear your eye protection!!!

1. Using the large capacitor:

    - Charge the capacitor from a current limited 12-24 V DC power supply.

    - Momentarily touch the leads connected across the shorted cell to the charged capacitor, + to +, - to -. CAUTION: Polarity is critical - do it backwards and you will make the problem worse, probably terminal. There will be sparks. The voltage on the cell may spike to a high value - up to the charged voltage level on the capacitor. The capacitor will discharge almost instantly.

2. Using the high current power supply:

    - Turn on the supply.

    - Momentarily touch the leads connected across the shorted cell to the power supply output, + to +, - to -. CAUTION: Polarity is critical - do it backwards and you will make the problem worse, probably terminal. There will be sparks. DO NOT maintain contact for more than a couple of seconds. The NiCd may get warm! While the power supply is connected, the voltage on the cell may rise to anywhere up to the supply voltage.

Now check the voltage on the (hopefully previously) shorted cell.

If the dendrites have blown, the voltage on the cell should have jumped to anywhere from a few hundred millivolts to the normal 1 V of a charged NiCd cell. If there is no change or if the voltage almost immediately decays back to zero, you can try zapping couple more times but beyond this is probably not productive.

If the voltage has increased and is relatively stable, immediately continue charging the repaired cell at the maximum SAFE rate specified for the battery pack. Note: if the other cells of the battery pack are fully charged as is likely if you had attempted to charge the pack, don't put the entire pack on high current charge as this will damage the other cells through overcharging.

One easy way is to use your power supply with a current limiting resistor connected just to the cell you just zapped. A 1/4 C rate should be safe and effective but avoid overcharging. Then trickle charge at the 1/10 C rate for several hours. (C here is the amp-hour capacity of the cell. Therefore, a 1/10 C rate for a 600 mA NiCd is 50 mA.)

This works better on small cells like AAs than on C or D cells since the zapping current requirement is lower. Also, it seems to be more difficult to reliably restore the quick charge type battery packs in portable tools and laptop computers that have developed shorted cells (though there are some success stories).

My experience has been that if you then maintain the battery pack in float service (on a trickle charger) and/or make sure it never discharges completely, there is a good chance it will last. However, allow the bad cells to discharge to near 0 volts and those mischievous dendrites will make their may through the separator again and short out the cell(s).

Tom's Comments on NiCd Care and Feeding

(From: Tom Lamb (tlamb@gwe.net).)

- Measuring NiCd capacity - I use a very simple/effective system. Put a 2.5 ohm resistor across the contacts of a cheap travel analog clock, which will time the rundown. It is quite consistent for good cells. A good typical AA NiCd will run one hour.

- NiCd zapping - I use a 1 ohm power resistor in series with a car battery, though a series headlight will also work. I charge for about 30 secs or until warm, which will clear the whisker and put in enough charge to see if the cell is salvageable.

Battery Juice and Corroded Contacts

Unless you have just arrived from the other side of the galaxy (where such problems do not exist), you know that so-called 'leak-proof' batteries sometimes leak. This is a lot less common with modern technologies than with the carbon-zinc cells of the good old days, but still can happen. It is always good advice to remove batteries from equipment when it is not being used for an extended period of time. Dead batteries also seem to be more prone to leakage than fresh ones (in some cases because the casing material is depleted in the chemical reaction which generates electricity and thus gets thinner or develops actual holes).

In most cases, the actual stuff that leaks from a battery is not 'battery acid' but rather some other chemical. For example, alkaline batteries are so called because their electrolyte is an alkaline material - just the opposite in reactivity from an acid. Usually it is not particularly reactive (but isn't something you would want to eat).

The exception is the lead-acid type where the liquid inside is sulfuric acid of varying degrees of strength depending on charge. This is nasty and should be neutralized with an alkaline material like baking soda before being cleaned up. Fortunately, these sealed lead-acid battery packs rarely leak (though I did find one with a scary looking bulging case, probably due to overcharging - got rid of that is a hurry).

Scrape dried up battery juice from the battery compartment and contacts with a plastic or wooden stick and/or wipe any liquid up first with a dry paper towel. Then use a damp paper towel to pick up as much residue as possible. Dispose of the dirty towels promptly.

If the contacts are corroded, use fine sandpaper or a small file to remove the corrosion and brighten the metal. Do not an emery board or emery paper or steel wool as any of these will leave conductive particles behind which will be difficult to remove. If the contacts are eaten through entirely, you will have to improvise alternate contacts or obtain replacements. Sometimes the corrosion extends to the solder and circuit board traces as well and some additional repairs may be needed - possible requiring disassembly to gain access to the wiring.

Exploding Batteries - These Things Really Happen

(From: Greg Raines (ghr@ix.netcom.com).)

When I was about 10 years old I was sitting in my dad's driveway in a '65 Plymouth Fury III station wagon while he disconnected the trickle charger from the '67 Fiat in the garage. I heard a pop and saw my dad throw his hands over his face, run to the back door and start kicking it to get someone to open it. Fortunately he wasn't injured. But it was an eye opener. It was probably 30 or below, there was no flame present, and the double garage door was open (this happened in Connecticut). Also in a Fiat 850 sport coupe the battery is in the trunk (front) so there really isn't anything up there that would cause a spark (engine & gas tank in back). So it must have been a spark off of the charger when he pulled it off the terminal (he hadn't unplugged the charger).

Soldering Tabs Onto NiCd Batteries

When replacing NiCd batteries in packs or portable tools, it is often necessary to attach wires to the individual cells. It may be possible to obtain NiCds with solder tabs attached (Radio Shack has these) but if yours do not, here are two ways that work. They both require a (Weller) high wattage soldering gun.

I use a high power Weller (140 W) soldering gun. Use fine sandpaper to thoroughly clean and roughen up the surface of the battery cell at both ends. Tin the wires ahead of time as well. Arrange the wire and cell so that they are in their final position - use a vise or clamp or buddy to do this. Heat up the soldering gun but do not touch it to the battery until it is hot - perhaps 10 seconds. Then, heat the contact area on the battery end while applying solder. It should melt and flow quite quickly. As soon as the solder adheres to the battery, remove the heat without moving anything for a few seconds. Inspect and test the joint. A high power soldering iron can also be used.

Here is a novel approach that appears to work:

(From: Clifford Buttschardt (cbuttsch@slonet.org).)

There is really no great amount of danger spot welding tabs! They usually are made of pure nickel material. I put two sharp pointed copper wires in a soldering gun, place both on the tab in contact with the battery case and pull the trigger for a short burst. The battery remains cool.

(From: mcovingt@ai.uga.edu (Michael Covington).)

Of course! A soldering gun is a source of about 1.5 V at 100 A RMS. Should make a fine spot-welder. You should write that up for QST ("Hints and Kinks") or better yet, send it in a letter to the editor of "Electronics Now" (the magazine I write for).

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Battery Related Information

Automotive Power

While it is tempting to want to use your car's battery as a power source for small portable appliances, audio equipment, and laptop computers, beware: the power available from your car's electrical system is not pretty. The voltage can vary from 9 (0 for a dead battery) to 15 V under normal conditions and much higher spikes or excursions are possible. Unless the equipment is designed specifically for such power, you are taking a serious risk that it will be damaged or blown away.

Furthermore, there is essentially unlimited current available from the battery (cigarette lighter) - 20 A or more. This will instantly turn your expensive CD player to toast should you get the connections wrong. No amount of internal protection can protect equipment from fools.

My recommendation for laptop computers is to use a commercially available DC-AC inverter with the laptop's normal AC power pack. This is not the most efficient but is the safest and should maintain the laptop's warranty should something go wrong. For CD players and other audio equipment, only use approved automotive adapters.

How Do Those On-Battery or On-the-Package Battery Testers Work?

There is a graded width resistance element that gets connected when you pinch those two points. It heats up - substantially, BTW. Some sort of liquid crystal or other heat sensitive material changes from dark to clear or yellow at a fairly well defined temperature.

Incidentally, since the current is significant, repeated 'testing' will drain the batteries - as with any proper under-load battery test! This isn't an issue for occasional testing but if the kids figure how to do this....

Personally, I would rather use a $3 battery checker instead of paying for throw-away frills!

Battery Eliminator for Laptop or Appliance with Dead NiCds

Even where you have the AC adapter, it is quite likely that simply removing the (shorted) battery pack will not allow you to use it. This is because it probably uses the battery as a smoothing capacitor. You cannot simply replace the battery with a large electrolytic capacitor because the battery also limits the voltage to a value determined by the number of cells in the pack. Without it, the voltage would be much too high, possibly resulting in damage. You could use N power diodes in series (i.e., N=Vb/.7) to drop the approximate voltage of the battery pack AND a large capacitor but you would be wasting a lot of power in the form of heat.

One alternative is to substitute a regulated power supply with an output equal to the the battery voltage and current capacity found by dividing the VA rating of the normal wall adapter by the battery's nominal terminal voltage (this will be worst case - actual requirements may be less). Connect this directly in place of the original battery pack. Unless there is some other sort of interlock, the equipment should be perfectly happy and think it is operating from battery power!

Also see the other parts of this document dealing with AC Adapters and Transformers.

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Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies

Version 2.82

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Careless troubleshooting of a line powered switchmode power supply can result in severe electrical shock or electrocution. This is potentially more lethal than the high voltage section of a TV or monitor due to the high current availability. Even the charged on the main filter capacitors with the unit unplugged can kill.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Introduction

The switchmode power supply (SMPS)

Until the 1970s or so, most consumer electronic equipment used a basic power transformer/rectifier/filter capacitor type of power supply for converting the AC line into the various voltages needed by internal circuitry. Even regulation was present only where absolutely needed - the high voltage supplies of color TV sets, for example. Remember those old TVs with boat anchor type power transformers? (Of course, if you recall those, you also recall the fond days of vacuum tube sets and the corner drugstore with a public tube tester!)

Switchmode supplies had been commonplace in military and avionic equipment long before they found their way into consumer electronics. I have some DC-DC and DC-AC converter modules from a Minuteman I missile from around 1962 as one example. I suppose that the cost of the switching transistors wasn't as big a deal with a $100 million missile as a $300 TV (even in 1960s dollars).

Nowadays, all TVs, monitors, PCs; most laptop and camcorder power packs; many printers, fax machines, and VCRs; and even certain audio equipment like portable CD players use this technology to reduce cost, weight, and size.

Switchmode power supply repair

Unlike PC system boards where any disasters are likely to only affect your pocketbook, power supplies, especially line connected switchmode power supplies (SMPSs) can be dangerous. Read, understand, and follow the set of safety guidelines provided later in this document whenever working on line connected power supplies as well as TVs, monitors, or other similar high voltage equipment.

Having said that, repairing a power supply yourself may in fact be the only economical option. It is very common for service centers to simply replace the entire power supply board or module even if the problem is a 25 cent capacitor. It may simply not pay for them to take the bench time to diagnose down to the component level. Many problems with switchmode power supplies are easy to find and easy and inexpensive to fix. Not all, but surprisingly many.

This document will provide you with the knowledge to deal with a large percentage of the problems you are likely to encounter with the common small switchmode power supplies found in many types of consumer electronic equipment including PCs, printers, TVs, computer monitors, and laptop or camcorder power packs. It will enable you to diagnose problems and in many cases, correct them as well. With minor exceptions, specific manufacturers and models will not be covered as there are so many variations that such a treatment would require a huge and very detailed text. Rather, the most common problems will be addressed and enough basic principles of operation will be provided to enable you to narrow the problem down and likely determine a course of action for repair. In many cases, you will be able to do what is required for a fraction of the cost that would be charged by a repair center - assuming they would even bother.

Should you still not be able to find a solution, you will have learned a great deal and be able to ask appropriate questions and supply relevant information if you decide to post to sci.electronics.repair. It will also be easier to do further research using a repair text such as the ones listed at the end of this document. In any case, you will have the satisfaction of knowing you did as much as you could before taking it in for professional repair. With your new-found knowledge, you will have the upper hand and will not easily be snowed by a dishonest or incompetent technician.

Most Common Problems

The following probably account for 95% or more of the common SMPS ailments:

- Supply dead, fuse blown - shorted switchmode power transistor and other semiconductors, open fusable resistors, other bad parts. Note: actual cause of failure may be power surge/brownout/lightning strikes, random failure, or primary side electrolytic capacitor(s) with greatly reduced capacity or entirely open - test them before powering up the repaired unit.

- Supply dead, fuse not blown - bad startup circuit (open startup resistors), open fusable resistors (due to shorted semiconductors), bad controller components.

- One or more outputs out of tolerance or with excessive ripple at the line frequency (50/60 Hz) or twice the line frequency (100/120 Hz) - dried up main filter capacitor(s) on rectified AC input.

- One or more outputs out of tolerance or with excessive ripple at the switching frequency (10s of kHz typical) - dried up or leaky filter capacitors on affected outputs.

- Audible whine with low voltage on one or more outputs - shorted semiconductors, faulty regulator circuitry resulting in overvoltage crowbar kicking in, faulty overvoltage sensing circuit or SCR, faulty controller.

- Periodic power cycling, tweet-tweet, flub-flub, blinking power light - shorted semiconductors, faulty over voltage or over current sensing components, bad controller.

In all cases, bad solder connections are a possibility as well since there are usually large components in these supplies and soldering to their pins may not always be perfect. An excessive load can also result in most of these symptoms or may be the original cause of the failure. And don't overlook the trivial: a line voltage select switch in the wrong position or between positions (possibly by accident when moving the supply, particularly with PCs), or damaged.

Repair or replace

Some manufacturers have inexpensive flat rate service policies for power supplies. If you are not inclined or not interested in doing the diagnosis and repair yourself, it may be worthwhile to look into these. In some cases, $25 will get you a replacement supply regardless of original condition. However, this is probably the exception and replacements could run more than the total original cost of the equipment - especially as in the case of most TVs and many computer monitors, where the power supply is built onto the main circuit board.

Nothing really degrades in a switchmode power supply except possibly the electrolytic capacitors (unless a catastrophic failure resulted in a total meltdown) and these can usually be replaced for a total cost of a few dollars. Therefore, it usually makes sense to repair a faulty supply assuming it can be done reasonably quickly (depending on how much you value your time and the down time of the equipment) and, of course, assuming that the equipment it powers is worth the effort. Most replacement parts are readily available and kits containing common service components are also available for many popular power supplies (such as those found in some terminals, MacIntosh and other Apple computers, various brands of video monitors, and some TVs and VCRs).

Where an exact replacement power supply is no longer available or excessively expensive, it may be possible to simply replace the guts if space allows and the mounting arrangement is compatible. For example, for an older full size PC tower, the original power supply may be in a non-standard box but the circuit board itself may use a standard hole configuration such that an inexpensive replacement may be installed in its place.

Alternatively, many surplus electronics distributors have a wide selection of power supplies of all shapes, sizes, output voltages, and current capacities. One of these may make a suitable replacement for your custom supply with a lot less hassle than attempting to repair your undocumented original. It will likely be much newer as well with no end-of-life issues like dried up electrolytic capacitors to deal worry about. Of course, you must know the voltage and current maximum current requirements of each of the outputs in order to make a selection.

For the specific case of SMPSs for standard computers (PC, Macs, workstations, servers), it often doesn't make sense to spend much time or money on repair. The cost of replacement of power supplies for PCs in particular is so low, that just buying a new power supply may be the best course of action. Furthermore, the risk of a faulty repair causing expensive or fatal damage to the mainboard and peripherals including total loss of all data stored on disk, makes repair a risky endeavor unless thorough testing can be performed before installation. However, it won't hurt to check for obvious problems like bad connections. Put the dead one aside and considering trying to repair it if there isn't anything better to do. Realistically, this will be never. :)

Related Information

See the manuals on "Failure Diagnosis and Repair of TVs" and "Failure Diagnosis and Repair of Computer and Video Monitors" for problems specific to that type of equipment. For computer power supplies and other general info, also see: "PC Switchmode Power Supplies". These are all available at this site under the Repair Menu.

Lazar's SMPS Design Corner has many links to switchmode power supply information and suppliers.

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Switchmode Power Supplies

Power Supply Fundamentals

A typical line connected power supply must perform the following functions:

- Voltage conversion - changing the 115/230 VAC line voltage into one or more other voltages as determined by application.

- Rectification - turning the AC into DC.
- Filtering - smoothing the ripple of the rectified voltage(s).
- Regulation - making the output voltage(s) independent of line and load variations.
- Isolation - separating the supply outputs from any direct connection to the AC line.

Linear power supplies (LPSs)

A typical linear power supply of the type found in most audio equipment includes a line power transformer which converts the 115/230 VAC 50/60 Hz to other (usually lower) voltages (now that most equipment has done away with vacuum tubes except for CRTs, more on that later). The power transformer also provides the isolation between the load and the line. The outputs are rectified by a diode bridge or other solid state configuration. Filtering is accomplished with electrolytic capacitors and sometimes inductors or resistors arranged as a low pass filter C-L-C (pi) or C-R-C or other configuration.

Where regulation is important - that is, it is desirable for the output voltage to be relatively independent of line or load variations, a regulator stage is added. This may take the form of a Zener diode if the current requirements are modest, discrete transistor circuit, or an integrated 3 terminal regulator like an LM317 (variable), 7805 (+5), or 7912 (-12). There are many more as well as linear regulators for higher voltages such as +115 VDC or +125 VDC for TV power supplies and multiple output (e.g., +5.1 VDC, +12 VDC) hybrid regulators for VCRs.

The regulator circuit essentially compares the output (possibly only one if there are multiple outputs in the same package) with a reference and adjusts the current flow to make the output(s) as nearly equal to the desired voltage as possible. However, a significant amount of power may be lost in the regulator especially under high line voltage/high load conditions. Therefore, the efficiency of linear power supplies is usually quite low - under 50% overall is typical.

Notable characteristics of LPSs are excellent regulation and low output ripple and noise.

What is a switchmode power supply?

Also called switching power supplies and sometimes chopper controlled power supplies, SMPSs use high frequency (relative to 50/60 Hz) switching devices such as Bipolar Junction Transistors (BJTs), MOSFETs, Insulated Gate Bipolar Transistors (IGBTs), or Thyristors (SCRs or triacs) to take directly rectified line voltage and convert it to a pulsed waveform.

Most small SMPSs use BJTs or MOSFETs. IGBTs may be found in large systems and SCRs or triacs are used where their advantages (latching in the on state and high power capability) outweigh the increased complexity of the circuitry to assure that they turn off properly (since except for special Gate Turn Off (GTO) thyristors, the gate input is pretty much ignored once the device is triggered and the current must go to zero to reset it to the off state.)

The input to the switches is usually either 150-160 VDC after rectification of 115 VAC, or 300-320 VDC after doubling of 115 VAC or rectification of 220-240 VAC. Up to this point, there is no line isolation as there is no line connected (large, bulky, heavy) power transformer.

A relatively small high frequency transformer converts the pulsed waveform into one or more output voltages which are then rectified and filtered using electrolytic capacitors and small inductors in a 'pi' configuration C-L-C, or for outputs that are less critical, just a capacitor.

This high frequency transformer provides the isolation barrier and the conversion to generate the multiple voltages often provided by a SMPS.

Feedback is accomplished across the isolation barrier by either a small pulse transformer or opto-isolator. The feedback controls the pulse width or pulse frequency of the switching devices to maintain the output constant. Since the feedback is usually only from the "primary" output, regulation of the other outputs, if any, is usually worse than for the primary output. Also, because of the nature of the switching designs, the regulation even of the primary output is usually not nearly as good both statically and dynamically as a decent linear supply.

DC-DC converters are switchmode power supplies without the line input rectification and filtering. They are commonly found in battery operated equipment like CD players and laptop computers. They have similar advantages to SMPSs in being compact, light weight, and highly efficient.

Description of typical flyback type SMPS

Probably the most common topology for small switchers is the flyback circuit shown below and in Block Diagram of Basic Flyback Switchmode Power Supply.

```
           CR1                             CR2        L :::::
 H o-------|>|---+----+---------+ T1 +-----|>|------+---^^^^^---+---+----o V+
          line   |    |          )||(     Main    +_|_        +_|_  |     Main
          rect.  |    /          )||(    output  C ___ LC Pi C ___  |    Output
                 |    \ R1       )||(     rect.   - |  filter - |   |
  AC       HV  +_|_   /       +-+    +--------------+-----------+---|----o V-
 Line    filter ___   \       |                                     |
  in       cap - |    |     |/       +-------+   +-----------+   +-----+
                 |    +-----+--------|  PWM  |<--| Isolation |<--| REF |
                 |      Q1 |\       +-------+   +-----------+   +-----+
                 |            |
 N o-------------+------------+
```

The input to the supply is the AC line which may have RFI and surge protection (not shown). There may be several inductors, coupled inductors, and capacitors to filter line noise and spikes as well as to minimize the transmission of switching generated radio frequency interference back into the power line. There may be MOV type of surge suppressors across the three input leads (H, N, G). A line fuse is usually present as well to prevent a meltdown in case of a catastrophic failure. It rarely can prevent damage to the supply in the event of an overload, however.

Line rectification is usually via a voltage doubler or diode bridge. One common circuit uses a bridge rectifier as a doubler or normal bridge by changing one jumper. The voltage across the switching transistor is usually around 160-320 V. Some universal supplies are designed to accept a wide range of input voltages - 90-240 VAC (possibly up to 400 Hz or more) or DC - and will automatically work just about anywhere in the world as long as a suitable plug adapter can be found.

When Q1 turns on, current increases linearly in T1 based on the voltage applied and the leakage inductance of T1's primary winding. Little power is transferred to the secondary during this phase of the cycle. When Q1 turns off, the field collapses and this transfers power to the output. The longer Q1 is on, the more energy is stored (until saturation at which point it blows up). Thus, controlling the pulse width of the Q1 on-time determines the amount of power available from the output.

The output rectifier, CR2, must be a high efficiency, high frequency unit - a 1N400X will not work. The pi filter on the output smooths the pulses provided by CR2. Sometimes, a full wave configuration is used with a center tapped transformer secondary.

Note that the transformer, T1, is a special type which includes an air gap in its core (among other things) to provide the inductive characteristics needed for operation in flyback mode.

Multiple output windings on T1 provide for up to a half dozen or more separate (and possibly isolated as well) positive or negative voltages but as noted, only one of these is usually used for regulation.

A reference circuit monitors the main output and controls the duty cycle of the switching pulses to maintain a constant output voltage. (Secondary outputs are not shown in the above schematic.)

R1 is the startup resistor (some startup circuits are more sophisticated) and provides the initial current to the switchmode transistor base. In the old days, SMPS controllers were designed with discrete components. Assuring stable operation is a challenge with any SMPS but particularly with the flyback topology where leaving the drive on for too long will result in transformer core saturation and instant smoke. Nowadays, an IC PWM controller chip is almost always used. The block diagram of a one very popular PWM controller IC is shown below.

Many small SMPSs use opto-isolators for the feedback. An opto-isolator is simply an LED and a photodiode in a single package. As its name implies, an opto-isolator provides the isolation barrier (between the low voltage secondary outputs and the line connected primary) for the feedback circuit. Typically, a reference circuit on the output side senses the primary output voltage and turns on the LED of the opto-isolator when the output voltage exceeds the desired value. The photodiode detects the light from the LED and causes the pulse width of the switching waveform to be reduced enough to provide just the right amount of output power to maintain the output voltage constant. This circuit may be as simple as putting the photodiode across the base drive to the BJT switch thus cutting it off when the output voltage exceeds the desired value. The reference is often a TL431 or similar shunt regulator chip monitoring a voltage divided version of the primary output. When the shunt regulator kicks in, the opto-isolator LED turns on reducing the switchmode transistor drive. There may be an adjustment for the output voltage.

Other designs use small pulse transformers to provide isolated feedback.

Where additional regulation is needed, small linear regulators may be included following the output(s).

There are many other topologies for switching power supplies. However, the basic principles are similar but the detail differ depending on application. The flyback topology described above is one of the most common for small multi-output supplies. However, you may find other types of circuits in TVs and monitors. Some are downright strange (to be polite). I sometimes wonder if engineers are given bonuses based on the uniqueness and difficulty level of understanding their designs!

Advantages of SMPSs compared to LPSs

The benefits provided by implementing switch mode operation are with respect to size, weight, and efficiency.

- Size and weight - since the transformer and final filter(s) run at a high frequency (we are talking about 10 kHz to 1 MHz or more), they can be much smaller and lighter than the big bulky components needed for 50/60 Hz operation. Power density for SMPSs compared to LPSs may easily exceed 20:1.

- Efficiency - since the switching devices are (ideally) fully on or fully off, there is relatively little power lost so that the efficiency can be much higher for SMPSs than for LPSs, especially near full load. Efficiencies can exceed 85% (compared to 50-60% for typical LPSs) with improvements being made continuously in this technology.

Since the advent of the laptop computer, cellular phone, and other portable devices, the importance of optimizing power utilization has increased dramatically. There are now many ICs for controlling and implementing SMPSs with relatively few external components. Maxim, Linear Technology, and Unitrode (now part of Texas Instruments) are just a few of the major manufacturers of controller ICs.

Where are SMPSs used?

Switch mode power supplies are commonly used in computer and other digital systems as well as consumer electronics - particularly TVs and newer VCRs though audio equipment will tend to use linear power supplies due to noise considerations. You will find SMPSs in:

- PCs, workstations, minicomputers, large computers.

- Laptop and notebook computers, PDAs - both internal DC-DC converters and their AC power packs.

- Printers, fax machines, copiers.

- Peripheral and expansion boxes

- X-terminals and video terminals, point of sale registers.

- TVs, computer and video monitors.

- Many VCRs.

- Camcorder AC adapters.

In additional, you will find DC-DC converters which are SMPSs without the AC line connection, internally in an increasing number of consumer and industrial applications including things like portable CD players.

The up side is that they are usually quite reliable, efficient, and cool running.

The down side is that when a failure occurs, it may take out many parts in the supply, though not usually the equipment being powered unless the feedback circuitry screws up and there is no overvoltage protection.

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Switchmode Power Supply Troubleshooting

SAFETY

The primary danger to you is from the input side of the supply which is directly connected to the AC line and will have large electrolytic capacitors with 320 V or greater DC when powered (often, even if the supply does not work correctly) and for some time after being unplugged (especially if the power supply is not working correctly but does not blow fuses).

WARNING: The filter capacitors used in many switchmode power supplies can store an amount of energy that can kill - always discharge and confirm this before touching anything.

There is also risk of instantly destroying expensive parts of the supply (and any attached equipment as well) like the switchmode power transistor if your probe should slip and short something either directly or by killing the feedback circuit.

These guidelines are to protect you from potentially deadly electrical shock hazards as well as the equipment from accidental damage.

Note that the danger to you is not only in your body providing a conducting path, particularly through your heart. Any involuntary muscle contractions caused by a shock, while perhaps harmless in themselves, may cause collateral damage - there are many sharp edges inside this type of equipment as well as other electrically live parts you may contact accidentally.

The purpose of this set of guidelines is not to frighten you but rather to make you aware of the appropriate precautions. Repair of TVs, monitors, microwave ovens, and other consumer and industrial equipment can be both rewarding and economical. Just be sure that it is also safe!

- Don't work alone - in the event of an emergency another person's presence may be essential.

- Always keep one hand in your pocket when anywhere around a powered line-connected or high voltage system.

- Wear rubber bottom shoes or sneakers.

- Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current, or get caught in moving parts.

- Set up your work area away from possible grounds that you may accidentally contact.

- Know your equipment: TVs and monitors may use parts of the metal chassis as ground return yet the chassis may be electrically live with respect to the earth ground of the AC line. Microwave ovens use the chassis as ground return for the high voltage. In addition, do not assume that the chassis is a suitable ground for your test equipment!

- If circuit boards need to be removed from their mountings, put insulating material between the boards and anything they may short to. Hold them in place with string or electrical tape. Prop them up with insulation sticks - plastic or wood.

- If you need to probe, solder, or otherwise touch circuits with power off, discharge (across) large power supply filter capacitors with a 2 W or greater resistor of 5-50 ohms/V approximate value (e.g., for a 200 V capacitor, use a 1K-10K ohm resistor). Monitor while discharging and/or verify that there is no residual charge with a suitable voltmeter. In a TV or monitor, if you are removing the high voltage connection to the CRT (to replace the flyback transformer for example) first discharge the CRT contact (under the insulating cup at the end of the fat red wire). Use a 1M-10M ohm 1W or greater wattage resistor on the end of an insulating stick or the probe of a high voltage meter. Discharge to the metal frame which is connected to the outside of the CRT.

- For TVs and monitors in particular, there is the additional danger of CRT implosion - take care not to bang the CRT envelope with your tools. An implosion will scatter shards of glass at high velocity in every direction. There is several tons of force attempting to crush the typical CRT. Always wear eye protection.

- Connect/disconnect any test leads with the equipment unpowered and unplugged. Use clip leads or solder temporary wires to reach cramped locations or difficult to access locations.

- If you must probe live, put electrical tape over all but the last 1/16" of the test probes to avoid the possibility of an accidental short which could cause damage to various components. Clip the reference end of the meter or scope to the appropriate ground return so that you need to only probe with one hand.

- Use a proper high voltage probe or high voltage meter to measure voltages which are potentially beyond the capabilities of your DMM or VOM - not something cobbled together from 1/4 watt resistors! Note that fault conditions or even testing at *reduced* input voltage may result in greatly excessive voltage on one or more outputs due to lack of regulation.

- It may be possible to perform some of the tests at greatly reduced voltage (e.g., 30 VDC to the chopper instead of 300 VDC) by supplying external power to the controller chip (if used) and injecting base/gate drive from a signal generator. This would greatly reduce the shock hazard as well as equipment damage from a slipped probe or missed faulty component.

- Perform as many tests as possible with power off and the equipment unplugged. For example, the semiconductors in the power supply section of a TV or monitor can be tested for short circuits with an ohmmeter.

- Use an isolation transformer if there is any chance of contacting line connected circuits. A Variac(tm) is not an isolation transformer! The use of a GFCI (Ground Fault Circuit Interrupter) protected outlet is a good idea but will not protect you from shock from many points in a line connected TV or monitor, or the high voltage side of a microwave oven, for example. (Note however, that, a GFCI may nuisance trip at power-on or at other random times due to leakage paths (like your scope probe ground) or the highly capacitive or inductive input characteristics of line powered equipment.) A fuse or circuit breaker is too slow and insensitive to provide any protection for you or in many cases, your equipment. However, these devices may save your scope probe ground wire should you accidentally connect it to a live chassis.

- Don't attempt repair work when you are tired. Not only will you be more careless, but your primary diagnostic tool - deductive reasoning - will not be operating at full capacity.

- Finally, never assume anything without checking it out for yourself! Don't take shortcuts!

Tips on SMPS troubleshooting

The diagnosis of problems in switchmode power supplies is sometimes made complicated due the interdependence of components that must function properly for any portion of the power supply to begin to work. Depending on design, SMPS may or may not be protected from overload conditions and may fail catastrophically under a heavy load even when supposedly short circuit proof. There is particular stress on the switching devices (they are often 800 V transistors) which can lead to early or unexpected failure. Also, SMPS may fail upon restoration of power after a blackout if there is any kind of power spike since turn-on is a very stressful period - some designs take this into account and limit turn on surge.

However, the cause of many problems are immediately obvious and have simple fixes - the blown chopper transistor or dried up main filter capacitor. Don't assume your problem is complex and convoluted. Most are not. You should not avoid attempting a repair just because there is a slight chance it will be more challenging!

A low power (e.g., 25 W) fine tip soldering iron and fine rosin core solder will be needed if you should need to disconnect any soldered wires (on purpose or by accident) or replace soldered components. A higher power iron or small soldering gun will be needed for dealing with larger components. Never use acid core solder or the type used for sweating copper pipes!

CAUTION: You can easily turn a simple repair (e.g., bad solder connections) into an expensive mess if you use inappropriate soldering equipment and/or lack the soldering skills to go along with it. If in doubt, find someone else to do the soldering or at least practice, practice, practice, soldering and desoldering on a junk circuit board first! See the document: Troubleshooting and Repair of Consumer Electronic Equipment for additional info on soldering and rework techniques.

Test equipment

The most valuable piece of test equipment (in addition to your senses) will be a DMM or VOM. These alone will suffice for most diagnosis of faulty components (like shorted semiconductors or open fusable resistors).

CAUTION: If the SMPS (or any other piece of equipment) is capable of producing voltages beyond 1,000 V (or the max range on your meter), make sure you use a proper high voltage probe or high voltage meter - fault conditions could easily result in voltages in the system that are way beyond those that are expected, even if run at reduced input voltage and/or with a series current limiter.

In designs using controller ICs, an oscilloscope comes in handy when there are startup or overcurrent/voltage shutdown or cycling problems. Since everything runs at a relatively low frequency, almost any scope will do.

Incredibly handy widgets

These are the little gadgets and homemade testers that are useful for many repair situations. Here are just a few of the most basic:

- Series light bulb for current limiting during the testing of TVs, monitors, switching power supplies, audio power amplifiers, etc. I built a dual outlet box with the outlets wired in series so that a lamp can be plugged into one outlet and the device under test into the other. For added versatility, add a regular outlet and 'kill' switch using a quad box instead. The use of a series load will prevent your expensive replacement part like a switchmode power transistor from blowing if there is still some fault in the circuit you have failed to locate. (Now, if I would only remember to do this more often!). See the section: The series light bulb trick.

- A Variac. It doesn't need to be large - a 2 A Variac mounted with a switch, outlet and fuse will suffice for most tasks. However, a 5 amp or larger Variac won't hurt. If you will be troubleshooting 220 VAC equipment in the US, there are Variacs that will output 0-240 VAC from a 115 VAC line (just make sure you don't forget that this can easily fry your 115 VAC equipment.) By varying the line voltage, not only can you bring up a newly repaired monitor gradually to make sure there are no problems; you can also evaluate behavior at low and high line voltage. This can greatly aid in troubleshooting power supply problems. WARNING: a Variac is an autotransformer - not an isolation transformer and does not help with respect to safety. You need an isolation transformer as well.

Note: Some SMPS designs require power to be applied instantly to provide the startup voltage to the controller. If this is the case with yours, it won't be possible to bring up the voltage slowly (unless you power that chip separately). However, it should still be possible to run the unit somewhat reduced line voltage. Also, running any SMPS at reduced line voltage is stressful. It may also result in outputs that are not properly regulated and go much higher than normal. Thus, a Variac should be used with caution - with the outputs connected to dummy loads instead of the powered equipment and a series current limiter (e.g., light bulb) in the input.

- Isolation transformer. This is very important for safely working on live chassis equipment like line connected switchmode power supplies (primary side). You can build one from a pair of similar power transformers back-to-back (with their highest rated secondaries connected together. I built mine from a couple of similar old tube type TV power transformers mounted on a board with an outlet box including a fuse. Their secondary high voltage windings were connected together to couple the two transformers together. The unused low voltage windings can be put in series with the primary or output windings to adjust voltage. Alternatively, commercial line isolation transformers suitable for TV troubleshooting are available for less than $100 - well worth every penny.

  There is absolutely no imaginable reason not to use an isolation transformer for troubleshooting SMPSs except possibly for the final test where confirmation is needed that the inrush from a direct line connection (which will have virtually unlimited instantaneous current capability) will not damage the newly repaired supply.

- Variable isolation transformer. You don't need to buy a fancy combination unit. A Variac can be followed by a normal isolation transformer. (The opposite order also works. There may be some subtle differences in load capacity.).

Safe discharging of capacitors in switchmode power supplies

A working SMPS may discharge its capacitors fairly quickly when it is shut off but DO NOT count on this. The main filter capacitors may have bleeder resistors to drain their charge relatively quickly - but resistors can fail and the term 'quickly' may be relative to the age of the universe. Don't depend on them.

The technique I recommend is to use a high wattage resistor of about 5 to 50 ohms/V of the working voltage of the capacitor. This isn't critical - a bit more or less will be fine but will affect the time it takes to fully discharge the capacitor. The use of a current limiting resistor will prevent the arc-welding associated with screwdriver discharge but will have a short enough time constant so that the capacitor will drop to a low voltage in at most a few seconds (dependent of course on the RC time constant and its original voltage).

Then check with a voltmeter to be double sure. Better yet, monitor while discharging.

Obviously, make sure that you are well insulated!

For the power supply filter capacitors which might be 400 uF at 200 V, a 2 K ohm 10 W resistor would be suitable. RC=.8 second. 5RC=4 seconds. A lower wattage resistor (compared to that calculated from V^^2 / R) can be used since the total energy stored in the capacitor is not that great (but still potentially lethal).

The discharge tool and circuit described in the next two sections can be used to provide a visual indication of polarity and charge for TV, monitor, SMPS, power supply filter capacitors and small electronic flash energy storage capacitors, and microwave oven high voltage capacitors.

Reasons to use a resistor and not a screwdriver to discharge capacitors:

- It will not destroy screwdrivers and capacitor terminals.
- It will not damage the capacitor (due to the current pulse).
- It will reduce your spouse's stress level in not having to hear those scary snaps and crackles.

Capacitor discharge tool

A suitable discharge tool for each of these applications can be made as quite easily. The capacitor discharge indicator circuit described below can be built into this tool to provide a visual display of polarity and charge (not really needed for CRTs as the discharge time constant is virtually instantaneous even with a multi-M ohm resistor.

- Solder one end of the appropriate size resistor (for your application) along with the indicator circuit (if desired) to a well insulated clip lead about 2-3 feet long. For safety reasons, these connections must be properly soldered - not just wrapped.
- Solder the other end of the resistor (and discharge circuit) to a well insulated contact point such as a 2 inch length of bare #14 copper wire mounted on the end of a 2 foot piece of PVC or Plexiglas rod which will act as an extension handle.
- Secure everything to the insulating rod with some plastic electrical tape.

This discharge tool will keep you safely clear of the danger area.

Again, always double check with a reliable voltmeter or by shorting with an insulated screwdriver!

Capacitor discharge indicator circuit

Here is a suggested circuit which will discharge the main filter capacitors in switchmode power supplies, TVs, and monitors. This circuit can be built into the discharge tool described above.

A visual indication of charge and polarity is provided from maximum input down to a few volts.

The total discharge time is approximately 1 second per 100 uF of capacitance (5RC with R = 2 K ohms).

Safe capability of this circuit with values shown is about 500 V and 1000 uF maximum. Adjust the component values for your particular application.

```
(Probe)
<-------+
 In 1   |
        /
```

```
        \    2 K, 25 W     Unmarked diodes are 1N400X (where X is 1-7)
        /                   or other general purpose silicon rectifiers.
        \
        |
        +-------+--------+
      __|__   __|__      |
      _\_/_   _/_\_      /
        |       |        \ 100 ohms
      __|__   __|__      /
      _\_/_   _/_\_      |
        |       |        +-----------+
      __|__   __|__    __|__      __|__      Any general purpose LED type
      _\_/_   _/_\_    _\_/_ LED  _/_\_ LED   without an internal resistor.
        |       |        |    +      |    -  Use different colors to indicate
      __|__   __|__      +-----------+        polarity if desired.
      _\_/_   _/_\_      |
 In 2   |       |        |
>-------+-------+--------+
(GND Clip)
```

The two sets of 4 diodes will maintain a nearly constant voltage drop of about 2.8-3 V across the LED+resistor as long as the input is greater than around 20 V. Note: this means that the brightness of the LED is NOT an indication of the value of the voltage on the capacitor until it drops below about 20 volts. The brightness will then decrease until it cuts off totally at around 3 volts.

Safety note: always confirm discharge with a voltmeter before touching any high voltage capacitors!

Voltage checkers

Whereas a multimeter is intended to measure voltages (and other things), a checker is used mostly to just produce a quick indication of the presense of voltage, its polarity, and other basic parameters. One use is a quick, but reliable indication of the status of the charge on a BIG capacitor. An, example of a simple version of such a device is the "capacitor discharge indicator circuit" described above.

(From: Ian Field (ionfieldmonitors@ic24.net).)

The version of the checker that I have, also contains a miniature 12 V battery for continuity checking - any resistance less than about 22K will produce some glow. It's handy for quick checks of semiconductor junctions - in general if it produces a slight glow it's leaky, but transistor B/E junctions have an inherent zener voltage, so there is usually some glow. Also schottky-barrier diodes give a reverse leakage glow - this does not mean they're faulty, check the Vf with the diode-check on a DMM before binning! Any zener diode above 10-11 V can be given a quick test for S/C, lower Vz will produce some glow - again check Vf before binning.

These checkers are getting hard to obtain, most of the component stockists here only carry vastly over complicated (and expensive) versions with built-in measurement computer and LCD - these wouldn't last 5 min's around flyback circuitry! Some Automotive accessory shops have a simpler version with no battery - always check that it's stated to be capable of measuring AC or DC at 4 to 380 V before parting with money! The internal circuit should contain the LED's, a 15 ohm resistor to limit the maximum surge current when the PTC is cold and the special PTC film-thermistor. The battery can be added with a button from a VCR front panel - but don't blame me if you kill yourself because you didn't insulate the added components properly! There is a more complicated non-battery version with 2 LED's close to the front of the handle to indicate polarity and a row of LED's along the length of the handle to indicate the voltage-range. This version contains 2 special PTC's and a discrete-transistor bargraph circuit - there might be room to add a battery inside the case. As for the special PTC this is the only place I've seen them - one possibility that might be worthy of looking into is the Siemens PTC SMPSU startup thermistor for TDA4600 control chips, this usually has a series resistor of at least 270 ohms and is more likely to turn-up in European TV set's, but I have seen it in early Matsushita IBM displays and a few others (possibly Tandon) the PTC thermistor is always blue and looks like a very-miniature copy of the Philips white-plastic PTC degauss thermistor.

The series light bulb trick

When powering up a monitor (or any other modern electronic devices with expensive power semiconductors) that has had work done on any power circuits, it is desirable to minimize the chance of blowing your newly installed parts should there still be a fault. There are two ways of doing this: Use of a Variac to bring up the AC line voltage gradually and the use of a series load to limit current to power semiconductors.

Actually using a series load - a light bulb is just a readily available cheap load - is better than a Variac (well both might be better still) since it will limit current to (hopefully) non-destructive levels.

CAUTION: Running any SMPS at greatly reduced line voltage will be stressful for it, especially if the output load is a significant fraction of its full load ratings. In addition, at some range of line voltage, the output regulation may not work properly and the output(s) may go much higher than expected. Use dummy loads in place of the valuable equipment if possible when doing such testing!

What you want to do is limit current to the critical parts - usually the switchmode (chopper) power transistor of an SMPS or horizontal output transistor (HOT) of a TV or monitor. Most of the time you will get away with putting it in series with the AC line. However, sometimes, putting a light bulb directly in the B+ circuit will be needed to provide adequate protection. In that location, it will limit the current to the HOT from the main filter capacitors of line connected power supplies. This may also be required with some switchmode power supplies as they can still supply bursts of full (or excessive) current even if there is a light bulb in series with the AC line.

Actually, an actual power resistor is probably better as its resistance is constant as opposed to a light bulb which will vary by 1:10 from cold to hot. The light bulb, however, provides a nice visual indication of the current drawn by the circuit under test. For example:

- Full brightness: short circuit or extremely heavy load - a major fault probably is still present.
- Initially bright but then settles at reduced brightness: filter capacitors charge, then lower current to rest of circuit. This is what is expected when the equipment is operating normally. There could still be a problem with the power circuits but it will probably not result in an immediate catastrophic failure.
- Pulsating: power supply is trying to come up but shutting down due to overcurrent or overvoltage condition. This could be due to a continuing fault or the light bulb may be too small for the equipment.

Note: for a TV or monitor, it may be necessary (and desirable) to unplug the degauss coil as this represents a heavy initial load which may prevent the unit from starting up with the light bulb in the circuit.

The following are suggested starting wattages:

- 40 W bulb for VCR or laptop computer switching power supplies.
- 100 W bulb for small (i.e., B/W or 13 inch color) monitors or TVs.
- 150-200 W bulb for large color monitors or projection TVs.

A 50/100/150 W (or similar) 3-way bulb in an appropriate socket comes in handy for this but mark the switch so that you know which setting is which!

Depending on the power rating of the equipment, these wattages may need to be increased. However, start low. If the bulb lights at full brightness, you know there is still a major fault. If it flickers or the TV (or other device) does not quite come fully up, then it should be safe to go to a larger bulb. Resist the temptation to immediately remove the series light bulb totally from the circuit at this point - I have been screwed by doing this. Try a larger one first. The behavior should improve. If it does not, there is still a fault present.

Note that some TVs and monitors simply will not power up at all with any kind of series load - at least not with one small enough (in terms of wattage) to provide any real protection. The microcontroller apparently senses the drop in voltage and shuts the unit down or continuously cycles power. Fortunately, these seem to be the exceptions.

What about SMPSs in TVs and monitors?

TVs and monitors have at least one SMPS - the horizontal deflection flyback circuit and may have an additional SMPS to provide the low voltages or the DC for the horizontal output transistor. Most of the theory of operation and troubleshooting techniques apply to these as well. However, manufacturers of TVs and monitors tend to be really creative (can you say, obscure?) when it comes to these designs so a little more head scratching is often necessary to decipher the circuit and get into the mind of the designer. However, the basic failure modes are similar and the same test procedures may be used.

Comments on SMPS capacitor discharging and testing with series loads

(From: Ian Field (ionfieldmonitors@ic24.net).)

At a pinch, discharging BIG electrolytic capacitors with a test lamp (230 V, 60 W in the UK; 115 V, 25 W in series in the US) will do, but if the lamp has blown you are in for a nasty surprise! While I am not criticising the use of spare high-wattage resistors, I tend to find that these get tidied away, so there's none about when you need one!

The lamp sometimes get's used if I can't find an NTC, but I always check with a voltage checker because of the risk! - power resistors can go O/C as well whereas NTC thermistors generally fail S/C - which usually happens as a result of some transient phenomenon such as a lightning-strike near the underground power line.

This is unlikely with the energy dump of discharging an off-line electrolytic (unless the equipment is still powered at the time!). My bench isn't the tidiest in the world, so gadgets tend to get misplaced - including power resistors with added discharge-progress LED indicators. This is where an inrush-suppressor NTC comes into it's own, even without selecting the type - it will discharge a capacitor almost instantaneously with the minimum of arc-burn on the solder pads. Obviously the energy causes some heating - in the case of large electrolytics direct-off-line rectifier smoothing/reservoir the amount of heating is just sufficient to give an idea of the condition of the capacitor - capacitor failure is comparatively rare, so it's not often anticipated and can cause misleading symptoms - so making this double as a routine check occasionally saves a hell of a lot of time!

The trick I have found works even better is to use a NTC inrush-current suppressor thermistor. These items can be salvaged from a scrap monitor or PSU, and careful selection may reveal some types with a "room temperature resistance" of several kohms - with the line-voltage on a capacitor discharging through them, self-heating reduces the resistance to a few ohms. This reduces the welding-sputter as the contact current is only a few milliamps - this rises to a few amperes as the capacitor "dumps" its charge as the NTC resistance fall's with self-heating.

One point I would disagree on is that not all of the many electrolytics need discharging! Most SMPSU's of any appreciable power have high energy electrolytics in the secondary - whether this is expressed as high voltage or high current. In the case of monitors, the post PWM-B+ rail has a large storage electrolytic which can do appreciable damage in the event that line-drive failure has prevented use of it's energy. The NTC thermistor method helps here; after "dumping" the line voltage electrolytics - the NTC is at a lower resistance and ready for following up on the lower charge electrolytics.

There is a point concerning "test-lamp dummy loads" this has more to do with monitors than SMPSU boxes. As well as the suggested use to limit inrush current to a safe value on SMPSU boxes - I also use this method on line-O/P stages especially to verify that flyback-transformer failure was not the original cause of B+PWM or SMPSU blow-up. Recently I have been caught-out a few times because some "energy-star" designs are so efficient that the inrush current of the lamp itself is ample to cause catastrophic damage! The UK 220/230 V 60 W test lamp I have here has a calculated operating resistance of 806.7/881.7 ohms compared to a measured cold resistance of about 67 ohms so the PTC effect of the filament tends to limit the advantage!

To clarify my comment on confirming whether a faulty flyback transformer has damaged the B+PWM; older circuits use a MOSFET buck-regulator, in which S/C failure of the MOSFET feeds unregulated B+ to the line-O/P stage - This invariably destroys the HOT and sometimes the transformer, but either could as easily be the original cause. In any event - bypassing the B+PWM MOSFET via the test lamp passes just enough current to see if the transformer is operable - with the price of replacements, very few quotes are accepted - so it's well worth making sure before ordering an expensive replacement or doing too much repair work! More recently, the trend has been for flyback - step up B+ regulators. When the B+ MOSFET fails S/C it simply stalls the main SMPSU (sometimes destroying the rectifier!). Since this type of B+PWM is step-up, the operability of the flyback transformer can be checked by simply removing the S/C MOSFET. The most recent designs appear to be based on semi-resonant SMPSU topology - they resemble buck-regulator PWM controllers, but the PWM MOSFET is at chassis potential and the transformer primary is at full PSU-rail, the line-O/P transistor is between the two with the drive transformer connected to provide an emitter-coupled blocking oscillator configuration, to add "regen" to the base drive. The boost diode often includes the buck-regulators "ringing-choke" in the "net inductive component" that it recovers energy from! As the later configuration most closely resembles the buck-regulator type, the test lamp is required to confirm transformer operability - but the weird and wonderful circuit arrangements can make it lots of fun working out where to connect it!

A voltage checker that I find indispensable is the Steinel Master check 3 from; Steinel GmbH & Co. (KG Dieselstrabe 80-86 D-4836 Hertzebrock 1, Germany). The version I have consists of a pair of "inverse-parallel" LED's in series with a metal-film PTC thermistor on a tiny ceramic tube former - this has a very low thermal inertia so the PTC thermistor limits the current to a safe value for the LED's for any applied voltage between 4 & 380 V the combination of 2 LED's give a clear indication of AC or DC polarity. When this checker is used around SMPSU's, you can clearly see the effect of minority carrier transition time losses in the rectifiers, because the leading-edge of the waveform pushes the rectifiers Vf well in excess of 0.7 V for the minority carrier injection delay - before the rectifier begins to conduct. Where a PSU rectifier has two electrolytics and a choke in a Pi filter, the checker will often reveal negative transients on the electrolytic closest to the rectifier - which is a clear sign of capacitor ESR failure.

SMPS failure modes

Also see the section: Sounds that SMPSs make.

SMPS fail in many ways but the following are common:

- Faulty primary-side components. Rectifier diodes, filter capacitor(s), MOVs, and other parts located before the switchmode (chopper) transistor(s) may short due to a surge or lightning, or for no apparent reason. Main fuse will blow instantly.

  Symptoms: Totally dead supply, fuse blows instantly (vaporizes or explodes) even if switchmode transistor is removed unless a fusable resistor has blown to protect the fuse. :) Test all components on line side of high frequency transformer for short circuit failures with a multimeter.

- Shorted switchmode transistor - may take out additional parts such as fusable flameproof resistors in collector or emitter circuits of bipolar transistors or source or drain circuits for MOSFETs as well as gate components like the 15 or 18 V protection zener. Main fuse will blow unless protected by fusable resistors and one or more of them blows first.

  Symptoms: Totally dead supply, fuse blows instantly (vaporizes or explodes unless fusable resistor has opened). Measuring across C-E or D-S of switchmode transistor yields near zero ohms even when removed from circuit.

- Shorted rectifier diodes in secondary circuits - these are high frequency high efficiency diodes under a fair amount of stress.

  Symptoms: In a very basic supply without overcurrent protection, the failure of one or more of these diodes may then overload the supply and cause a catastrophic failure of the switchmode power transistor (see above) and related components. Thus, these should be checked before reapplying power to a supply that had a shorted switchmode transistor.

  On short circuit protected supplies, the symptom may be a periodic tweet-tweet-tweet or flub-flub-flub as the supply attempts to restart and then shuts down. Any power or indicator lights may be blinking at this rate as well.

  Test with an ohmmeter - a low reading in both directions indicates a bad diode. Sometimes these will test OK but fail under load or at operating voltage. Easiest to replace with known good diodes to verify diagnosis. Rectifiers either look like 1N400X type on steroids - cylinders about 1/4" x 1/2" (example: HFR854) or TO220 packages (example: C92M) with dual diodes connected at the cathode for positive supplies or the anode for negative supplies (the package may include a little diagram as well). These may either be used with a center-tapped transformer, or simply parallel for high current capacity. If in doubt, remove from the circuit and test with the ohmmeter again. If not the output used for regulation feedback, try the supply with the rectifier removed. As noted, a test with an ohmmeter may be misleading as these rectifiers can fail at full voltage. When in doubt, substitute a known good rectifier (one half of a pair will be good enough for a test).

- Bad startup circuit - initial base (gate) drive is often provided by a high value, high power resistor or resistors from the rectified AC voltage. These can simply open for no good reason.

  Symptoms: In this case the supply will appear totally dead but all the semiconductors will check out and no fuses will blow. Check the startup resistors with an ohmmeter - power resistors in the AC line input section. WARNING: there will be full voltage on the main filter capacitor(s) - 1X or 2X peak or around 160 or 320 VDC depending on design. Discharge before probing.

- Dried up capacitors - either input or output side.

Symptoms: The main filter capacitor may dry up or open and cause the output to be pulsing at 60 (50) or 120 (100) Hz and all kinds of regulation problems. Measure voltage across main filter capacitor(s). If the reading is low and drops to a much lower value or 0 instantly upon pulling the plug, then one of these capacitors may be open or dried up. If you have an oscilloscope, monitor for ripple (use an isolation transformer!!). Excess ripple under moderate load is an indication of a dried up or open capacitor.

In extreme cases, a main filter capacitor with greatly reduce capacity or that is totally open may result in failure of the switchmode transistor and a dead supply that blows fuses or fusable resistors. Therefore, it is always a good idea to test the electrolytic capacitors whenever repairing a SMPS that has blown its switchmode transistor.

Capacitors in the low voltage section may fail causing regulation problems. Sometimes there are slew rate limiting capacitors which feed from the primary output to the regulator controller to limit initial in-rush and overshoot. A failure of one of these may mess up regulation at the very least. For example, excess leakage may reduce the output of the main output (and as a consequence, all the others as well).

Where a controller like a UC3842 is used, a failure of the capacitor on its Vcc pin may result in a aborted startup or cycling behavior as it is starved for juice each time it pulses the switchmode power transistor:

(From: John Hopkins (bugs71@ptdprolog.net).)

> "I have encountered a bad cap (10uf 35v) on the Vcc input of a UC3842 IC in the power supply. Turn unit on, get very short burst of power supply output, then nothing. Every time the 3842 output a pulse, it ran out of VCC. Small part, big problem."

In almost all cases, when in doubt parallel a known good capacitor of similar capacitance and at least equal voltage rating (except for these slew rate limiting capacitors where substitution is the only sure test).

For Panasonic (and other) VCR power supplies, it is common - almost assured after a few years - that one or more the output filter capacitors commonly fail and replacing all of them, while perhaps a brute force solution, will fix a whining supply or one having bad regulation or noise. However, check the semiconductors as well before applying power. See the section: Panasonic VCR SMPS.

- Bad connection/cold solder joints - as with all other mass produced power systems (including TVs and monitors), cracked or defective solder connections are very common especially around the pins of high power components like transformers, power resistors and transistors, and connectors.

  These are particularly common with portable equipment. Universal AC adapters for camcorders and laptop computers are often abused to the point of failure. Large components like the line filter choke and high frequency transformer are prone to crack the solder bond at their pins or even break loose from the circuit board.

  Symptoms: almost any kind of behavior is possible. The unit may be erratic, intermittent, or totally dead. Visually inspect the solder side of the circuit board with a bright light and magnifying glass if necessary. Gently prod or twist the circuit board with an insulating stick to see if the problem can be made to change. Note that a one-time intermittent can blow many components so inspecting for intermittents is a really good idea even you believe that all bad components have been replaced.

- Regulation problems - outputs high or low.

  Symptoms: voltage has changed and adjustment pot if one exists has no effect or is unable to set voltage to proper value. Check components in the feedback regulator, particularly the opto-isolator and its associated circuitry. A weak opto-isolator may allow for excessive output voltage. A shorted photodiode in the opto-isolator may prevent startup. An open photodiode may lead to a runaway condition. WARNING: probe these circuits with care both because of the safety issues but also since any slip of the probe may lead to a runaway condition and catastrophic failure of the switchmode transistor and its related parts as well as damage to any attached equipment.

Note that the high frequency transformer does not make the top 10 list - failure rates for these components are relatively low. You better hope so in any case - replacements are usually only available from the original manufacturer at outrageous cost.

Most other parts are readily available from places service parts distributors like MCM Electronics as well as general electronics distributors like DigiKey and Mouser.

Rebuild kits are available for many common supplies used in VCRs, monitors, terminals. See the section: Repair parts sources.

Also, while it is tempting to suspect any ICs or hybrid controllers since it is thought that replacements are difficult and expensive to obtain, these parts are pretty robust unless a catastrophic failure elsewhere sent current where it should not have gone. And, ICs at least, are usually readily available.

Sounds that SMPSs make

Most switchmode power supplies when operating normally produce little or no detectable sound. The switching frequencies are usually well above the range of human hearing, but your dog or pet dolphin might be driven nuts!

However, under various fault conditions, and sometimes when lightly loaded, there may be tell-tail audible indications of the SMPS's state of happiness. The cause may be in the SMPS itself or its load.

1. Tweet-tweet-tweet or chirp-chirp-chirp (sometimes flub-flub-flub) - Short circuit or current overload. This is usually an indication of a shorted secondary-side rectifier and/or if in a TV or monitor using an SMPS, a shorted horizontal output transistor. The power supply is in a repeating cycle attempting to start up, being dragged down by the overload, and shutting down.

2. High pitched, but audible, whine - Excessive load. Like (1), this may be caused by shorted components. For example, a common failure a Panasonic VCR power supply is for the 18 V zener diode across the 15 V output to short due to dried up electrolytic capacitors. The result in an overload and whine, but usually not a catastrophic failure of anything else.

Which of (1) or (2) actually present will depend on the particular design of the SMPS and the severity of the overload. If the design uses a hard SCR crowbar, an overvoltage condition may trigger one of the symptoms!

3. Tick-tick-tick - Too little or no load. In a TV or monitor using an SMPS, this is likely due to a lack of horizontal drive or a blown fuse or fusable resistor in the horizontal deflection system. The power supply is in a repeating cycle of starting up, being unable to limit the regulated voltage to a safe value, and shutting down. Attempting to power up an SMPS without an adequate dummy load may result in these symptoms.

4. Hissing or white noise - possibly from inductors - this may be normal under certain conditions:

   (From: Charlie Allen (charlie.allen@usa.net).)

   > "Some switchmode power supply inductors will make a hissing or white noise sound, typically when the circuit is lightly loaded and running in a "pulse skip" or PFM mode. I have heard it on many DC/DC circuits. You could try removing the coil and pouring in some epoxy."

General SMPS troubleshooting approach

The following sections provide a set of guidelines for attacking SMPS problems. Those in the next 5 paragraphs are common to SMPS using both discrete and integrated controllers:

1. First, determine that it is not something trivial like a blown fuse due to a legitimate overload (that has since been removed). I have a SCSI peripheral box that will blow its SMPS fuse if the SCSI cable is inserted live.

2. Categorize the problem into: startup problem, catastrophic failure, incorrect outputs, or excessive ripple or noise.

3. Determine what the proper output voltages should be. Identify the main (regulated) output.

4. Disconnect the supply from the equipment it is powering if possible. This will prevent the possibility of expensive damage should the output voltages soar to stratospheric levels for some reason. If this is not possible, you will need to be extra careful - always use a Variac to bring up the input slowly and monitor the main output at all times.

   Note: Some SMPS designs require power to be applied instantly to provide the startup voltage to the controller. If this is the case with yours, it won't be possible to bring up the voltage slowly (unless you power that chip separately). However, it should still be possible to run the unit somewhat reduced line voltage.

   CAUTION: Running any SMPS at greatly reduced line voltage will be stressful for it, especially if the output load is a significant fraction of its full load ratings. In addition, at some range of line voltage, the output regulation may not work properly and the output(s) may go much higher than expected. Use dummy loads in place of the valuable equipment if possible when doing such testing!

5. Determine an appropriate load for the outputs (if not connected to the equipment). A typical SMPS will want a minimum of 5% to 20% of full load current at least on the main output to regulate properly. Others may not need any load - it depends on the design or they may have an internal load. Here are some typical load currents:

   - VCR - 0.2 A on +5 V and +12 V outputs.
   - PC - 2 A on +5 V, 1 A on +12 V. A dual beam auto head light works well.
   - Monitor - 0.2 A on +60 V to +120 V output.
   - Typical 40 W switcher = 1 A on +5 V and +12 V.

Troubleshooting SMPSs using discrete controllers

The following paragraphs apply mainly to SMPSs using discrete circuitry (no ICs) for pulse width control. For those using integrated controller chips, see the next section: Troubleshooting SMPSs using integrated controllers.

- Startup problems - check the power on the switchmode transistor and work back from there if there is none. Check for open fusable resistors in the return as well. Determine if there is startup base/gate drive. Check for open startup resistors, bad connections, blown parts in the controller circuitry.

- Blows fuses - check primary side components, switchmode transistor(s), and all other semiconductors for shorts. Then check for open fusable resistors and bad connections. Finally, check the electrolytic capacitors for reduced capacity and leakage.

- Power cycling - monitor current and voltage sensing signals to determine if they are actually signaling a fault. Open or out of tolerance resistors may result in incorrect sensing. With the series light bulb and/or Variac, disable each of these inputs by bypassing the appropriate components. If one of these experiments prevents the cycling behavior, either that circuit has a faulty component or the controller circuit is not functioning properly.

- Regulation or ripple/noise problems - check main HV filter capacitor and other filter capacitors for decreased value or opens. Check regulation components including shunt regulators and zener diodes.

Troubleshooting SMPSs using integrated controllers

Since there are usually several fault conditions that can result in an aborted startup or cycling behavior, the basic troubleshooting procedure needs to be modified when dealing with SMPS using controller ICs like the UC3840 or UC3842.

Also see the section: Typical controller ICs found in small switchmode power supplies for descriptions of two common integrated controller ICs.

The following paragraphs apply to SMPSs using integrated controllers. For those using discrete components only (no ICs), see the previous section: Troubleshooting SMPSs using discrete controllers.

- Startup problems - check the power on the switchmode transistor and work back from there if there is none. Check for open fusable resistors in the return as well. Check for power to the controller. Determine that no fault condition inputs have abnormal voltages during startup. Check for drive out of the controller IC and see if it reaches the switchmode transistor. You will probably need to power cycle the line input and monitor each of the relevant signals as you do so. (It may not be possible to bring up the voltage slowly with a Variac if the startup circuit uses capacitive or inductive coupling to generate the intial supply voltage for the controller chip. However, a Variac can still be used to run it at reduced voltage if this is the case.) Determine if the supply is shutting down abnormally due to a legitimate or bogus over-current or over-voltage condition or is never actually starting up due to a lack of a voltage or a stuck-at fault on a sense line. Monitor its power to determine if it is stable during startup - a bad capacitor or diode could result in insufficient or decreasing voltage which causes the controller to give up.

  CAUTION: Running any SMPS at greatly reduced line voltage will be stressful for it, especially if the output load is a significant fraction of its full load ratings. In addition, at some range of line voltage, the output regulation may not work properly and the output(s) may go much higher than expected. Use dummy loads in place of the valuable equipment if possible when doing such testing!

  Powering the controller separately may aid in troubleshooting of these and related problems. This will decouple the chopper drive from the voltage usually derived via a winding on the high frequency transformer to power the controller once the supply is running.

- Blows fuses - check primary side components, switchmode transistor(s), and all other semiconductors for shorts. Then check for open fusable resistors and bad connections. There is a chance that a blown transistor took out the controller chip as well. Under normal conditions, controllers like the UC3840 or UC3842 should current limit on a PWM cycle-by-cycle basis. Therefore, a blown fuse indicates a failure of either the switchmode transistor, controller or both.

- Power cycling - First make sure you are providing the minimum load if one is required. Many SMPSs will cycle on overvoltage if there is none. Some may blow up! Assuming the load conditions are normal, monitor current and voltage sensing and Vcc inputs to controller to determine which, if any, are at fault. Open or out of tolerance resistors may result in incorrect sensing. Check for faulty reference setting components like zener diodes. With the series light bulb and/or Variac, disable each of the sense inputs by bypassing the appropriate components. If one of these experiments prevents the cycling behavior, either that circuit has a faulty component or the controller IC's input characteristics have changed and it will need to be replaced. It should be possible to determine if these sensing reference levels are correct from the controller specifications and thus should be ignored by the controller as within normal limits.

- Regulation or ripple/noise problems - check main HV filter capacitor and other filter capacitors for decreased value or opens. Check regulation feedback components to controller including any reference voltage output and zener diodes. Determine if the controller is responding to error voltage. If possible, monitor both error and PWM drive signals on a dual trace scope.

Initial post-repair testing

Once defective parts have been replaced, if possible remove the normal load from the supply if you have not already done so just in case it decides to put excessive voltage on its outputs and replace with a dummy load. For a multiple output supply, the most important output to have a load on is the one that is used for regulation but some modest load on all the outputs is preferred. You should be able to determine a suitable value by considering the application. For something like a VCR, a few hundred mA on the main output is probably enough. This would require something like a 25 ohm 2 W resistor for a 5 or 6 volt output or 50 ohm 5 W resistor for a 12 volt output (depending on which is the primary output). For a PC power supply, a couple of amps may be needed - a 2 or 3 ohm 15 W resistor on the +5 output. The minimum load is sometimes indicated on the specification sticker. In the case of a TV or monitor, disconnecting the load may not be possible (or at least, easy).

If available, use a Variac to bring up the input voltage slowly while observing the main output. You should see something at about 50% of normal input voltage - 50 or 60 V for a normal 115 VAC supply. With a small load, the output should very quickly reach or even exceed its normal value. Regulation at very low line voltage may be far off - this is often normal. Just make sure you're using dummy loads so your equipment can't be damaged.

Note: Some SMPS designs require power to be applied instantly to provide the startup voltage to the controller. If this is the case with yours, it won't be possible to bring up the voltage slowly (unless you power that chip separately. So, if nothing happens when doing this, don't panic - it may be a feature, not a bug. :) It should still be possible to run the unit somewhat reduced line voltage on the Variac.

If you do not have a Variac, put a light bulb in series with the line (this is desirable in any case). Use a 100 W bulb for a TV or PC, 40 W for a VCR typical. The light bulb should limit the current to a non-destructive value long enough to determine whether everything is OK. It may not permit normal operation under full load, however. When power is first applied, the light bulb will flash briefly but may just barely be glowing once the output has stabilized. If it is fairly bright continuously, there is likely still a problem in the supply. See the section: The series light bulb trick.

Once you are finished, save your schematic and notes for the future. For example, multiple models of VCRs even from different manufacturers use the same basic design, maybe even the same supply.

Some general switchmode power supply repair comments

Any time the switchmode transistor requires replacement, check all semiconductors for shorts and fusable resistors for opens. even if you locate what is thought to be **the** problem early on. Multiple parts often fail and just replacing the transistor may cause it to fail as a result of something else still being bad. In particular, check primary side electrolytic capacitors for reduced capacity or opens. These conditions can result in a blown switchmode transistor as it attempt to supply adequate current during the troughs of the rectified high voltage DC. It only takes a few more minutes. For other problems like an open startup resistor this excessive caution is unnecessary as these are usually isolated failures. However, if any dried up electrolytics are found, it is good practice to test them all - or just replace them all since the cost and time will be minimal. As they say, 'peas in a pod fail at nearly the same time'.

It is often helpful to trace the circuit by hand if a service manual is not available. You will gain a better understanding of this supply and be able to put the knowledge to use when the next one shows up on your bench - there is a lot of similarity even between different manufacturers. A bright light behind the circuit board may help to make the foil runs and jumpers more visible. The only difficult part will be determining how the transformer windings are hooked up. An ohmmeter will help but even if you cannot entirely determine this, just make a note. For most purposes, the exact topology of the windings is not critical for diagnostic procedures.

Periodic power cycling problems

These are of the form: tweet-tweet-tweet or flub-flub-flub or some other similar variation. Any LEDs may be flashing as well and in the case of something like a monitor or TV, there may be HV static or even a partial raster in synchrony with the sounds. These types of problems are more common with sophisticated implementations - the simple ones just blow up!

As noted elsewhere, shorted secondary components are a very likely cause of this behavior. These include diodes, capacitors, and overvoltage SCRs. The fact that there is some output suggests that the main switchmode (chopper) transistor is working. There would likely be no output at all if it were bad.

Note that an underloaded supply may be cycling due to overvoltage and there may actually be nothing wrong! Many SMPSs require a minimum load to maintain stability and to provide proper regulation. This is typically 20 percent of maximum on the primary output (the one which drives the feedback loop). However, minimum loads may also be needed on other outputs depending on design. The only way to be sure is to check the manufacturer's specs.

Other possibilities for periodic or pulsing outputs:

1. One of the diodes is failing at volage - quite possible. As long as you do not remove both from the output that is used for feeback, it should be safe to take them out one at a time and then substitute for the one remaining in the feedback voltage. Use a Variac and series light bulb when testing in this manner and constantly monitor the main output.

2. Some other cause of excessive current - shorted capacitor, transformer (though not likely), etc.

3. Faulty current sense circuit - open or increased value resistor.

4. Faulty voltage sense circuit - detecting overvoltage or regulation defective and it is shutting down (correctly).

5. Faulty component in the startup circuit. This could be a bad diode, resistor, or even an electrolytic capacitor that has changed value or is open at low voltage (when the controller is just waking up).

6. Faulty controller IC (if applicable).

Testing a SMPS without startup drive

Where an SMPS doesn't start and it isn't obvious why, it might help to drive the chopper from an external signal source to see what then works. The only time this is really practical is where a single transistor or MOSFET is used - generating a push-pull waveform probably isn't worth it.

This will always be a risky procedure both for you and the power supply. The switching frequency is likely unknown but for these tests you can assume it is in the 10 to kHz range. You can reduce the risk somewhat (to the supply at least) by using a series light bulb load and/or running on reduced line voltage. The most important thing to avoid is putting in an excessively long drive pulse which will result in the high frequency transformer saturating, huge amounts of current, and likely a dead transistor and possibly other parts if there is nothing to limit the current. If you have the option, start with a narrow pulse waveform to minimize on-time and don't push your luck! :)

Similarly, where a power supply attempts to start but cycles or shuts down, consider powering the controller chip from a separate supply to eliminate any issues of the transformer derived voltage that normally runs it after startup.

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Components Found in Switchmode Power Supplies

Common, unusual, and strange

Most of the components used in switchmode power supplies are common and easily identified. However, some may be unfamiliar and unrecognizable. Others could be totally custom parts - ASICs or hybrid circuits - developed specifically for a particular model or product line. However, these rarely fail despite your temptation to blame them specifically *because* locating a replacement is difficult and most likely expensive.

Common components like transistors, diodes, capacitors, and resistors, can usually be tested with a multimeter at least for total failure. Also see the documents: "Testing of Bipolar Transistors with a VOM or DMM" and "Testing Capacitors with a Multimeter and Safe Discharging".

Of course, with catastrophic failures, no equipment beyond your eyeballs and nose may be needed.

Switchmode (chopper) transistors and other semiconductors

Also see the document: Basic Testing of Semiconductor Devices.

- Bipolar power transistors (often BU or 2SC/2SD numbers) - high voltage power types are used for the main switchmode (chopper) transistor.

Test for shorted and open junctions. These are the most common failures for the power transistors. Partial failure where there is some leakage or various parameters change value are unlikely.

Substitution of a transistor with at least equal voltage and current ratings should be fine for testing as long as you use a series light bulb to limit the current should something still be wrong elsewhere in the circuit. A not-exact match may run hotter than normal. Always use a heatsink.

- Power MOSFETs (2SK numbers) - many newer supplies are using these rather than the bipolar type. In some ways they are more robust but testing is more difficult.

  Testing for shorts is still possible but anything beyond the "moist finger test" requires additional equipment than a multimeter. However, the original problem did not blow a fuse or fusable resistor, if the MOSFET is not shorted, there is an good chance that it is still fine and you should look elsewhere for the problem. It may be a problem with the startup circuit or controller. There is also usually a 15 or 18 V zener across G-S for protection. This may blow when the MOSFET dies.

Note: if your supply produces any output (say, more than 10% of rated voltage), it is unlikely that the chopper transistor is bad as it must be working to some extent and, as noted, these usually blow totally.

- Small bipolar transistors - these may be found in feedback and control functions.

  Test for shorted and open junctions with a multimeter. Substitute with similar known good transistor is best, however. I have seen little silicon transistors that had developed enough leakage to prevent a 400 W supply from coming up!

- Diodes and rectifiers - a bridge or set of 2 or 4 discrete diodes is usually used for the AC line rectification and/or doubling. High efficiency and/or fast recovery types are used in the secondary side for rectification of the various output voltages. These may look like normal axial lead diodes or may be combined in pairs inside TO220 type packages.

  Test for shorted and open junctions. However, sometimes, diodes will only fail with full voltage in-circuit but test good with a multimeter.

  Replacements for the primary side rectifiers are very inexpensive and readily available. If the unit blows fuses with the switchmode transistor and main filter capacitors pulled, the rectifiers may indeed be bad.

  It is usually safe to remove secondary rectifiers one at a time to see if the supply will come up. As long as you do not remove all diodes for the output that provides the feedback for the regulation, this should be relatively low risk. (However, do this with a dummy load - not your expensive laptop computer just in case.) Even removing those diodes is usually safe if you can power the supply using a Variac since you will be able to limit the input (while monitoring the main output) should the outputs go overvoltage.

- SCRs - small SCRs may be found in the overvoltage protection circuitry of some supplies. Note that SCR type of crowbars are used across the output as a way to guarantee that an overvoltage condition will kill the output regardless of the reason for the overvoltage condition. Hopefully, the supply's overcurrent protection will kick in rather than having the supply blow up. This is not always the case, unfortunately.

  Test for shorts if output on which SCR is connected is not coming up. Remove the SCR. Now, using a Variac to bring up the voltage slowly, see if the relevant output is going over voltage, is still clamped at a low level, or is the correct voltage (under load). A momentary overvoltage spike at turn-on could also trip the crowbar. This could be due to a faulty inrush/slew rate limiting circuit.

- TL431 or similar shunt regulator IC - either a TO92 or 8 pin DIP. Has 3 active terminals - A, C, and R. Current will flow from C to A if R-A is greater than 2.5 V.

  Test for shorts but substitution is best. However, with care (using a Variac AND series light bulb to limit the input current, it is possible to determine if the circuit in which these are connected is working. Short across TL431 - supply should either turn off or run at greatly reduced output. Remove the TL431 - there should be no regulation - outputs should continue to climb as Variac is increased. By monitoring input to TL431 it should be possible to determine if it is doing its job.

- Optoisolator - either a 4 or 6 pin DIP or a 4 pin cylindrical object. This provides the regulator feedback across the isolation barrier. Replacements are readily available.

  Test by putting 10-20 mA through LED and measuring decrease in resistance of reverse biased photodiode. However, this will not identify a weak optoisolator. Swapping is best.

Capacitors (filter and bypass)

- Filter capacitors - electrolytic type are used for filtering of the rectified (possibly doubled) AC line input and for filtering of the various outputs of the power supply.

  If no capacitor checker is available, test for opens, shorts, and leakage with a multimeter. For electrolytics, this is straightforward. Inspect the capacitor for any discoloration, a bulging case, or other evidence of trauma.

  An ESR meter is a convenient device for rapidly checking the health of electrolytic capacitors. The ESR (Effective Series Resistance) of a capacitor increases as the capacitor deteriorates ('dries up'). Even a capacitor that tests good on a capacitor checker may not work properly due to excessive ESR.

  When in doubt, the best approach is to substitute a known good capacitor of at least equal working voltage and similar uF rating.

  Also see the document: Capacitor Testing, Safe Discharging and Other Related Information.

  (From: Steve (libertytek@aol.com).)

  > "When you find a position that eats electrolytic caps, replace them but add a parallel .22 to .47 uF ceramic monolithic.
  >
  > Whenever these crappy caps are used with even small high frequency currents passing through them, they break down chemically causing other failures also. Even the "high ripple current" rated caps won't tolerate what they should and are often rated at 1,000 - 2,000 hours.
  >
  > I also often find too little heat sinking and will add more surface to improve cooling."

- Bypass Capacitors - high quality plastic dipped or rectangular molded capacitors as part of RFI filter. These rarely fail.

Test for shorts - your multimeter will probably not be able to detect the small capacitance. Substitute if in doubt.

Note that many of these are special high quality low loss types with regulatory approval for use across the power line in the line filter. Exact replacements are required for safety.

Resistors (normal and flameproof), NTC thermistors, MOVs

- Resistors - test for correct value with a multimeter. If measured in-circuit, value may read low if shunted by other components. If a higher than normal reading is obtained in-circuit, the resistor is bad. Metal film types like to go open circuit - especially very high value resistors.

  Startup resistors in particular tend to go open-circuit resulting in a dead supply but no blown fuses or fusable resistors. These are usually high value (100K typical) medium wattage and run hot since they are across the full rectified line voltage.

- Flameproof or fusable resistors (They are the same) - these are often designated 'FR'. They will look like power resistors but will be colored blue or gray, or may be rectangular ceramic blocks. They should only be replaced with flameproof resistors with identical ratings. They serve a very important safety function: they cannot catch fire when overheated and will open rather than changing value which implements an overload protection function.

  These usually serve as fuses in addition to any other fuses that may be present (and in addition to their function as a resistor, though this isn't always needed). If an FR type resistor has blown, you probably have shorted semiconductors that will need to be replaced as well. Check all the transistors and diodes in the power supply with an ohmmeter. You may find that the main switch mode transistor has decided to turn into a blob of solder - dead short. Check everything out even if you find one bad part - many components can fail or cause other components to fail if you don't locate them all. Check resistors as well, even if they look OK.

  The most common location for these in a small SMPS is in the return circuit of a the switchmode transistor. However, they may be in the power feed as well. The value may be a fraction of an ohm but can be larger.

  In TVs and monitors, these are often found in the hot power feed to the main low voltage power supply and in various secondary supply feeds as well. For the main supply, they will be 5-25 W rectangular ceramic power resistors. For the secondary supplies, they may be the 1/2-2 W blue or brown tubular variety.

  Test for opens. Those in the return circuits are usually very low value - a fraction of an ohm to a few ohms - if in the return of the switchmode (chopper) transistor. The type in the power feeds may be anywhere from a fraction of an ohm to several K ohms depending on the circuit load.

  For testing ONLY, a normal resistor may be substituted but the proper replacement MUST be installed before returning the supply to service.

  Since they function as fuses, flameproof resistors should not be replaced with higher wattage types unless specifically allowed by the manufacturer. These would not blow at the same level of overload possibly resulting in damage to other parts of the circuitry and increasing the risk of fire.

- MOVs - Metal Oxide Varistors - look like brightly colored plastic coated disk capacitors but not marked with capacitance. These are surge suppressors. A severe surge or lightning strike may obliterate one or more of these. There will usually be either 1 between the Hot and Neutral or 3 across H, N, and safety ground.

If they are visibly damaged in any way, just remove (for now) or replace. Test with an ohmmeter - resistance should be nearly infinite.

- NTC resistors (thermistors) - Negative Temperature Coefficient resistors act as inrush surge limiters. There may be one or two of these in series with the AC input. These are a high value when cold but drop to a low value once they heat up due to current flow into the supply. These often look like fat black disk capacitors.

  Test when cold and hot (use a hot air gun or hair dryer if not in-circuit). Resistance should drop from 10s of ohms to a very low value.

Transformers and inductors

- High frequency transformers - these include the switchmode power transformer and any feedback (toroidal or E-I core type) transformers.

  The main transformer which provides line isolation and generates the multiple output voltages from the 150-320 VDC input rail. These are usually custom wound for each model power supply and replacements are only available from the manufacturer. However, some distributors will stock replacements for a few TVs and computer monitors.

  Testing for opens is usually easy since connections to the input (chopper) and output rectifiers are fairly obvious. However, feedback windings may be involved and these are not readily determined without a schematic or tracing the circuit (and, possibly not even then.) The good news is that failures of these transformers is less common than one might fear.

  Some supplies use small transformers for feedback rather than optoisolators. These can be tested for opens but rarely cause problems. There may also be transformers in series with the input that can be similary tested.

  Identifying shorted turns requires a 'ring test' or measurement of the Q. See the document: Testing of Flyback (LOPT) Transformers.

- Control/standby power transformers - used to provide power to the controller of some units when the main chopper is idle. These may be damaged by a power surge, usually with an open primary winding. Test with an ohmmeter. A shorted winding will result in overheating.

- Inductors - test for opens. Identifying shorted turns requires a 'ring test' or measurement of the Q. See the document: Testing of Flyback (LOPT) Transformers.

  AC line input inductors can just be bypassed if they test open.

  Output 'pi' filter inductors rarely fail but if you suspect one, just remove it and jumper across the pads for testing - ripple just won't be quite as good.

- Coupled Inductors - used as part of the Pi type RFI filter in the AC input circuit. These look like small transformers but the windings are in series with the AC line. There are usually 1 or 2 of these on better supplies and they are very reliable.

Test for opens. Identifying shorted turns requires a 'ring test' or measurement of the Q. See the document: Testing of Flyback (LOPT) Transformers. These inductors can just be removed and bypassed during testing if they are open since they only affect input line noise filtering.

Fans

Many small SMPSs don't have any fans built in but expect there to be a fan or fans elsewhere in the equipment designed draw air over the power supply. Most computer power supplies do have a fan inside - and these are high failure items due to how cheaply they are made.

A bad or tired fan, or even clogged air filters, can result in overheating and outright failure, or at the very least, increased stress on components and reduced life expectancy. Thus, periodic maintenance is highly recommended. Inspection of the fan(s) and filter(s) should be one of the first steps in any testing procedure.

The most common problem with fans is dry/gummed up/worn bearings. Ball bearings are rarely found in PC power supplies (the manufacturer saved 25 cents). Even on expensive workstation computers, mediocre fans may be used (Sun Microsystems had to replace a whole bunch of fans on state-of-the-art Ultra-Sparc systems because of bad bearings). Quick test: With the power off, give the fan a spin. If it continues to coast for at least a couple of seconds, the bearings are probably good. If it stops instantly, they are gummed up. If in doubt, replace the fan with a good quality ball bearing type. It's really not worth attempting to disassemble and oil the bearings unless you have nothing better to do.

Fan motors do go bad but this is much less common than bad bearings. With modern brushless DC motors, one phase could be defective resulting in sluggish operation and/or failure to start if stopped in just the wrong position.

On more sophisticated equipment with temperature sensing to adjust fan speed, the speed control circuitry could also be bad.

WARNING: Replacement of the fan on SMPSs requires access to the interior. Make sure the equipment is unplugged and the large filter capacitors are fully discharged before doing anything inside the case - both for your safety and to prevent damage to the supply.

For more on fans, fan motors, and lubrication, see the document: Notes on the Troubleshooting and Repair of Small Household Appliance and Power tools.

(From: Clive Cooper (clpc@cooperware.com).)

I spent 3 days searching for a problem on a SMPS. It turned out to be a simple fault that eluded me for some time.

The SMPS worked fine for about 10 minutes and then the output voltages dropped slowly and eventually the supply went dead.

It turned out that the fan, although it appeared to be working fine was only getting 60% of the supply voltage it needed. This was due to a faulty temperature sensor that just told the fan that the supply was cold even when it was hot.

Conclusions: A fan that is blowing is not necessarily blowing what it should be blowing and the fact that it seems to be working doesn't mean its working at maximum efficiency.

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Items of Interest

Panasonic VCR SMPS

The same power supply design is used with minor variations in a wide variety of Panasonic (and clone) VCRs from the 1980s and 1990s (and may continue to this day). Depending on the specific model, there may slightly different output voltages and number of outputs but the general organization is identical. These use discrete components throughout with feedback from the primary output (5 to 5.2 V depending on model) using an optoisolator to essentially short out the drive to the main chopper transistor (Q1) when the output equals the desired voltage. The most common problems found with any of these supplies is dried up electrolytic capacitors. Generally, the first to go will be C16 and C17 on the +5.1 VDC line and/or C21 in the feedback path (actual part type and number may vary slightly with model). Symptoms will be either that the primary output is somewhat low (4 to 4.5 VDC) or that the supply has gone overvoltage and blown the protection zener (D15) resulting in a high pitched whine as the chopper struggles to drive current into a short circuit (this usually doesn't damage any other parts if caught in a reasonably timely manner). If any capacitor related problems are found, it is a good idea to replace all the electrolytics in the supply. Model specific capacitor kits as well as total rebuild kits are available from places like Studio Sound Service and MCM Electronics.

The Panasonic VCR power supply schematic is available in both PDF and GIF format:

* Get VCRPS: vcrps.pdf or vcrps.gif.

Typical controller ICs found in small switchmode power supplies

Here is some information on the Unitrode UC3840 programmable off-line PWM controller and its simplified cousin, the UC3842. These are typical of the types of sophisticated inexpensive integrated SMPS controller ICs that are now readily available.

* Unitrode Datasheets gets you Unitrode's power conversion controllers (more than 40 different devices!).

  Or, from the Philips site:

* UC3842 Datasheet

* UC3842 Application Note

The information below is just a summary.

These devices generate the PWM pulse control to the switchmode (chopper) transistor as well as various fault sensing and other control functions.

Parts such as these are now found in many small switchmode power supplies and provide much more precise control during startup and normal operation, and better handling of fault conditions compared to most implementations using discrete circuitry.

However, they also result in additional head scratching when troubleshooting since many faults or incorrectly detected faults can shut down the unit or cause a power cycling type of behavior. Therefore, a datasheet for the controller chip will prove essential. In many cases a scope will be needed to monitor the various sense, control, and drive signals. A systematic troubleshooting approach must be used to eliminate power, startup, sensing, and control components one at a time once obvious shorted or open parts or bad connections have been eliminated from consideration.

Unitrode UC3840 programmable off-line PWM controller

Features of the Unitrode UC3840 include:

1. Fixed frequency operation set by user selected components.
2. A variable slope ramp generator for constant volt-second operation. providing open-loop line regulation and minimizing or in some cases, even eliminating the need for feedback control.
3. A drive switch for low current start-up off of the high voltage line.
4. A precision reference generator with internal over-voltage protection.
5. Complete over-voltage, under-voltage, and over-current protection including programmable shutdown and restart.
6. A high current single-ended PWM output optimized for fast turn-off of an external power switch.

The following pin descriptions for the Unitrode UC3840 were derived from a Unitrode application note. Errors in interpretation are quite possible.

```
Pin 1: Compensation         Error amplifier (op amp) compensation network.

Pin 2: Start/U.V. lockout   This comparator performs three functions.  With
                            an increasing voltage, it generates a turn-on
                            signal at a start threshold. With a decreasing
                            voltage, it generates an under-voltage fault
                            signal at a lower level separated by a 200uA
                            hysteresis current.  At the under-voltage
                            threshold, it also resets the Error Latch if
                            the Reset Latch has been set.

Pin 3: OV sense             Over-voltage input from power supply output(s).

Pin 4: Stop (Ext stop)      External logic signal to inhibit power.

Pin 5: Reset                External logic signal to reset error condition
                            caused by (1) over-voltage, (2) over-current, (3)
                            input under-voltage detect, (4) external stop.
```

Pin 6: Current threshold	This voltage input sets the over-current trigger levels for the internal comparators.
Pin 7: Current sense	This is the pulse-by-pulse PWM current control. The input is a voltage taken across a series resistor in the switchmode transistor's return. There are two internal comparators with a difference in threshold of 400 mV. The one with the lower threshold limits the current for each PWM cycle. The one with the higher threshold sets the error flop-flop and shuts down the supply if its threshold is ever exceeded.
Pin 8: Slow start	This input limits the maximum PWM duty cycle. During power-on, an RC delay can therefore control the rate at which the output ramps up. The final value limits the maximum PWM duty cycle during normal operation.
Pin 9: Rt/Ct	R and C determine the constant PWM oscillator frequency.
Pin 10: Ramp	Ramp generator output.
Pin 11: Vi sense	This voltage is normally derived from the DC input and controls the slope of the ramp.
Pin 12: PWM output	This is the drive signal to the switchmode transistor. This is an open collector output and will normally be used in conjunction with the Driver bias (Pin 14) signal to provide total drive to the switchmode transistor.
Pin 13: Ground	Signal and drive common.
Pin 14: Driver bias	Supplies drive current to external power switch to provide turn-on bias and pullup during normal operation. Disabled for shutdown if the Error Latch is set.
Pin 15: Vcc	UC3840 chip supply derived from the DC input rail during startup and secondary winding on high frequency transformer during normal operation.
Pin 16: 5 V reference	Stable voltage reference (output) for regulation control.
Pin 17: Inv input	Error amplifier inverting input.
Pin 18: Non inv input	Error amplifier non-inverting input. The difference between the inputs on Pins 17 and

18 control PWM duty cycle. These will generally be derived by comparing the main output with the desired voltage reference.

Unitrode UC3842 off-line PWM controller

The UC3842 provides the necessary functions to implement an off-line fixed frequency current mode control schemes with a minimal external parts count. Note how most of the pin functions are subsets of those found in the more sophisticated UC3840. The UC3842 retains most of the features of the UC3840 but requires fewer external components and comes in a much smaller package (8 vs. 18 pins).

The following pin descriptions for the Unitrode UC3842 were derived from a Unitrode application note. Errors in interpretation are quite possible.

```
Pin 1: Compensation           Error amplifier (op amp) compensation network.

Pin 2: Vfb                    Error amplifier (non-inverting) input for
                              regulation feedback.

                              This input is used to control PWM duty cycle
                              and is normally derived from the main regulated
                              output voltage.  It is similar in function to
                              The non-inverting input, Pin 18, of the UC3840.

Pin 3: Current sense          This is the pulse-by-pulse PWM current control.
                              The input is a voltage taken across a series
                              resistor in the switchmode transistor's return.

Pin 4: Rt/Ct                  R and C determine the constant PWM oscillator
                              frequency.

Pin 5: Ground                 Signal and drive common.

Pin 6: PWM output             This is the drive signal to the switchmode
                              transistor.  It uses a totem pole output which
                              has a high current drive capability both high
                              and low.

Pin 7: Vcc                    UC3842 chip supply derived from the DC input rail
                              during startup and secondary winding on high
                              frequency transformer during normal operation.

Pin 8: 5 V reference          Stable voltage reference (output) for regulation
                              control.
```

Description of UC3842 startup operation and cycling problems

Depending on the particular circuit design, a variety of fault conditions can result in cycling or shutdown of an SMPS controlled by a chip like the UC3842. And, an underloaded supply may be cycling due to overvoltage!

In addition to the overload condition described below, a dried up electrolytic capacitor on the Vcc line can also result in this cycling behavior since it is unable to hold up the voltage between output pulses. In addition, the sense inputs can trigger shutdown. In all, an often complex difficult to understand and troubleshoot situation - sometimes too much so for its own good!

(Portions from: Yves Houbion (yves.houbion@fundp.ac.be).)

Pin 7 is the power supply (Vcc). The oscillator inside the 3842 begins to work above 16 V on Vcc and stops working when this voltage drops below 11 V. With a stopped oscillator, the current consumption is very low, around 1 mA; with a working oscillator, the current is much higher, about 12 mA. (The specific voltages and currents are typical values for one particular version of the 3842 and can vary from device to device and depending on model.)

Vcc is generally powered in two ways: a high value power (startup) resistor connected to the main bridge (e.g., +300V) and a from a winding off the transformer (via a rectifier/filter capacitor). The value of the startup resistor is selected such that there is more than 16 V with 1 mA but less than 11 V at 12 mA. So the oscillator can't continue to work with only the startup resistor supplying power.

Suppose we apply AC power to the supply. The +300V comes on. First, the 3842 consumes only 1 mA, Vcc reaches 16 V, and the oscillator starts up. If all is well (no overloads), the transformer provides the necessary 12 mA current to maintain Vcc at more than 11 V.

However, if the transformer is overloaded, Vcc falls under 11 V and the oscillator stops working. The current decreases to 3 mA, the voltage increase (coming from the +300V) the oscillator start again, ad-infinitum.

Tweet-tweet-tweet....

Switching between 115 VAC and 230 VAC input

Assuming it is not a wide compliance 'universal type', a common way to do this is with a jumper (or switch) in the line input circuitry below (also shown in Typical SMPS Input Voltage Select Circuit):

```
              D1
AC o-----+----|>|-------+---------+-----o DC (+)
        ~|    D2        |+        |
         +----|<|----+  |       +_|_
              D3     |  |     C1 ---
         +----|>|----|--+       - |
         |    D4     |    +--o-o--+     +320 VDC to chopper
AC o---+-+----|<|----+ -  |  J1   |
       |~            |    |     +_|_
       +-------------|----+   C2 ---
                     |          - |
                     +------------+-----o DC (-)
```

- With the jumper, J1, installed, the circuit is a voltage doubler for use on 115 VAC. (D3 and D4 never actually conduct because they are always reverse biased.)
- With the jumper, J1, removed, the circuit is a simple bridge rectifier for use on 230 VAC.

Changing the input voltage of a switchmode power supply

Would it be possible to modify a power supply designed for operation on 120 VAC for use overseas where the power is 240 VAC?

I don't advise it. There are many factors involved in changing a power supply unless it is designed for dual voltage or autoswitching. They saved a few cents if it is not easily switched, what can I say?

The problem is that it is probably a flyback converter and these are pretty finicky about changes. In addition to the caps, and switching transistor, the transformer would probably saturate at the higher voltage unless the switching frequency were also doubled. Getting these things to work normally without blowing up is touchy enough. To change one without a thorough understanding of all the design parameters would be really risky.

Going the other way may be more realistic if (and this is a big if) you will not be running at anywhere near full capacity. Many switchmode power supplies will run on much lower than their rated input voltage. However, regulation may be poor and the switchmode transistor will need to be passing much higher current to maintain the same power output. To maintain specifications could require extensive changes to the circuitry and replacement of the switchmode transistor and possibly transformer and other parts as well. Again, I do not recommend this.

Use a small stepup or stepdown transformer instead. The only exceptions are:

- If there are clearly marked jumpers to select the input voltage.

- You can reverse engineer enough of the input circuitry to add/remove the needed connection with confidence.

  CAUTION: As they say in wood-working: "Measure twice, cut once". Make sure you are dealing with the correct jumper AND you are going the right way (increasing or decreasing as needed). If the manufacturer didn't include this feature, there may be a good reason!

- The supply is clearly marked as being autoswitching or having universal power input.

Also see the secton: "Switching between 115 VAC and 230 VAC input".

Slightly modifying the output voltage of a PC power supply

Surplus PC power supplies are widely available and inexpensive. However, what do you do if 5 V isn't exactly what you need for a project?

(From: Winfield Hill (hill@rowland.org).)

Some of the PC power supplies I've dissected do have pots, by they have a limited voltage-adjustment range. One interesting thing, every design used a TL431 chip, which is a 3-pin TO-92 regulating IC, as the voltage reference and opto-feedback component. Find this chip and trace out the resistors connected to it to determine which part to change to make a higher voltage.

But, watch out for the SCR over-voltage circuit in some supplies. This is usually set to trip around 6 to 6.5 volts, and its trip point would need to be modified as well.

As far as the step-down transformer turns ratio, there's little trouble one will encounter here, because the power supply is no doubt designed to function properly with reduced AC line voltages. The penalty one will pay for turning up the output voltage is a higher minimum AC voltage.

In most designs, the +12 and -12 V supplies merely track the 5V supply, and are not separately regulated. They may soar to higher voltages anyway if unloaded, but will be additionally increased in voltage by the ratio of 5V output increase. Even though the rating of the 5V electrolytic may not be exceeded, and still have a sufficient safety margin, this may not be the case for the 12 V outputs. So that issue should be examined as well.

Finally, a reminder for any reader tempted to break open the box and start experimenting. Voltages of up to 320 V are present, so be careful. Know what you're doing. For safety, stay away from open supplies when plugged in, or always keep one hand behind your back when probing. Remember a the AC bridge and HV DC and flyback transformer portion of all these supplies is operating straight from the AC line, so don't connect the ground of your oscilloscope to any of that circuitry. A battery-operated multimeter is best.

Use of surge suppressors and line filters

Should you always use a surge suppressor outlet strip or line circuit? Sure, it shouldn't hurt. Just don't depend on these to provide protection under all circumstances. Some are better than others and the marketing blurb is at best of little help in making an informed selection. Product literature - unless it is backed up by testing from a reputable lab - is usually pretty useless and often confusing.

Line filters can also be useful if power in you area is noisy or prone to spikes or dips.

However, keep in mind that most well designed electronic equipment already includes both surge suppressors like MOVs as well as L-C line filters. More is not necessarily better but may move the point of failure to a readily accessible outlet strip rather than the innards of your equipment if damage occurs.

Very effective protection is possible through the use of a UPS (Uninterruptible Power Supply) which always runs the equipment off its battery from the internal inverter (not all do). This provides very effective isolation power line problems as the battery acts as a huge capacitor. If something is damaged, it will likely be the UPS and not your expensive equipment. Another option is to use a constant voltage transformer (SOLA) which provides voltage regulation, line conditioning, and isolation from power spikes and surges. Manufacturers of these products may even provide equipment damage warranties which will reimburse for surge damage to the powered equipment while using their products. I am not sure how one proves that the UPS was being used at the time, however!

It is still best to unplug everything if the air raid sirens go off or you see an elephant wearing thick glasses running through the neighborhood (or an impending lightning storm).

GFCI tripping with monitor (or other high tech equipment)

Ground Fault Circuit Interrupters (GFCIs) are very important for minimizing shock hazards in kitchens, bathrooms, outdoors and other potentially wet areas. They are now generally required by the NEC Code in these locations. However, what the GFCI detects to protect people - an imbalance in the currents in the Hot and Neutral wires caused possibly by someone touching a live conductor - may exist safely by design in 3 wire grounded electronic equipment and result in false tripping of the GFCI. The reason is that there are usually small capacitors between all three wire - Hot, Neutral, and Ground in the RFI line filters of computer monitors, PCs, and printers. At power-on and even while operating, there may be enough leakage current through the capacitors between Hot and Ground in particular to trip the GFCI. Even for ungrounded 2 wire devices, the power-on surge into inductive or capacitive loads like switching power supplies may falsely trip the GFCI. This is more likely to happen with multiple devices plugged into the same GFCI protected outlet especially if they are controlled by a common power switch.

Therefore, I do not recommend the use of a GFCI for computer equipment as long as all 3 wire devices are connected to properly grounded circuits. The safety ground provides all the protection that is needed.

Why do power supplies seem to fail after a power outage?

Startup is the most stressful time for a typical switchmode power supply. The output filter capacitors as well as the load must be driven while the input voltage is changing - possibly wildly. With careful design, these factors can be taken into consideration. Not all power supplies are designed carefully or thoroughly tested under all conditions. When power is restored, surges, dips, brownouts, and multiple on-off cycles are possible. This is why it is always recommended that electronic equipment be unplugged until power has been restored and is stable.

Supplies that are autoselecting with respect to input power are vulnerable to voltages at an intermediate value between their low and high ranges. At some values, they may autoselect the incorrect input range:

(From: Mike Diack (moby@kcbbs.gen.nz).)

A subject dear to my heart due to a recent unpleasant experience - Was using a Picturelel videoconference ISDN codec on a job when, because of a powerline fault, the line voltage dropped to 170 volts. The PicTel has a big Onan switchmode PSU which is autoswitching between 100-120 and 200-240 volts. It got confused, and (regrettably) chose the former.... with very smelly results.

Moral: turn off things with cunning PSUs when brownouts occur (oh yes the airconditioner units got very hot and tripped out, too)

Buzzing or other sounds from SMPSs

Two common causes are (1) loose transformer (or other cores) vibrating at a subharmonic of the switching frequency and (2) dried up electrolytic capacitors (primary side) introducing 120 Hz hum under load.

(From: Ray Hackney (rhackney@unicomp.net).)

Simplistically speaking, the sound comes from something moving.

With non switch mode power supplies (SMPS), it may be ferrous material (like a metal cover) being drawn toward the power transformer. That's obvious since pushing on the cover will soften the hum. The frequency is usually 60Hz or 120Hz.

The only time you should hear a "noise" from a SMPS is during a period of "unstable" operation (i.e. their "loop" isn't stable and in regulation.) That's why you may hear them "chirp" or whistle when you first turn them on or off. It may also indicate a PC type power supply that's overloaded. In years gone by, I've seen a quiet PC become a whistler after having a new, big (30 meg, full height!) hard disk added. Sometimes the pitch of the whistle would change depending on what parts of the system were being accessed or what software was being executed. (Usually, when the old Intel AboveBoard was being accessed in this '286, the audible pitch was lower indicating greater current draw.)

For all power supplies, it may be the windings on the "magnetics" (inductor or transformer). If they're not wound tightly and secured they can vibrate. Many video monitors exhibit this problem when their flyback transformer emits a whistle. It may be the windings themselves moving or the winding assembly may be loose on the core.

Sometimes the capacitors in a SMPS will emit sound. Caps in SMPS' frequently have high AC current levels. If the supply is supposed to have what's known as "continuous current" and goes into "discontinuous current" mode, the capacitor plates get stressed pretty heavily and move in the capacitor body (but only with some types). Since the SMPS will go into and out of discontinuous mode at a rate < 10kHz, it's audible. I've run into this on breadboards I've built for 200W and 2.5kW SMPS'.

Cool electrolytics - temperature rating versus ESR

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

Electrolytic capacitors like to be kept cool! If there's anything that these capacitors can't stand, it's heat. It causes them to dry out.

Electrolytic capacitors exist in (at least) two different temperature ratings: 85 C and 105 C. The latter are obviously more temperature resistant. Unfortunately they also tend to have a higher ESR than their 85 C counterparts. So in an application where the heat is due to I^2 * ESR dissipation, the 105 C type may actually be a *worse* choice! If the heat is due to a nearby hot heatsink then 105 C is indeed a better choice.

When better may be worse

ESR is usually something to be minimized in a capacitor. However, where the original design depended (probably by accident) on a certain ESR, this may not always be the case:

(From: Lee Dunbar (dunbar@unitrode.com).)

Substitutions of low ESR caps into circuits which had lousy caps is not always the good idea that it appears to be.... Caution is advised, as low ESR caps will not limit surge currents.

The circuits' series impedance drops (compare substituted capacitors ESR when new with the original capacitor's ESR was when it was a new capacitor), which, in turn, lets the surge magnitude rise, the higher currents destroy can semiconductors and other components.

I guess what the industry needs is a good capacitor cross reference guide for aluminum electrolytics!

Alan's SMPS troubleshooting technique

(From: Alan Liefting (aliefting@ihug.co.nz).)

1. Replace all faulty components and check all semiconductors and resistors.

2. Remove switching MOSFET or disconnect its supply voltage.

3. Connect variable DC PSU to main secondary voltage (one which is monitored).

4. Connect an oscilloscope to the gate of the switching MOSFET. As the DC voltage from the external PSU is increased to the value of what the SMPS output should be, a change in the mark-space ratio of the PWM

waveform can be observed. Only a small change in the supplied voltage around the SMPS output voltage is required to observe the effect as the power supply attempts to regulate.

If the supplied voltage is increased further the PWM waveform will cease as the control circuit will detect an overvoltage.

With this technique the whole power supply can be tested without fear of destroying MOSFETs and it can be determined if the SMPS is regulating to the correct voltage (if known!).

This will not work with all SMPS's. It depends on the design.

John's notes on SMPS repair

(From: John Croteau (croteau@erols.com).).

Switchmode power supply repairs can be difficult. The problem is manufacturers don't usually give you an easy test set up. They should tell you if it will run at no load or what dummy load to use. Secondly they should tell you what voltage or resistance to use to replace the opto-isolator (or transformer) for that load. The SMPS hot side is a high frequency oscillator whose 'on time' is varied by feedback supplied through the opto-isolator. The troubleshooting procedure should normally be in this order.

1. First eliminate external causes such as shorts or no load as the cause of the shutdown.

2. Eliminate the secondary side shorted diodes, capacitors, etc.

3. After eliminating overloads on the outputs check the DC supply to the power device.

4. Check the bias coming from the feedback. Trace the bias supplied by the feedback and try to determine what is the correct bias for that situation (usually no power same as start-up).

   - If the bias is as on the schematic then troubleshoot the hot (primary) side as any oscillator.

   - If the bias is wrong and there is no short on the output then concentrate on why the feedback doesn't supply the expected voltage to bias the scillator on.

5. If you work on many of the same type SMPS:

   - Determine the normal load and make a dummy load.

   - Determine the value of resistance that is created at the output of the opto-isolator (hint: use Ohm's law). Then remove one leg of the output of the opto-isolator and replace it with a resistor as calculated.

   By using a fixed load and cutting out the feedback it is very easy to troubleshoot. Don't forget to check the voltages and waveforms in your test set-up and record them for future reference.

Russell's comments on SMPS repair

(From: Russell Houlton (71101.2454@CompuServe.com))

I wanted to pass on some comments on repair of switchmode power supplies. I've fixed a few myself.

1. I see quite a few where the filter capacitors have failed. Not all electrolytic capacitors are the same. You should get capacitors that are rated for high frequency service. Use of "normal" caps that one finds in the local electronics stores are likely to go bad in about a year. Not something a professional who values his reputation wants to see happen. In fact, I suspect that some manufacturer fail to understand this and use the wrong caps causing common failures in their units. Especially units that may be subjected to use in warmer areas. I see this mostly with specialized devices rather then mass consumer items.

   I highly recommend the Panasonic HFS series cap that can be bought from DigiKey (and other places I'm sure). These unit are specially designed for good size as well as use in switching supplies. They are also rated for 105 degrees C as opposed to the more common 85 degrees C temperature rating. I have never had to replace a HFS cap I installed, where I've had to replace "common" caps in repair situations. (No I don't sell the HFS or have stock in DigiKey, I'm just passing some info that has worked well for me.) (Note: The HFS series caps have been discontinued by Panasonic. They recommended using the EEU-FC (FC series) as a replacment. --- Sam.)

2. SMPS usually try to regulate one of the output voltages by using the switcher, usually it's the output with the most power, but might be the one that's most voltage critical. If the filter caps go bad in the main output voltage, the auxiliary output voltages will go high. The SMPS may also start to make high-pitched sounds as the ripple messes with the feedback system. The aux output voltages may go so high that the secondary regulator may go into foldback to protect itself. I found this out the hard way. It's really something that can kick you in the pants because normally one would not check the 5V supply if the problem seems to be a bad 23.5 V regulator.

3. Noisy (whining or buzzing) SMPSs that still work tend to be either bad main output voltage capacitors or bad electrolytics in the power oscillator circuit. See the section: Buzzing or other sounds from SMPSs.

4. Most SMPSs have also have a *minimum* power draw requirement from their loads. This is especially true of the main output voltage. If not enough power is drawn from the supply, the supply may not be stable and can not supply full power on the auxiliary voltages. An example of this is using a 250 W PC power supply just to drive a disk drive. Without the heavy 5 V power draw of a motherboard, the supply may not start up reliable or provide the needed 12 V power for the hard drives.

5. I've also seen cases where one of the voltage doubler caps will open up causing failure in one of the switching transistor(s). It will short out a single transistor unit, but in a dual switching unit, the transistor associated with the good cap will over-work itself and open. An easy way to test is to remove the other switching transistor (in a dual unit) and apply power for 2 seconds. (Take all prudent precautions for working around a live and open unit!) Disconnect power and use your voltmeter to check the voltage across each of the caps. They should discharge at a roughly equal rate. A bad cap will lose all it's voltage in less then 2 seconds. A good cap will hold it's charge much longer.

6. Lastly, some unit that have the switch mode power supply in the same enclosure as the CRT will have a sync signal that comes from the horizontal flyback transformer. This keeps the SMPS in sync with the display so that the small magnetic fields that are created by the SMPS don't create a wavy pattern on the screen. Something to remember if a newly re-assembled unit shows a window screen like interference pattern on the display.

Bob's description of how a typical PC power supply works

(From: Bob Wilson (rfwilson@intergate.bc.ca).)

I really suggest you refer to a handbook on basic switchmode power supply design for the nitty-gritty.

I have a schematic of a 200 Watt PC power supply, and I assure you that there are enough cost-saving clever shortcuts in the design, that unless you know a fair amount about the design of switchers, it will just totally and completely baffle you.

Nearly all 200 W PC power supplies are *identical* knock offs of one-another (except for the power-good comparator section). The transformer has a +5 V output which is what is regulated. It also has a +12 V output and a -12 V output. The -5 V output is derived from the -12 V output using a 7905 regulator. All transformer outputs are related in voltage by the transformer turns ratio. The power supply topology is a Half Bridge, which normally requires a "buck section" in each output (namely an inductor, catch diode and capacitor). To vastly improve the cross regulation between windings, a common core is used to wind all the 3 output inductors on.

Basically, however, a 200 W PC power supply is a half-bridge design, with a bridge-type voltage doubler in front which simply rectifies 220 V, or doubles 110 V to 220 V. So the thing is basically a 220 Volt design.

The controller is typically a TI TL494 that operates off the output of the supply. This means that in order to start, there must already be an output voltage present! How they do this is really really clever, and also extremely confusing. The power transformer is itself, self oscillating. This generates a rudimentary output voltage that allows the thing to bootstrap up to normal operation, and the controller chip to take over.

The +12 Volt output is what is used to power the PWM chip. Thus, the supply runs off its own output. This is done to eliminate the need for troublesome opto-coupler feedback. To boot itself up (after all, there is no initial +12 V to allow itself to start), the driver transformer is modified (very cleverly) to form part of a blocking oscillator. Thus the unit initially self oscillates in a crude fashion until there is enough voltage on the +12 V output to allow the PWM to start, which then swamps out the self oscillation and normal operation commences.

Since the controller resides on the output side of the transformer, the drive to the 2 half-bridge NPN bipolar transistors is by a driver transformer (a direct connection cannot be made because the transistors are on the primary side).

Frequency of operation is 50 kHz, which is low by today's standards, but this means lower cost transformer winding (Litz wire is not needed, for example).

Steve's comments on PC power supply operation and repair

(From: Steve Bell (service@bell-electronics.freeserve.co.uk).)

There are not normally schematics available for PC power supplies.

If the PC's are very old, some service manuals included the PSU schematics - but these will be very very old, like the early Apricot that used the Astec AC9335, the Olivetti XT, and some PC's that ran CPM like the LSI Octopus.

Most AT class computers never had schematics available for their power supplies, the manufacturers simply intended them to be swapped out. Schematics were produced by the power supply manufacturers for companies such as Compaq, Sun Microsystems etc, but these where only released to their authorized service centres. These are far and few between and sign non disclosure agreements, so schematics are not available to anyone else. I used to work for one such company, they repaired all of Sun's power supplies from throughout Europe.

Here in the UK, and also in the USA, if a 'standard' AT or ATX power supply fails it's often cheaper to replace. Many PC power supplies aren't standard - we repair many from Compaq, Elonex, HP, Apple, Sun etc that are non standard and can be repaired far cheaper than the manufacturers exchange unit. Also in many countries a swap out isn't available or can be costly.

Even without schematics power supplies can be repaired. The same type of circuitry repeats itself. Older power supplies often used the TL494C pwm IC, newer use the UC3842/3/4/5 series driving MOSFETs. Some older still used the NE5560, SG3524 etc., many didn't use a PWM IC, but instead discrete components. Data sheets on the IC's used are very useful.

Considering the 'standard' 200 W AT PSU, these usually use 2 T0220 power transistors, and at power on a resistor, usually around 270 - 330 K turn on the top transistor, and current flows in the inverter transformer. A winding on the secondary supplies a voltage that is rectified and smoothed to feed the PWM IC and its drivers. These then drive the 2 transistors via a transformer and the power supply is running. The 5 V output voltage is then sensed and fed back to the PWM IC to maintain regulation. Most faults on these types of power supplies involve the high value resistors failing associated with the inverter transistors, the transistors and associated components, bridge rectifier shorted - also check inrush thermistor for cracks or pinholes. Secondary rectifiers can fail, and electrolytic caps can fail if the fan stops. The PWM circuitry can always be fed with an external DC supply and checked independently.

The other type of power supply, less common in older power supplies, uses the UC3842 series PWM IC driving a single MOSFET. This IC sits on the primary side, so its ground is floating high. An isolating transformer is needed when scoping anything on the primary, with the scope ground clip to primary ground.

Sourcing substitute components isn't normally difficult. I'd start by obtaining some decent transistor, diode and MOSFET data books so you can relate faulty parts to what's available locally.

If the power supplies are all 200 W, a simple resistive load will suffice for testing made from large ally clad resistors on a substantial heat sink. These will toast when running for longer, so will need fan cooling - a cheap desk fan is sufficient. If you are going to be repairing a lot of varying power and type over a prolonged period, it may be better to build an active load. This is basically banks of 2N3055's (for 5V & 3.3V) and 2N3773 (for 12 V upwards) in series with low value power resistors than can have their conduction varied and current monitored by other circuitry. You simply have a lead for each power supply type you test/repair. Also don't forget to check the PG o/p on the power supply.

PC power supply information (pinouts, testing and non-standard uses)

When testing or operating a common PC (computer) power supply without being connected to its mainboard and peripherals, a substitute load must be provided. This would be the case if you wanted to determine whether a supply was good or wanted to use the supply for other purposes.

To test the supply, you want to:

- Remove all of the (expensive) stuff - mainboard, drives, etc. Unplug all of the power supply connectors.
- Provide a dummy load to +5 and +12 outputs.
- Typical (but not always) color codes for PC power supplies:

    - Red: +5, Yellow: +12, Black: Gnd (Probably case as well).
    - White: -5, Blue: -12, Orange: Power_good (output).

  (Some newer supplies may have a +3.3 output as well which may be green).

- PC power supplies (as well as most other switchers) need a minimum load on +5 and possibly on +12 as well. An amp (e.g., 5 ohms on +5) should be enough.

  I use an old dual beam auto headlight. It adds a touch of class as well to an otherwise totally boring setup. :-) You can also use auto tail light bulbs or suitable power resistors or old disk drives you don't really care about (you know, those boat anchors).

- There are no sense lines. There is a 'Power_Good' line which is an output from the power supply to the mainboard and can be ignored unless you want to connect it to an indicator to let you know all the outputs are within specs (it may need a pullup and I don't know its drive capability).

- Pinout for the standard PC and clone connector (some companies like Compaq do NOT use this type of connector, however.). Black (Gnd) wires together for the P8 and P9 connectors when installed to mainboard.

```
      J8: Pin 1 = Power_Good   J9: Pin 1 = Gnd
          Pin 2 = +5               Pin 2 = Gnd
          Pin 3 = +12              Pin 3 = -5
          Pin 4 = -12              Pin 4 = +5
          Pin 5 = Gnd              Pin 5 = +5
          Pin 6 = Gnd              Pin 6 = +5
```

  Note: for an XT only, J8-Pin 1 is Gnd, J8-Pin 2 is no connect.

- The peripheral connectors are: Pin 1: +12, Pin 2 and 3: Gnd, Pin 4 = +5.

Safe PC power supply loading

PC power supplies are often ideal for other purposes but the required loads represent wasted power. So, it would be nice to be able to eliminate them. Unfortunately, it probably isn't easy to modify a PC power supply so less/no load is needed for regulation. However, it is worth testing a supply to see how low you can actually go on the loads - many WILL regulate the +5 with no load on the +12 but probably not the reverse. While 20 percent load is often recommended, 5 percent or less may work just fine. And, some don't need any additional loads on either output (they will probably include a minimal load resistor internally).

CAUTION: Usually, a PC power supply will just shut down with too little load. However, some may be much more unhappy. Thus attempting to determine a safe minimum load does entail some risk of letting the smoke out.

The reason that you need a load is that the PWM controller can't do down to really small duty cycles needed for low loading. The design would need to be changed and differs from unit to unit.

Typical PC and ATX power supply schematic

- Domaci Stranka's Web Site has a reverse engineered 200 W ATX PC Power Supply. (Local copy of diagram: Schematic of Typical ATX Power Supply.)

- Tecknik.net has several PC and an ATX power supply under "Circuits". (The ATX supply is the same one as above.)

Notes on ATX power supply testing

You don't need a fancy "mainboard simulator" or "special ATX test tool" to run an ATX power supply on the bench.

(From: Stefan Krommes (stkro@gmx.net).)

There is a wire (Power_Supply_On) on the ATX connector that will turn on the main supply when pulled low. This color of that wire is mostly labeled on the side of the supply - or (as with fortron supplies) it is the one that is not labeled (green). If you look on top of the ATX connector as if it was plugged into the board the wire in question is the 4th from the right hand side on the top row (where there is the clip) - a look into your mainboard manual might give you a visual idea since the ATX connector is often depicted there with pins labeled.

As said if you fire up your supply it would be wise to load it. Check the label on the supply and load the main +5V and +12 V line to about 15-20% of their max. current capability. - Some automotive bulbs (headlight, brakelight, etc.) come handy not only for the 12 V but for the main 5 V line too. Below about 20% load there is the chance of the supply not regulating the voltage properly but it should start.

The 5 V standby line does not need any load - it should read a clean 5 VDC as soon as the supply is plugged in and the mains power switch is switched on.

The main supply should get on-line as soon as the Power_Supply_On wire gets pulled to ground and the voltages should measure within 5% if loaded to about 20% of maximum power.

(From: Sam.)

CAUTION: I have seen one case where an ATX supply actually blew up without a load using this "hot wire" technique. I don't know if there was already a problem with the unit or it really absolutely required a load. But almost immediately after grounding the green wire, multiple electrolytic caps on the secondary side exploded and spilled their guts, one of the MOSFETS shorted, and *then* the power fuse blew. :(It may be that the designers of this supply in their infinite wisdom assumed that since power is enabled via the mainboard, there would never be a circumstance where there wouldn't be at this that as a load!

(From: Arthur Jernberg (stubbie45@hotmail.com).)

Here is the pinout for an ATX mainboard:

Left to right: First row voltage; Second row current/color:

```
[+3.3V] [+5V] [+12V] [-12V] [-5V] [+5VSB] [COM] [P-ON] [PG]
 [14A]  [22A]  [9A]   [1A]  [.5A]  [PUR]  [BLK] [GRN]  [GRY]
```

(From: Sam.)

IMPORTANT CAUTION: Apparently, Dell, who has followed industry standards in most respects, changed the ATX power supply pinout on their PCs sometime in 1998 and may still be using this proprietary pinout. See: Dell Proprietary (Non-Standard) ATX Design. Since there is absolutely no valid technical reason for doing this, one can only assume it is due to some, shall we say, shady business decision to prevent people from going to a third party for upgrades or replacement mainboards or power supplies. Worse, installing a non-Dell power supply with a Dell mainboard will result in a destroyed power supply and possible damage to the mainboard. Thanks Dell. :(It's straightforward though not trivial to change the power supply pinout back to standard (but it isn't a matter of just moving pins around in the connector since the number of wires for some signals has also changed). But there should be no need. Companies should compete by selling a better product, not a closed system.

Detailed Procedure for ATX Power Supply Fault Diagnosis

Before blaming the power supply, make sure the outlet is live, the main power switch (if any) is on, and that any line voltage select switch hasn't changed position or shifted to an intermediate position accidentally (possibly when moving the PC).

(From: Petrus Bitbyter" (p.kralt@hccnet.nl).)

I have written a set of notes on repairing ATX power supplies. It follows below and should contain all you need (and more) to decide whether your power supply has gone or not.

First of all read the document: SAFETY and the general information on SMPS repair elsewhere in this document.

Most of the times the fault is found between the mains connection and the transformer(s).

1. In the most simple cases only the fuse is blown. After replacing this fuse, connect the PS to the mains using the series light bulb trick.

   - If the bulb burns brightly, you know that the old fuse had a good reason to quit, so the case is not simple anymore. The first thing you have to do now is to find the short circuit. The most suspected components are the mains rectifier, the filter capacitors and one or more of the power transistors. Use eyes, nose and an ohmmeter to find scene of the crime. Remove and check the suspected components. Replace defective components except for the power transistors at this time. It makes no sense to continue until you fixed the short circuit

   - If the fuse is good but the PS still dead, you can start to check the voltages.

2. Check the voltage between pin 3 and pin 9 of the ATX to mainboard connector. This should be +5 VDC. If not you have to check the voltages on the mains side. Otherwise it will be wise to check the voltages on the mains side as well (Steps 3 to 5). Then continue reading up to Step 12, not to miss some explanation. Continue at Step 12.

3. The AC pins of the mains rectifier should show the mains AC voltage. If not you may have an interrupted trace or mains filter.

4. Between plus and minus of this rectifier you should find about +310 VDC or +325 VDC depending on your mains voltage. I call it the primary power voltage.

5. If not you may have a faulty mains rectifier.

6. If the voltage is much lower (analog meter) or jumping around (digital meter), the large filter capacitors (e.g., 470 uF, 200 V) are also suspected.

7. Both filter capacitors mentioned above are in series. The midpoint should be at half the primary power voltage. If it is not, the mains rectifier, the filter capacitors and the parallel resistors (parallel to the capacitors) may be defective. Another suspect is a third capacitor (typically 1 uF, 250 V) that leads from the midpoint to a transformer.

Explanation: ATX PSs usually has three power transistors at the mains side. One is connected to a small transformer, the other two connected to a larger transformer. You can recognize the pair of transistors best by finding the emitter of one of them connected to the collector of the other. First you have to deal with the one transistor and the small transformer. (Go to Step 8 if you removed this transistor already.)

6. Check the voltage on the collector of the transistor.

   - If this voltage is zero or very low there may be an interruption between the collector and the primary power voltage.

   - If this voltage is below the primary power voltage or jumping, there seems to be switching activity. You can check this with an AC voltmeter on a secondary coil of the transformer. The reading will not be correct, but if you find an AC voltage you have to continue checking the secondary rectifier and regulator.

   - If this voltage is the primary power voltage the transistor is not conducting (open or not being driven).

7. Check the voltage on the base of the transistor. If this voltage is less than 0.6 V, the startup resistor may be defective. Otherwise, the transistor may be gone (most likely.)

8. Disconnect the PS from the mains and take the safety precautions to discharge the capacitors.

9. Remove the suspected transistor and check it with an ohmmeter or a transistor checker. Most of the times you will have to provide a new transistor. (Beware! Even a transistor that looks good under test conditions may malfunction in the actual circuit.) This is also the time to remove, check and replace other fried, exploded or discolored components near the transistor/transformer combination.

10. Re-power the PS using the series light bulb.

    - If the lamp is burning brightly you have a short circuit in your PS. Most likely your (new) power transistor is conducting due to too high a continuous base current. You have to dive deeper into this part of the circuit until you find the cause of this problem.

    - If the lamp is dim or not burning at all you can re-check the voltage between pin 3 and pin 9 of the mainboard connector. Finding +5 VDC, you can continue. Otherwise you have to restart your investigation of the small transformer/one power transistor part of the circuit. (Step 6.) It makes no sense to continue until this part of the PS functions correctly.

11. Disconnect the PS from the mains when you are done so far.

Explanation: For the next part of the repair procedure you have to provide some load to the PS. This is simply because of some PSs will not function well without load. You may use an (old) main board. Someone ever told me he uses 12 V car bulbs, one on the +5 VDC and another on the +12 VDC outputs. I prefer a huge and heavy old harddrive. Those old basalt blocks (we use to strengthen our dikes) consume a lot of energy. The one I use, provided enough load for all the PSs I ever repaired.

12. Replace the power transistors you may have removed earlier. Reconnect the PS to the mains using the series light bulb. Check the voltage between pin 3 and pin 9 of the main board connector. Connect pin 14 of the main board connector to pin 13. This will switch on the main part of the PS, the part with the two power transistors and the large transformer.

    - If your loads start to work, check the voltages of the several power connectors. When they have the correct values your PS is on air again. Check it out by removing the series light bulb.

    - If (even after removing the series light bulb) some but not all of the values are correct, you have a problem. You have to investigate the failing voltages from the secondary coil of the transformer till the connector. Quite a challenge.

    - If the light bulb is burning brightly you have a short circuit. Most likely your power transistors are gone so you have to check (and almost sure replace) them and their surrounding components, especially the start resistors. Pay special attention to the freewheel diodes (between the collector and the emitter of the power transistors.) Don't forget to disconnect the PS and to discharge the filter capacitors first! When you are done, restart at Step 12.

    - If your lamp is dim or dark but your load does not work you may have defective or blocking power transistors. A fault on the secondary side of the transformer is another possibility.

13. Search for switching activity on the secondary coils of the transformer using an AC meter.

    - If you don't find AC voltage you have to check the voltages on the power transistors.

    - If you find an AC voltage you most likely have a defective rectifier, filter capacitor or regulator at the secondary side. Disconnect from the mains, discharge the filter capacitors and try to find the failing components with an ohmmeter. You will have to remove the rectifiers from the board prior to testing because of the secondary coils have only few windings of thick wire so they are the shortest shortcuts as far as your ohmmeter concerns. Another trick is to use a controllable power supply. Connect it to the point where the removed rectifier was connected to its filter capacitor. Beware of the polarity! Power on both PSs and increase the voltage of your controllable PS to the level of normal operating of your defective PS. The regulator that sucks to much current with respect to the light load will be the main suspect. You have to go deeper into the circuit of this regulator if you want to repair it. Another challenge.

14. Check the voltages on the power transistors. The collector of one of them should be at the primary power voltage, the emitter of the other should be at the common. The remaining collector and emitter are tied together and should be at half the primary power voltage.

    - If you can't find the primary power voltage at a collector you have an interruption. Maybe a bad soldering or the like.

    - If no emitter is connected to common you also have an interruption.

- If the tied collector-emitter is not at half the primary power voltage you most likely have defective power transistors. (In my experience they always die together.) Disconnect, discharge and remove, check and replace the power transistors and their surrounding components. Restart at Step 12.
- If the tied collector-emitter is at half the primary power voltage you can check the base-emitter voltage of the power transistors. If they are less than 0.6 V you may be lucky and find only defective start resistor(s) and/or other base circuit components. But most of the times a defective base circuit will kill its transistor which in turn will kill its neighbor. So you will have to replace them all.

Of course, this story does not cover all possible faults of PC-power supplies, but I only once failed to repair a PS using this scheme.

War stories - the Boschert 2-stage SMPSU

(From: Tony Duell (ard@p850ug1.demon.co.ku).)

In case you have been lucky enough not to have come across the beast, the basic idea is:

1. Rectify/smooth mains, giving 340V DC.
2. Put that into a non-isolated step-down switching converter using a fat power transistor, a freewheel diode and an inductor. The control IC for this is a 723 (!) with feedback applied via an optocoupler from the secondary side. Oh, and there's a current-limit shutdown from a 0R15 resistor in series with the 'load' (section 3, etc). The output of this stage is about 150V
3. The output of that feeds a pair of transistors that run as a free-running push/pull oscillator. That drives the primary of the main chopper transformer (which provides isolation from the mains).
4. The secondaries of that transformer are rectified to provide output voltages. There's a feedback to (2) as described, and also a crowbar.

Now for the failure mode (seen it happen):

1. The first chopper goes short-circuit because it feels like it. The 150 VDC line jumps to 340 VDC (remember, no isolation, and the inductor/transistor are in series from the 340 VDC line to the 150V line).
2. The crowbar fires, shorting the output. The primary-side current goes up as well.
3. The overcurrent trip operates, and the 723 tries to shut down. It removes the drive from the *first* chopper. But that's shorted, so removing the drive doesn't do a darn thing.
4. The 2 transistors in the push/pull circuit short as well.
5. Rectified mains is now connected acros : 3 shorted transistors, a few small windings (oscillator feedback transformer, inductor, etc), and the 0R15 resistor. The latter explodes.
6. 340 VDC is now applied across the connections of the ex-0R15 resistor. A few small transistors and the 723 expire, along with some PCB tracks.

7. The fuse (10 A, FF blow) fails.

Repairing that was an entertainment. I still have my photocopy of the schematic with all the dud components circled!

Capacitors, startup, and low voltage testing

(From: Kevin Beeden (kevin.beeden@rrl.co.uk).)

I was fighting with a Hitachi PSU (SP-13A unit from UK VT-F860E VCR).

Symptoms: Following line power disconnect, wouldn't start up. Traced circuit, found broken Tr in LV side, replaced, no good. No gate drive. Trouble figuring gate drive cct. Applied 30 VDC to HV side and drove gate from 10 kHz signal generator (5 V squarewave via 1K resistor). The MOSFET switcher was okay, output active but won't start. Startup drive is via a 1 uF, 250 V cap. Can't see any drive on gate when power applied from cold. Read these notes. Doh! Capacitor gone open circuit. Replace cap and now get gate drive until output settles.

I was happily surprised to find that the circuit worked off of 30 VDC, as I'm not keen on debugging live mains or 400 VDC! This may be a top tip for fellow debuggers. I simply connected 30 VDC to the post-rectification smoothing cap, hit the gate with the signal generator, and away it went. Note: this is under no load conditions; the PSU was removed from the VCR.

I also found a devious little component masquerading as a resistor. It appears to actually be back-to-back (Schottky? 1V3) diodes and a 220 ohm resistor in some series or parallel arrangement. Marked externally as 220R, identical appearance to other resistors.

Why is the main fuse rating so big?

On a typical SMPS (or piece of equipment like a TV, monitor, or VCR using an SMPS), the nameplate current rating may be much much smaller than the fuse rating (or equivalently, the nameplate power rating may imply a much smaller current). Why is this the case?

There are actually many reasons for the fuse to be much larger than the maximum current specified on the nameplate. Some of these include:

1. The peak current during power on is actually much higher due to the degauss coil and charging of the SMPS caps.

2. ?The power factor is much smaller than unity for a typical SMPS and this increase the average current - which is what the fuse sees.

3. The fuse for the SMPS is really there to protect against catastrophic failure so it can be much larger than the average expected current. If that fuse blows, it's usually the result of the failure of the main chopper transistor, not a slight overload (for which the SMPS should shut down).

Replacing the fuse with a smaller one really won't make the equipment any safer but may result in nuisance blowing.

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* Back to SMPS Repair FAQ Table of Contents.

Service Information

Advanced troubleshooting

If the solutions to your problems have not been covered in this document, you still have some options other than replacement.

(Also see the related document: Troubleshooting and Repair of Consumer Electronic Equipment.

Manufacturer's service literature: Service manuals may be available for for your equipment. Once you have exhausted other obvious possibilities, the cost may be well worth it. Depending on the type of equipment, these can range in price from $5-100 or more. Sometimes, these may even be free (yes, even in this day and age where you have to pay for free air at your local gas station!) Some are more useful than others. However, not all include the schematics so if you are hoping to repair an electronic problem try to check before buying.

Inside cover of the equipment: TVs often have some kind of circuit diagram pasted inside the back cover. In the old days, this was a complete schematic. Now, if one exists at all for a monitor, it just shows part numbers and location for key components - still very useful.

Sams Photofacts: These have been published for over 45 years mostly for TVs and radios. There are some for VCRs and a few for some early PC monitors and other pre-Jurassic computers. However, for the power supplies in TVs, there will nearly always be a Sams with complete schematics.

Whatever the ultimate outcome, you will have learned a great deal. Have fun - don't think of this as a chore. Electronic troubleshooting represents a detective's challenge of the type hat Sherlock Holmes could not have resisted. You at least have the advantage that the electronics do not lie or attempt to deceive you (though you may beg to differ at times). So, what are you waiting for?

SMPS info and datasheets on-line

Many companies now have very extensive information available via the World Wide Web. Here are a few company sites:

* International Rectifier
* Lambda Semiconductors
* Maxim Integrated Products
* SGS-Thomson
* Unitrode Corporation

The following site has a variety of information and links to SMPS related sites:

* SMPS Design by Jerrold Foutz.

References on SMPS technology and troubleshooting

There is a nice detailed article on PC power supply repair from Nuts and Volts Magazine on-line at: PC Power Supply Repair by T. J. Byers. This is probably a good place to start if you are specifically interested in the common PC power supply. It looks like this article is pre-ATX but most of the information still applies.

Also see the document: PC Switchmode Power Supplies.

Texas Instruments has an application note which is sort of the "short" version of SMPS repair. See: Off-Line SMPS Failure Modes PWM Switchers and DC-DC Converters.

Here are some suggested books with information relating to SMPS and DC-DC converter design, testing, troubleshooting, repair, etc.:

1. Power Supplies, Switching Regulators, Inverters & Converters, 2nd Edition.
   Irving Gottlieb
   TAB Books, 1994
   ISBN 0-8306-4404-0

2. Modern DC-to-DC Switchmode Power Converter Circuit
   Rudolf P. Severns and Gordon E. Bloom
   Van Nostrand Reinhold
   ISBN 0-442-21396-4

3. Principles of Solid State Power Conversion
   Ralph E. Tarter
   Howard W. Sams & Co., Inc.
   ISBN 0-672-22018-0

4. Advances in Switched-Mode Power Conversion
   R.D. Middlebrook & Slobodan Cuk
   Contact: TeslaCo, Pasadena, CA 91107 (last known address)

5. Simplified Design of Switching Power Supplies
   John D. Lenk
   Butterworth-Heinemann
   ISBN 0-7506-9821-7.

6. Power Electronics, 2nd ed.
   B.W. Williams
   McGraw-Hill, 1992
   ISBN 0-07-070439-2

7. Switching Power Supply Design
   Abraham Pressman, Second Edition
   McGraw-Hill, 1998
   ISBN 0-07-052236-7.
   ISBN 0-07-050806-2 (First Edition, 1991).

8. Switch Mode Power Conversion

K. Kit Sum

9. Switchmode Power Supply Handbook
   Keith Billings
   McGraw-Hill, 1989
   ISBN 0-07-005330-8

10. Power Supply Cookbook
    Marty Brown
    ISBN 0-7506-9442-4

11. Transformer and Inductor Design Handbook
    Colonel Wm. T. McLyman (yes, his 1st name is "Colonel" - not military)
    Marcel Dekker, Inc.
    ISBN 0-8247-6801-9

12. Magnetic Core Selection for Transformers & Inductors
    Colonel Wm. T. McLyman
    Marcel Dekker, Inc.
    ISBN 0-8247-1873-9

13. Magnetic Components, Design and Applications
    Steve Smith
    ISBN 0-442-20397-7.

14. Soft Ferrites, 2nd ed.
    E.C. Snelling
    Butterworth, 1988
    ISBN 0-408-02760-6

15. High Frequency Switching Power Supplies, Theory and Design
    George Chryssis
    McGraw-Hill Co., 1984

16. Switched Mode Power Supplies - Design and Construction
    Whittington, Flynn and Macpherson published
    Research Studies Press, Ltd.
    ISBN 0-863-80203-6

In addition, many smeiconductor manufacturers publish extensive information on switchmode technology. Mostly, this is in connection with their product lines but will also contain a lot of general information. Much of this is available on Internet via the World Wide Web. Companies include: Maxim, Linear Technology, and Unitrode.

(From: OneStone (OneStone@bigpond.com).)

"Try the Linear Technologies Website.

Look for their App notes:

- AN25 Switching regulators for Poets.
- AN19 LT1070 Design manual
- AN29 Some thoughts on DC-DC converters
- AN30 Switching regulator circuit collection.
- AN31 Linear Circuits for digital systems.

Then try one of their new data sheets, such as the LT1370, for some modern circuit configurations, such as SEPIC converters. The above APP notes are all contained in their Linear Applications handbook, Volume 1, 1990. If you are a designer they also have a CD-ROM available, which includes some switcher and filter design software. It's a bit limited, but a great starting point if you don't need to stretch the boundaries."

For diagnosing power problems in TVs and Computer or Video monitors, here is one book that includes many illustrations and case histories.

17. Troubleshooting and Repairing Solid State TVs
    Homer L. Davidson
    2nd Edition, 1992
    TAB Books, Inc.
    Blue Ridge Summit, PA 17214

(From: Ernst C. Land, Jr. (a6mech@ionet.net) and Mark Zenier (mzenier@eskimo.com or mzenier@netcom.com).)

The September 1996 (VOL. 17 NO. 9) issue of Nuts & Volts Magazine has a great article on theory, troubleshooting, and repair of PC power supplies. Their web site is: http://www.nutsvolts.com.

When you get there, click on [more], then [back issues]

Parts information

I have found one of the most useful single sources for general information on semiconductors to be the ECG Semiconductors Master Replacement Guide, about $6 from your local Philips distributor. STK, NTE, and others have similar manuals. The ECG manual will enable you to look up U.S., foreign, and manufacturer 'house' numbers and identify device type, pinout, and other information. Note that I am not necessarily recommending using ECG (or other generic) replacements if the original replacements are (1) readily available and (2) reasonably priced. However, the cross reference can save countless hours searching through databooks or contacting the manufacturers. Even if you have a wall of databooks, this source is invaluable. A couple of caveats: (1) ECG crosses have been known to be incorrect - the specifications of the ECG replacement part were inferior to the original. (2) Don't assume that the specifications provided for the ECG part are identical to the original - they may be better in some ways. Thus, using the ECG to determine the specifications of the parts in your junk bin can be risky.

Other cross reference guides are available from the parts source listed below.

Information sources on the Internet

Many manufacturers are now providing extensive information via the World Wide Web. The answer to you question may be a mouse click away. Perform a net search or just try to guess the manufacturer's home page address. The most obvious is often correct. It will usually be of the form "http://www.xxx.com" where xxx is the manufacturers' name, abbreviation, or acronym. For example, Hewlett Packard is hp, Sun Microsystems is sun, Western Digital Corp. is wdc. NEC is, you guessed it, nec. It is amazing what is appearing freely accessible via the WWW. For example, monitor manufacturers often have complete information including detailed specifications for all current and older products. Electronic parts manufacturers often have detailed datasheets and application notes for their product offerings.

Here is a non-commercial Web site that has some information and sample circuits (not necessarily tested!) on using Maxim parts in various DC-DC converter applications as well as a bunch of links to relevant SMPS chip manufacturers:

- Maxim Pirate Applications Web Site

Interchangeability of components

The question often arises: If I cannot obtain an exact replacement or if I have a monitor, TV, or other equipment carcass gathering dust, can I substitute a part that is not a precise match? Sometimes, this is simply desired to confirm a diagnosis and avoid the risk of ordering an expensive replacement and/or having to wait until it arrives.

For safety related items, the answer is generally NO - an exact replacement part is needed to maintain the specifications within acceptable limits with respect to line isolation, X-ray protection and to minimize fire hazards. Typical parts of this type include flameproof resistors, some types of capacitors, and specific parts dealing with CRT high voltage regulation. However, during testing, it is usually acceptable to substitute electrically equivalent parts on a temporary basis. For example, an ordinary 1 ohm resistor can be substituted for an open 1 ohm flameproof resistor to determine if there are other problems in the the SMPS chopper before placing an order as long as you don't get lazy and neglect to install the proper type before considering the repair complete.

For other components, whether a not quite identical substitute will work reliably or at all depends on many factors. Some deflection circuits are so carefully matched to a specific horizontal output transistor that no substitute will be reliable.

Here are some guidelines:

1. Fuses - same type (usually normal or fast blow), exact same current rating and at least equal voltage rating. I have often soldered a normal 3AG size fuse onto a smaller blown 20 mm long fuse as a substitute.

2. Resistors, capacitors, inductors, diodes, switches, potentiometers, LEDs, and other common parts - except for those specifically marked as safety-critical - substitution as long as the replacement part fits and specifications should be fine. It is best to use the same type - metal film resistor, for example. But for testing, even this is not a hard and fast rule and a carbon resistor should work just fine.

3. Rectifiers - many of these are high efficiency and/or fast recovery types. Replacements should have equal or better PRV, Imax, and Tr specifications. However, the AC input bridge can usually be replaced with anything with at least equal voltage and current ratings.

4. Main filter capacitor(s) - use replacements with at least equal working voltage and similar uF rating. For testing, even something with half the capacity will be fine. For the final replacement bigger is not always better and even using a smaller one (uF) will be fine as long as you are not running the supply near full load capacity. Use of a higher temperature rated capacitor than the original may be desirable as its life may have been shorteded by a hot environment. This practice will never hurt.

5. Transistors and thyristors (except SMPS choppers or HOTs) - substitutes will generally work as long as their specifications meet or exceed those of the original. For testing, it is usually OK to use types that do not quite meet all of these as long as the breakdown voltage and maximum current specifications are not exceeded. However, performance (like regulation specifications) may not be quite as good. For power types, make sure to use a heatsink.

6. SMPS chopper (or horizontal output) transistors - exact replacement is generally best but except for very high performance monitors, generic HOTs that have specifications that are at least as good will work in many cases. Make sure the replacement transistor has an internal damper diode if the original had one. For testing with a series light bulb, even a transistor that doesn't quite meet specifications should work well enough (and not blow up) to enable you to determine what else may be faulty. The most critical parameters are Vceo/Vcbo, Ic, and Hfe which should all be at least equal to the original transistor. I have often used by favorite BU208D as a temporary substitute for other HOTs and SMPS (chopper) transistors. Make sure you use a heatsink (with insulating washer if applicable) and thermal grease in any case - even if you have to hang the assembly with a cable-tie to make it fit.

   Also see the section: Replacement power transistors while testing.

The following are usually custom parts and substitution of something from your junk box is unlikely to be successful even for testing: flyback (LOPT) and SMPS transformers, interstage coils or transformers, microcontrollers, and other custom programmed chips.

Substituting entire circuit boards and other modules from identical models is, of course, possible and an excellent troubleshooting aid even if it is only used to confirm or identify a bad part. However, if the original failure was catastrophic, you do run some risk of damaging components on the substitute circuit board as well.

Replacement power transistors while testing

During testing of horizontal deflection circuits or switchmode power supplies, particularly where the original failure resulted in the death of the HOT or chopper, overstress on replacement transistors is always a possibility if all defective components have not be identified.

Therefore, using a part with better specifications may save you in the long run by reducing the number of expensive blown parts. Once all other problems have been located and repaired, the proper part can be installed.

However, this is not always going to work. In a TV and especially a high performance monitor, the HOT may be closely matched to the drive and output components of the deflection circuits. Putting in one with higher Vce, I, or P specifications may result in overheating and failure due to lower Hfe.

Where possible, a series load like a light bulb can be used limit the maximum current to the device and will allow you to power the equipment while checking for other faults. Some designs, unfortunately, will not start up under these conditions. In such cases, substituting a 'better' device may be the best choice for testing.

(From: Glenn Allen (glenn@manawatu.gen.nz).)

I been repairing SMPS of all types but when I started on those using MOSFETs I was blowning a few of them when replaced because something else was faulty.

Ever since I have been using a BUZ355 on a heat sink I haven't blown it. It is rated at 800 V, 6 A, and 220 W. it is a

TO218 case bigger than a T0220. It seems the higher ratings allows you to do repair where as a something like a 2SK1117 or MTP6N60 will just blow.

Testing of replacement chopper transistors

The following is useful both to confirm that a substitute replacement chopper transistor is suitable and that no other circuit problems are still present. However, this will not catch single shot events that may blow the transistor instantly without any increase in temperature.

It was written with TV and monitor horizontal output transistors in mind but applies to the switchmode/chopper transistors found in line powered SMPSs as well.

(From: Raymond Carlsen (rrcc@u.washington.edu).)

After installing a replacement HOT in a TV set or monitor, I like to check the temperature for awhile to make sure the substitute is a good match and that there are no other problems such as a weak H drive signal. The input current is just not a good enough indicator. I have been using a WCF (well calibrated finger) for years. For me, the rule of thumb, quite literally, is: if you can not hold your finger on it, it's running too hot, and will probably fail prematurely. Touching the case of the transistor or heat sink is tricky....

Metal case transistors will be connected to the collector and have a healthy pulse (>1,200 V peak!) and even with plastic case tab transistors, the tab will be at this potential. It is best to do this only after the power is off and the B+ has discharged. In addition, the HOT may be hot enough to burn you.

A better method is the use of an indoor/outdoor thermometer. I bought one recently from Radio Shack for about $15 (63-1009). It has a plastic 'probe' on the end of a 10' cable as the outdoor sensor. With a large alligator clip, I just clamp the sensor to the heat sink near the transistor and set up the digital display near the TV set to monitor the temperature. The last TV I used it on was a 27" Sanyo that had a shorted H. output and an open B+ resistor. Replacement parts brought the set back to life and the flyback pulse looked OK, but the transistor was getting hot within 5 minutes... up to 130 degrees before I shut it down and started looking for the cause. I found a 1 uF 160 volt cap in the driver circuit that was open. After replacing the cap, I fired up the set again and monitored the heat sink as before. This time, the temperature slowly rose to about 115 degrees and stayed there. I ran the set all day and noticed little variation in the measurement. Test equipment doesn't have to cost a fortune.

Repair parts sources

For general electronic components like resistors and capacitors, most electronics distributors will have a sufficient variety at reasonable cost. Even Radio Shack can be considered in a pinch.

However, for modern electronic equipment repairs, places like Digikey, Allied, and Newark do not have the a variety of Japanese semiconductors like ICs and transistors or any components like flyback transformers or degauss Posistors.

See the document: Major Service Parts Suppliers for some companies that I have used in the past and others that have been recommended.

In addition, specifically for VCR SMPS repair:

- Studio Sound Service
  Fax: 1-812-949-7743

Email: studio.sound@datacom.iglou.com.

Rebuild kits for many popular VCR switchmode power supplies, VCR parts, some components. They will be happy to identify specific VCR part numbers as well based on model and description as well.

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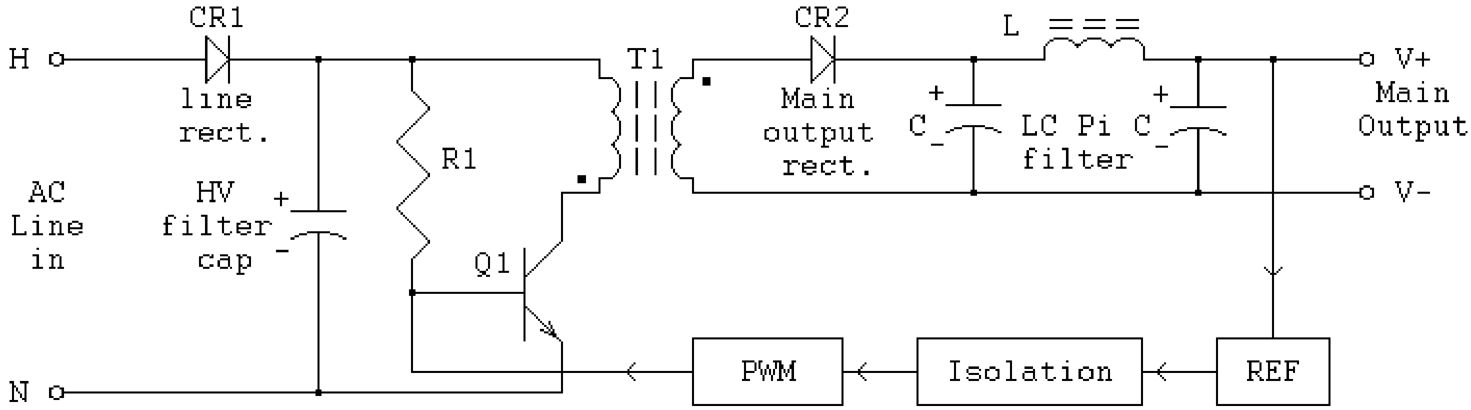
-- end V2.82 --



Block Diagram of Basic Flyback Switchmode Power Supply

Testing of Flyback (LOPT) Transformers

Version 1.57

For contact info, please see the [Sci.Electronics.Repair FAQ Email Links Page].

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

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Introduction

Scope of This Document

When problems develop in the horizontal deflection/high voltage subsystems of TVs or monitors (or even modern oscilloscopes and other CRT displays), the flyback transformer (or line output transformer for those on the other side of the Lake) is often a suspected cause. This is due in part to the fact that it is usually the most expensive and hard to find replacement part in the unit and because flybacks are often less well understood than other more common components.

This document addresses the operation and testing of flyback (LOPT) transformers: What they are, how they fail, why they fail, and how to test them. For more information on horizontal deflection systems, see the document: TV and Monitor Deflection Systems.

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Safe Troubleshooting of Flyback Transformers

WARNING: Read, understand, and follow the recommendations in the document: Safety Guidelines for High Voltage and/or Line Powered Equipment before attempting any TV or monitor repairs.

In particular, before touching or probing the flyback or circuitry in its vicinity:

- Unplug the equipment!!!
- Measure the voltage on B+ feed to the flyback and discharge the main filter capacitors if necessary.
- If going near the HV output, focus, or screen connections, discharge the CRT capacitance as well.

For specific information on safety for your equipment, see the documents: Notes on the Troubleshooting and Repair of Computer and Video Monitors or Notes on the Troubleshooting and Repair of Television Sets as appropriate.

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Flyback (LOPT) Transformers

What Does the Flyback (LOPT) Transformer Do?

The typical flyback or Line OutPut Transformer (LOPT) consists of two parts (you may also encount the term IHVT - Integrated High Voltage Transformer):

1. A special transformer which in conjunction with the horizontal output transistor/deflection circuits boosts the B+ (120 V typical for a TV) of the low voltage power supply to the 20 to 30 kV for the CRT as well as provides various secondary lower voltages for other circuits.

   A HV rectifier turns the high voltage pulses into DC and the CRT capacitance smooths it. The HV may be developed from a single winding with many many turns of wire or a lower voltage winding and a diode-capacitor voltage multiplier.

The various secondary voltages power the logic, tuner, video signal, vertical deflection circuits, and CRT filaments. In fact, with many TV designs, the only power not derived from the flyback is for the keep-alive circuitry needed to maintain channel memory and provide startup drive to the horizontal deflection/high voltage system.

2. A voltage divider that provides the focus and screen supplies. The pots are in this divider network - and these things fail resulting in poor focus, uncontrolled brightness, or fluctuating focus and/or brightness. A total short could also result in failure of other components like the horizontal output transistor. The focus and screen are generally the top and bottom knobs, respectively. In some TVs, the focus and screen divider and/or controls are external to the flyback and susceptible to dust and problems particularly on damp days.

How is a Flyback Transformer Different than a Regular Transformer?

While the following is not always strictly true for TV and monitor flyback transformers, it is a nice overview:

(From: Sivasankar Chander (siva@bond.bocaraton.ibm.com).)

1. The main difference between a flyback transformer and a regular transformer is that a flyback transformer is designed to store energy in its magnetic circuit, i.e., it functions like a pure inductor, whereas a regular transformer is designed to transfer energy from its primary to secondary and to minimize stored energy.

2. A flyback transformer in its simplest form has current flowing either in its primary, or in its secondary (but not both at the same time). (This is more complicated in practice because of finite turn-off times for transistors and diodes, need for snubber circuits, etc).

3. The reluctance of the magnetic circuit of a flyback transformer is usually much higher than that of a regular transformer. This is because of a carefully calculated air-gap for storing energy (it's an inductor).

4. The voltages applied to a flyback transformer on the primary side are almost always rectangular (pulsed) whereas regular transformers usually have sinusoidal voltages applied to them.

5. The currents flowing through either side of a flyback transformer are either increasing or decreasing linear sawtooths, whereas a regular transformer usually has sinusoidal currents.

6. Finally, due to the properties of core materials, flyback transformers are most conveniently operated in the range from 10^3 to 10^6 Hz, whereas regular transformers have a much wider range, from a few Hz to 10^12 Hz.

I may have succeeded in confusing you beyond redemption, so the best recourse for you would be to read any introductory textbook on switching power supplies for a more comprehensive picture.

The Origin of the Term, 'Flyback'

In the U.S. (possibly all of North America), the transformer that generates the high voltage in a TV, monitor, or other CRT based equipment, is called the 'flyback' or 'flyback transformer'. Most everywhere else in the world, it is either LOPT (Line OutPut Transformer) or simply LOT, or as noted IHVT - Integrated High Voltage Transformer (which is actually the most accurate term for modern units).

The term 'flyback' probably originated because the high voltage pulse that charges the CRT capacitance is generated by the collapse of the magnetic field in the core of the transformer during the short retrace period - when the electron beam in the CRT 'flies back' to the start of a new scan line. The flux in the core changes slowly during scan and is abruptly switched in polarity by the HOT turning off during the flyback or retrace period.

Many off-line switchmode power supplies and DC-DC converters are also of the 'flyback' type with energy transferred to their output circuits mainly during the same time in the cycle - but there is no CRT involved. Indeed, these high frequency ferrite transformers - which generally look like regular transformers often of E-I core construction - may also be referred to as flybacks in transformer company catalogs.

LOPT and LOT derive from the fact that it is the line scan circuit that is involved and the transformer is in the output stage.

I still think flyback is much more quaint! :-).

Of course, others have their own definition:

(From: Sam Riner (riner@inet2000.com).)

When I was about 12 I touched the wire coming from the FBT on the picture tube, this was a BIG floor model TV, and I flew about five feet backwards. I know this isn't the real history for the name but for many years I believed it was.

A Little History

So, how far back does the use of a flyback based high voltage go?

(From: Henry van Cleef (vancleef@netcom.com).)

A flyback HV supply was a feature of the 1946 RCA 630 and GE 801 sets. They used either an 807 or 6BG6 horizontal output tube, 6W4 damper, 1B3 rectifier.

The prewar TV's (yes, TV's were made and for sale before the NTSC standard was approved in 1941) generally used a 60 Hz. transformer and 2X2 similar to circuits used in RCA and Dumont oscilloscopes of the 1930's.

Zworykin/Morton "Television" (Wiley, 1940) has schematics and a project home-brew TV set using an 81 tube for the HV off a standard power transformer. Of course, to follow your way around this book, you have to know vacuum tube theory and a lot of physics reasonably well, but it is an historical gold mine.

(From: Brad Thompson (Brad_Thompson@pop.valley.net).)

Some of the early TV sets used an RF oscillator to generate the high voltage for electrostatic-deflection CRTs: a typical tube lineup might include a 6V6 oscillator and 1B3 (or 1X2) rectifier.

Why is the Deflection and High Voltage Combined?

One of the main reasons that TVs and many monitors are designed with horizontal deflection driven flybacks is simply economics - it provides a cheap way to get the high voltage and many or most of the other voltages for the set with minimal hardware. (High quality computer monitors sometimes use a separate high voltage supply so that the horizontal deflection is then used just for deflection to reduce interactions between changing scan rates and the HV.) A side benefit is that if the horizontal deflection dies, the HV power supply voltage goe with it and prevents the CRT phosphors from burning do to undeflected high intensity beam.

The use of the horizontal frequency rather than the AC line frequency of 50 or 60 Hz allows the power supply components to be small and light compared to a line operated power transformer and filter capacitors.

Flyback Construction

While details can vary somewhat, all flybacks consist of a set of windings on a gapped ferrite core. High voltage diodes and resistive dividers (often with adjustment pots) for focus and screen (G2) may also be present.

A typical flyback includes the following components:

- Drive winding - for a line powered TV, there will be perhaps a hundred turns of medium gauge (e.g., AWG #26) wire. For low voltage powered, it may only be a dozen turns of thicker wire. This is what is connected in series with the B+ to the horizontal output transistor in a TV or monitor.

- High voltage winding - several thousand turns. This winding may be split into several series sections with a high voltage rectifier for each or could be a single winding. An alternative is provide a lower voltage winding and use a voltage multiplier (diode-capacitor ladder) to boost this to that required by the CRT. Very fine wire (e.g., AWG #40) will be used for the high voltage winding. The high voltage lead to the CRT is fed from the highest voltage output of the rectifier or multiplier.

  Some TV and monitor designs use a physically separate (external - not part of the flyback transformer) voltage multiplier. In this case, the flyback high voltage winding will generate 6 to 10 kVAC and the multiplier will boost this typically 3X or 4X to 20 to 30 kVDC. The focus and screen (G2) network will generally be part of the multiplier module in this case.

- Resistive divider network for focus and screen (G2). This will probably be fed from only one of the series connected windings (if used). Often, there are adjustments for focus and screen right on the flyback. The outputs from this divider may be connected to pins in the base of the flyback or have their own separate leads which connect to the CRT socket/board.

- Auxiliary windings - anywhere from a couple of turns (for the CRT filament) to several hundred turns (for a boost source). These supply various voltages for the typical TV or monitor - CRT filament, logic power, analog power, boost source (where the flyback does not include its own screen supply), etc. The gauge of these windings will depend on the current requirements of each output. They are connected to solder pins at the base of the flyback.

- Ferrite core - consisting of two C shaped pieces clamped together with either a spring arrangement or studs and nuts. There will be a gap of a fraction of a mm provided by a set of spacers between the two C sections.

Most modern flybacks have all the windings on the same leg of the core. The drive winding and auxiliary windings will be wound and separately insulated under the high voltage winding. The high voltage winding will consist of many layers which have insulating material (i.e., mylar) between them.

The other components will be mounted in a separate part of the assembly and the entire unit is then potted in an Epoxy type filler. Part of the core is generally accessible - often one entire leg.

A flyback is not an ordinary transformer. The ferrite core contains a gap. Energy is stored in the magnetic field of the core during scan as the current is ramping up. Energy is also coupled to certain secondary outputs during scan. However, energy for the high voltage (HV) is coupled to the its secondary windings almost entirely when the primary current is shut off at the end of the scan (probably the source of the name flyback because it is during the retrace of the electron beam).

Which type of coupling is in effect depends on the direction of the rectifiers on the secondary side of the flyback:

```
                   _  _
                    \/                                   _/\_
    B+ ------+    +----|>|-----+---o +V1  B+ ------+    +----|>|-----+---o +HV
            o )::( o  Scan     |                  o )::(   Flyback   |
              )::(  Rectifier _|_                   )::(  Rectifier _|_
              )::(            ---                   )::(            ---
              )::(             |                    )::(             |
        _/\_  )::(             |              _/\_  )::( o           |
   HOT ------+    +------------+         HOT ------+    +------------+
                              _|_                                   _|_
                               -                                     -
```

Here, V1 is just a typical example of an auxiliary supply derived from a scan rectifier and HV is the best known example of the use of a flyback rectifier.

Note that the ratio of the number of turns for each winding *cannot* be used to calculate expected output voltages since the rate of collapse of the magnetic field (determined by the design of the horizontal output circuit) affects this.

The gap is critical to the proper operation and is usually determined by some plastic spacers. CAUTION: mark each one and replace them in exactly the same position if you disassemble the core for any reason.

Why You Don't Want to Fabricate Your Own Flyback or Rebuild a Bad One

Attempt to disassemble a flyback and you will understand why I don't recommend this unless the entire future of the explored *and* unexplored universe depends on the effort! You need specialized equipment to just wind the high voltage coil.

This isn't something you can do by hand in your basement and the only problem isn't the several thousand turns of nearly invisible wire used in a typical flyback. To sustain the high voltages without arcing and to minimize the interwinding capacitance, the high voltage winding is constructed as many individual layers - perhaps 50 layers in all - of 50 turns each using super fine wire (#40 typical - thinner than a human hair). Each layer must be wound perfectly flat with all wires side-by-side and then individually insulated with mylar tape. Just breathing on such wire will practically break it let alone wrapping several thousand turns in perfect order!

The other parts: drive and low voltage windings, focus and screen divider network, and high voltage rectifiers must be assembled with the high voltage winding and CRT leads and then the entire affair is potted in Epoxy.

Forget it - you have better things to do than spend a week on a transformer!

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Flyback Failure and Testing

Why do flyback Transformers Fail?

While flyback transformers can on occasion be blown due to a failure elsewhere in the TV or monitor's power supply or deflection circuits, in most cases, they simply expire on their own. Why?

Flybacks are wound with many layers of really really fine wire with really really thin insulation. This entire assembly is potted with an Epoxy resin which is poured in and allowed to cure.

In some ways, these are just short circuits waiting to happen.

Flybacks get hot during use and this leads to deterioration of the insulation. Any imperfections, nicks, or scratches in the insulation or trapped air bubbles and impurities in the Epoxy fill material contribute to failure. Temperature cycles and manufacturing defects result in fine cracks in the Epoxy potting material reducing the insulation breakdown particularly in the area of the high voltage windings, rectifiers, and focus/screen divider network. They also physically vibrate to some extent. A whole bunch of other factors are also no doubt important.

Once a breakdown - sparking or arcing - develops, it is usually terminal.

It is amazing they last as long as they do with the stresses they are under.

How Do Flyback Transformers Fail?

Flybacks fail in several ways:

1. Overheating leading to cracks in the plastic and external arcing. If there is no major damage to the windings, repair may be possible. However, arcing from the windings punctures their very thin insulation so that shorted windings may already have developed. Even if the windings are currently in good condition, long term reliability of any such repairs is questionable.

   Nonetheless, it doesn't hurt to try cleaning and coating with multiple layers of high voltage sealer, corona dope, or even plastic electrical tape (preferably as a temporary repair though I have gotten away with leaving this in place permanently). If possible, moving the point to which the flyback is arcing further away (i.e., a piece of metal or another wire) would also help.

   (The following from: Tom Riggs (thriggs@mail.netusa1.net))

   For sealing flyback transformers, I have found that silicone sealer has worked very well. I used the clear variety, though others will probably work as well. I have heard of burn through with corona dope. (Author's note: make sure you allow ample time for the silicone sealer to setup completely - or else it will breakdown instantly - at least 24 hours. Also, some types (those that smell like vineger - acetic acid - as they cure may result in corroded wiring in the long term).

2. Cracked or otherwise damaged core will effect the flyback characteristics to the point where it may not work correctly or even blow the horizontal output transistor and other expensive parts like the low voltage regulator or switchmode power supply. If the core can be reconstructed so that no gaps (other than the required ones where the two halves join) are present and clamped and/or glued in place, it should be possible to perform testing without undue risk of circuit damage but consider a replacement flyback as a long term solution.

3. Internal shorts in the FOCUS/SCREEN divider network, if present. One sign of this may be arcover of the FOCUS or SCREEN spark gaps on the PCB on the neck of the CRT.

4. Internal short circuits in the windings.

5. Open windings.

More than one of these may apply in any given case. As noted, temporary repair, at least, is sometimes possible for failures (1) and (2). For failures (3) to (5) replacement is usually the only alternative.

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Basic Testing

Initial Tests Using Your Senses and Perhaps a Multimeter

First, perform a careful visual inspection with power off. Look for cracks, bulging or melted plastic, and discoloration. Look for bad solder connections at the pins of the flyback as well. If the TV or monitor can be powered safely, check for arcing or corona around the flyback and in its vicinity, or at the sparkgaps or gas tube protectors on the CRT neck board.

Next, perform ohmmeter tests for obvious short circuits between windings, much reduced winding resistances, and open windings. Don't neglect to check between the CRT HV connector (suction cup) and the pins on the base. This should measure infinity.

For the low voltage windings, service manuals may provide the expected DC resistance (Sams' Photofact, for example). Sometimes, this will change enough to be detected - if you have an ohmmeter with a low enough scale. These are usually a fraction of an ohm. It is difficult or impossible to measure the DC resistance of the HV winding since the rectifiers are usually built in. The value is not published either.

WARNING: Make sure you have the TV or monitor unplugged and confirm that the main filter capacitor is discharged before touching anything as the flyback is usually connected to this point, perhaps directly! If you are going to remove or touch the CRT HV, focus, or screen wires, discharge the HV first using a well insulated high value resistor (e.g., several M ohms, 5 W) to the CRT ground strap (NOT signal ground).

Measurements that are much less than the published values likely indicate a partially shorted winding. However, a difference of 10% may not be at all significant. Higher than normal readings might simply indicate that a design change was made. Yes, I know, hard to believe they would not have informed you of this! For example, various versions of the flyback used in the Apple MAC Plus - 157-0042A,B,C - are functionally similar but have minor variations in winding parameters. It is not known what effects this would have but they are interchangeable at least for testing.

Of course, any continuity between separate windings is definitely a fault.

Partially short circuited windings (perhaps, just a couple of turns) and sometimes shorts in the focus/screen divider will drastically lower the Q and increase the load the flyback puts on its driving source with no outputs connected. It is these types of failures, not detectable by simple ohmmeter tests or visual inspection, which the techniques described in the sections under "Advanced testing" address.

While less common, I have seen shorts between the CRT HV connector and the low voltage windings on the base of the flyback. This implies a breakdown of the Epoxy potting material probably due to thermally induced microcracks or poor quality manufacturing. Once a small arc develops, it rapidly carbonizes the material around it further reducing the resistance. These rarely heal themselves and thus show up as obviously low resistance readings using an ohmmeter. It is an easy test and can be performed without removing the flyback. Discharge the CRT HV (though this will probably be dead) and just remove the connector from the CRT.

It is also possible that various types of flyback faults can damage other circuitry (beyond taking out the horizontal output transistor and its associated parts). For example, a sudden short between the CRT HV connector and a low voltage winding or a short between two low voltage windings could conceivably blow solid state components powered from the flyback. This damage will generally not be apparent until the flyback is replaced. Therefore, if shorts are detected in the flyback, it is worth testing some of the components in the vicinity and vice-versa.

The Process of Elimination

Before attempting the more advanced tests suggested below, there may be ways of being more certain that your flyback is the problem component. The following assumes that running the TV or monitor with the suspect flyback results in an excessive load on the low voltage (B+) power supply blowing a fuse (or attempting to blow a fuse - excessively bright series light bulb). The B+ likely drops from its normal 65 VDC to 140 VDC or more (depending on the actual TV or monitor and mode) to some low value like 25 VDC when measured on the low voltage power supply side of the flyback drive winding. (Measuring at the HOT can result in all sorts of weird readings due to the pulse nature of the waveform and is not recommended - especially when everything is working properly - 1,500 V pulses!).

- Disconnect all the secondary loads from the suspect flyback including the CRT. Connect only the drive (B+ and HOT).

  Power up the TV or monitor (preferably with a series light bulb or on a Variac.

  If the B+ now climbs to a more normal value, a problem with the HV (CRT short) or one of the secondary loads is indicated. Connect each of these up one a time (or test individual components) to localize the fault. The flyback is likely good.

- Remove the suspect flyback and connect just the HOT and B+ to the drive winding of a known good flyback for a similar size TV or similar type of monitor (as appropriate). It may be close enough to keep the drive circuitry happy.

  Power up the TV or monitor (preferably with a series light bulb or on a Variac.

  If the B+ now climbs to a more normal value, a problem with the original flyback is indicated. However, more thorough testing may be desirable to be absolutely certain.

  If you do this regularly, keeping a selection of 'flyback simulators' - just the drive windings and cores may be desirable.

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Advanced Testing

When the Basic Tests Don't Reveal Anything

Also see the section: Flyback Testing Equipment.

There are several ways of testing flybacks (assuming you do not actually have special test equipment for this purpose). Here are two possibilities. The first is easier if you have a scope but the second is more fun.

Method 1

The following technique, called a 'ring test', works for flybacks, chopper transformers, motors, mains transformers, deflection yoke windings, VCR video and other magnetic heads, and other transformers, coils, or inductors.

However, note that it can miss certain problems like open windings (if they are not used for the test) as well as shorts or opens that occur only when the flyback is driven near full voltage. Thus, do the basic tests FIRST and don't assume that the flyback is 100 percent good just because it passes the ring test (though the likelihood of this is very high).

(Portions from: Gabe (ggabe@mcs.com).)

This is called a 'ring test' and is the method often used by commercial flyback (or other coil/transformer) testers. The theory is that a faulty flyback (which cannot be found by simple resistance measurements) will have shorted turns in one of the coils. In such a case, the 'Q' of the transformer is greatly reduced. If excited by an impulse, a faulty transformer will resonate with a highly damped oscillation while a good one will decay gradually.

1. Connect a high quality capacitor across one winding of the suspect device. Hope for a resonant frequency of a few kHz. You may need to select the capacitor value for best results. I have found that a capacitor in the .001 uF to 1 uF (non-polarized) will usually be satisfactory.

   Note that it doesn't matter whether the excitation is applied to the shorted winding or any other one. However, you should avoid trying to connect the generator to one of the very small windings like those for the CRT filament which may only have 2 or 3 turns.

2. Apply a pulse waveform to the parallel resonant circuit. In 1960, most scopes had a 'sync out' on the timebase that provided a few 10s of volts at enough current for this. A circuit in "Television" magazine a couple of years ago used a BU508, a 12 V power supply, and a small oscillator built from a 4011 chip. A function generator or a 555 timer based circuit will also make a satisfactory stimulous. Also see the section: Flyback Testing Equipment.

3. Look at the waveform across the resonant circuit with a 'scope. A good unit will give a nicely decaying oscillation, of at least a few cycles, possibly 10's of cycles. If there is a shorted turn *anywhere* in the device, the oscillations will be seriously damped, and you'd be lucky to see 2 complete cycles. Experience and/or comparison with a known good device will tell you what to expect.

```
                              Scope
              _                 o
 Pulse or   _| |_               |      Device under Test
 function o---------------------+-----------+    +---
Generator                       |            )::(
                 High Quality  _|_           )::(     All other
                 Non-polarized ---           ):: +--- windings
                     Capacitor  |            ):: +--- left open
                                |            )::(
   Ground o---------------------+-----------+    +---
```

(From: James Elliott (jelliott@stlnet.com).)

I tried the Q evaluation method using the 100 volt CAL voltage pulse from a Tektronix scope. It worked best when I used a series 200 pF capacitor. I got maybe 100 pulses before it decayed to zero. If I shorted two of the primary pins, the decaying pulse train went to zero almost immediately. So it works!

I thought of another method. The Q of a resonant circuit is equal to the center frequency divided by the half power bandwidth. I applied an audio generator through a 22k resistor, found the peak frequency, then went off that frequency to .707 of that amplitude. Double this would be the bandwidth. I got Q's of 26 and 16 for two I tried. (Editor's note: This appears to be a valid approach.)

Method 2

The circuit below excites the flyback in much the same way as in normal operation. The only caution is that this tester probably does not put enough stress on the flyback to find an intermittent that fails only under full operating conditions. However, most flyback failures are solid - once a short develops, there is a meltdown of sorts and it is there to stay.

You will require a 12 V power source of at least 2 or 3 amps capacity (regulation is not important - I just use a simple transformer, rectifier, filter capacitor type of power supply).

The circuit is shown below. None of the component values are critical.

```
+12     Q1   +----------------+
 o           |                 )::
 |       B |/ C                )::         <-- Flyback Under Test -->
 |  +------|    2N3055         )::
 |  |      |\ E            5T  )::            +------|>|----------o +HV
 |  |        |                 )::         ::(   HV Diode(s),
 |  |       -_-                )::         ::(   usually built in.
 |  |                          ):: +-----+ ::(
 +--|-------------------------+ ::(       )::(
 |  |   Q2  _-_                )::(  10T  )::(
 |  |        |                 )::(  each )::(
 |  |    B |/ E            5T  )::(   _   )::(
 |  |  +---|    2N3055         )::(  _|_  )::(
 |  |  |   |\ C                ):: +-- --+ ::(
 |  |  |     |                 )::  Switch ::(
```

```
    |   |   |       +---------------+ ::         ::(
    |   |   |                         ::         ::(
    |   |  ---------------------+ ::            +------------------o -HV
    |   |                    2T  )::
    |   |             +-----------+ :: (Numerous other windings not shown.)
    |   |             |      2T  )::
    |   +-----------------------+      Note: :: denotes ferrite core.
    |                 |
    |          R1     |     R2
    +--------/\/\/\--+--/\/\/\---+
               110        27     _|_
               2W         5W      -
```

Note: if the circuit does not start oscillating at about 5 volts or less, interchange the two feedback connections to the transistor bases.

The tester is just a chopper feeding the salvaged core from an old flyback (I removed the inductance control spacers for this core). The drive (5T+5T) and feedback (2T+2T) coils can be wound from hookup wire (#14-#20) and well insulated with plastic electrical tape. Connect the center taps directly to the coils - do not bring out a loop of wire. Make sure all the turns of each coil are wound in the same direction. Wind the feedback coil directly on top of the drive coil. The secondary of this core is a 10 turn well insulated coil similar to the other two wound on the opposite side of the ferrite core.

You will need to remove the suspect flyback from the TV or monitor. Another 10 turn coil is wound on the suspect flyback core anywhere it will fit. Connect one end of this coil to one end of the 10 turn coil on your old flyback core. Use a wire nut or twist together securely. Provide an easy way of connecting the other ends momentarily - a pushbutton comes in handy.

Make sure you locate the HV return lead on the flyback and use that as the return for the arc. Otherwise, you may puncture the insulation when the high voltage finds it own path to ground.

Identifying the High Voltage Return on a Flyback

It is essential that this be correctly connected or else the high voltage *will* find a suitable path to ground - and it may not do the other circuitry any good!

There are several approaches that can be taken - possibly in combination:

- Process of elimination - the HV return will often be an isolated pin on the flyback not connected to anything else. Therefore, if you test between all combinations of pins on the flyback (removed from the circuit board) and find a pin that appears open to all other pins but is connected to a pad on the circuit board, it is quite likely the HV return.
- Check all connections on the circuit board and identify those that go to ground. One of these flyback pins will be the HV return. It will do no harm to connect them all to ground during testing.
- Use a 100 VDC or greater power supply and high value resistor, say 100K. Connect the power supply negative output through this resistor to the HV lead on the flyback (suction cup connector):

```
                    100K
       PS- o--------/\/\--------+--------o CRT (suction cup) connector on flyback
                                |
                                o
                                -
     100 VDC           Measure voltage here
```

```
                                                  +
                                                  o
                                                  |
      PS+ o---------------------+--------o Probe to pins on base of flyback
```

Check each pin on the base of the flyback with the probe. Touching the return pin will result in the voltage reading dropping to perhaps 50 or 60 volts. This is the forward voltage drop across the high voltage rectifier stack inside the flyback. All other pins will result in it remaining at the supply voltage (except for the ground connection to the F/G2 divider if it is separate - then it may drop a fraction of a volt). Note that if you cannot locate the HV return, your flyback may indeed be defective; it may have an internal bad connection, open HV rectifier, or burnt out HV winding. Or, if other pins drop the voltage, you may have already found shorts in the flyback!

Method 2 Testing Procedure

Once everything is wired and double checked, turn on the juice.

- If the flyback is good, then with the coils connected there will be several kV at its output - enough to create a small arc (1/8" typical, up to 1/2" for color flybacks).

- The load imposed on the oscillator will be modest (the frequency increases in response to load).

If there are any shorted windings, then there will be no significant HV output and the load on the oscillator will increase dramatically.

- If you get arcing or corona from *under* the flyback - at the pins - either did not locate the correct HV return or there is a short inside resulting in HV arcing internally to the low voltage windings.

I have used this 'tester' on a dozen or so flybacks. It has never been wrong (though I have opted not to believe it and gotten screwed).

Other Flyback Testing Procedures and Comments

Here is a Web site with some notes on flyback testing procesures:

- Noahtech Flyback Testing Page

They have other useful information related to monitor repair as well.

(From: Terry (terwes1@juno.com).)

I first check for HOT shorts, secondary supply overloads, and everything else, disconnecting the flyback windings to any suspect circuits as I go. So, if I get to the following test, pretty much all connections to the flyback are now open anyway. Next, I perform "The Loop Test":

1. Ring the transformer at the HOT primary winding. You don't need fancy signal generators to inject a signal. Even the 60 Hz AC secondary from a 6 volt filament transformer will work, although you date yourself if you have one in your shop. (Note: I expect that the 6 VAC transformer works in this case because the core of the flyback saturates pretty quickly at this low frequency resulting in sharp edges to produce the ring pulse - I would rather use a 555 timer or pulse generator --- Sam.)

2. Scope any flyback secondary for the little ringing pulse. Observe the number of cycles in the damped pulse.

3. Run a small piece of wire around one post of the ferrite core and short the two ends of the wire together (loop).

4. If the number of damped cycles doesn't reduce dramatically then the transformer already has a *single turn short*

or *worse*. It's bad. There is little change because Q is already greatly reduced by the existing short in the failed flyback, even one turn. If it does reduce dramatically, then you've just strongly affected Q by introducing your own single turn short, so the flyback is OK. What is "dramatically"? Try out a few known good and bad ones and find out for yourself. :)

This *should* work in-circuit but any defective (heavy load, etc) circuit on any flyback lead will reduce Q, so you have to eliminate these other possibles anyway. It is my experience that the flyback almost always leaves physical evidence of its demise. If I don't see it, I check everything else before I try this loop test. I rarely have to use it.

I just love it when the $encore guys call to tell me I need $2000 worth of test equipment to reliably test horizontal circuits. When I tell 'em how I do it, they're pretty much speechless. Some are fascinated. Those are the ones who should switch from sales to tech.

(From: Wild Bill (kwag98@tcis.net).)

There are numerous instruments which will check certain flyback/IHVT parameters, and not others. Thorough testing can only be accomplished with several instruments. As far as I know, there is no single instrument which will test all parameters.

Testing for internal faults includes continuity, shorts, shorted turns, winding-to-winding and winding to core leakage, the HV rectifier (multiplier) stack, focus-screen divider (and internal spark gap), and a drive pulse input - relative proportional output test. And after all of the above tests, the device might still break down at the actual circuit working voltages/temperatures.

The minimum tests should include ohms, leakage, and ringing. An open in the HV winding can't be detected with an ohmmeter if the xfmr contains a HV rectifier stack. as the ohmmeter won't provide the necessary voltage to bias the rectifiers. A well designed (fairly inexpensive) leakage tester can provide the necessary voltage to check this.

(From: Jurb6005 (jurb6005@aol.com).)

I test flybacks by clipleading a beefy old TO3 horizontal output transistor into the circuit. This tests it at the actual operating voltage and will show all faults. Believe it or not, this also works on sets that use a GCS (Gate Control Switch, GTO SCR?) like the 2SG264 and 613. If you use it on one of these sets it may get hot, but it will run long enough to test things. (Even a 'beefy old HOT' may not survive certain faults. --- Sam.)

Also, on sets that use a linear regulator (not a switchmode power supply or regulator) there is usually a ballast resistor. If you simply leave the shorted regulator disconnected, it will run through the ballast and viola! You can non-destructively test the circuit.

These methods are especially good if you are writing the estimate, you need not solder anything in!

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Additional Flyback Testing and Service Information

Flyback Testing Equipment

Sencore and others sell test equipment that includes the 'ring test' or similar capabilities built in. For the professional, these are well worth the expense.

However, the hobbyist could probably purchase lifetime TV replacements for the cost of once of these fancy gadgets.

Bob Parker (of ESR Meter fame) has now designed an inexpensive, easy to use LOPT/Flyback Tester avaiilable through Dick Smith Electronics. Information is available at:

- Bob Parker's FBT Page

Other flyback testers are described at:

- Kephart's FBT Page
- VAAG FBT Page

Various electronics magazines have published construction articles for various types of simplified versions of these devices. Here is a pointer to one such article:

The "Think Tank" column of Popular Electronics, December, 1998, provides information on a unit for testing inductors and transformers (including flybacks) which displays characteristics on an oscilloscope.

(Portions from: Tony Duell (ard@p850ug1.demon.co.uk).)

The February 1998 issue of 'Television' magazine, has a simple circuit for an LOPT (Line Output Transformer - flyback transformer) tester.

It uses a TBA920 chip as an oscillator, driving a BUT11AF which supplies the primary of the LOPT. The voltage developed across this winding (the back EMF when the transistor is turned off) is shown on a DMM. There's also a 'scope point to look at the waveform produced.

Another chip or an oscillator constructed from discrete transistors can be substituted for the TBA920. Some possibilities: 555 timer or MC1391, or a multivibrator can be built from 2N3904s.

However, there are a few errata in the article:

1. The supply voltage is 12 V as mentioned in the text, not 2 V as shown on the schematic.

2. The peak amplitude given in fig. 3 of 8 V should be after the divider network, not at the transformer itself.

3. There is a capacitor shown from pin 13 (decoupling) which almost certainly should be a bypass to ground, not to the collector of the drive transistor.

Quickie In-Circuit Flyback Tests

Note: Larry has 'beta tested' Bob Parker's (of ESR meter fame) flyback tester described at: http://www.ozemail.com.au/~bobpar/fbt.htm.

(From: Larry Sabo (sabo@storm.ca).)

Checking out flybacks can be frustrating and very time consuming without a good tester.

Now, it just takes me a second to check for ringing on the HOT collector. No ringing? Check the HOT with a DVM for shorts. No shorts? Unsolder all flyback legs except the primary winding and check for rings again. No rings? Shorted turns in the flyback!

Bob's estimate that 20% of faulty flybacks have internal leakage or arcing, or bad HV diodes, seems about right. And an LC102 (tester) won't catch these either :-). I've found that about half of these show up with a low resistance measurement between the EHT cap and ground.

Sometimes scoping the output at the EHT cap shows unrectified ringing but stray capacitance probably accounts for that.

Other times, it's clearly rectified, so go figure. As a last resort, I resort to Sam's chopper to wrestle the hold-outs to the ground, but it takes a bit of time to remove the flyback and put 10-15 turns around the core. The ringer has also helped me isolate a defective yoke, which explained why things wouldn't ring.

Anyway, I think Bob's tester is a great little unit and am glad I have had the opportunity to test it--and keep the prototype! :-)

(From: John Robertson (jrr@flippers.com).)

I use an audio signal generator set it to about 15 kHz and a scope or AC voltmeter on one of the output windings.

Connect the generator to the leads that the horizontal output transistor and ground use (out of circuit, use HOT and B+ leads --- sam). You should see on the scope a reasonably nice waveform similar to the input. If you are using a voltmeter, you should get approximatly the correct ratio output voltage relative to the original voltages. So if your generator puts out 10 VAC and the original HV input levels were 100 VDC, then the voltage levels should be about 1/10th of the original. I do this in-circuit, and try to get a square wave as the source, but the theory is consistant.

(From: Quick Fix (iradg@guru.nu).)

If you don't don't repair that many TVs, the cheapest way to check a FBT is to connect its primary winding in series with the yoke (low side) of a working set. If the picture shrinks a few inches on both sides evenly and with no ringing or jail bars, your FBT is good. You can even measure the high voltage on your FBT with this method.

Testing for Bad High Voltage Diodes

A single diode failure would be tough to find if it is in series with other diodes (as is typical on larger flybacks) as it would only be a problem when run near full output. However, this sort of failure is unlikely.

General diode failure (shorts) would probably not be detected with the sorts of tests described above or with typical flyback testing equipment. Actually, a simple ohmmeter test between the HV output and return might suffice! If this doesn't reveal anything, I suggest the following:

One possible way to test for this would be to attach a high voltage capacitor between the HV output and return of the flyback. If the diodes are good, the tester's excitation should then charge this cap up (watch out - the voltage might get to be quite high!). While charging, this load will make the flyback fail any ring test. Once charged, it should pass. However, if the diodes are shorted, I would expect the flyback to test bad as the cap will continue to present an AC load on the output and never charge properly.

I haven't tried this, however, so no guarantees.

(From: dB King ((netrekker@pdq.net).)

Sencore Z-Meters are capable of applying sufficient bias to check those diodes for forward conduction and reverse leakage. Forward conduction should be confirmed first to rule out an open -- almost all multimeters will always show open HV diodes due to their limited voltage output.

Indispensable for capacitor tests as well. I dunno how I got by w/o mine! They also have built-in yoke/flyback ringer. :)

Quite expensive. You might wanna try to find a used one.

Why Do All Flyback Transformers Seem to be Unique?

(Most of these comments also apply to SMPS high frequency transformers.)

Of all the components in a monitor or TV, the flyback is very likely to be a unique part. This is not so much due to the high voltage winding and/or HV multipler but rather related to its usual function as the source of multiple secondary power supply voltages used by various tuner, deflection, video, and audio subsystems. In addition, inductance, capacitance, pin configuration, and HV, focus, and screen outputs must be compatible.

ECG and similar companies do have a line of generic FBTs and should have a catalog/cross reference for these similar to the one for semiconductors. See the section: Replacement Flyback Transformers.

However, FBTs are where the designers of TVs and monitors can be really creative. After all, specifying the flyback windings gives them complete freedom to pick the number and types of secondary voltages! Your chances of picking up something off the street so-to-speak and expecting it to fit anything you have ever owned - or ever will own - isn't great.

(From: an engineer at a TV manufacturer).

We have one guy whose mission in life is doing exactly that... (and specifing HOT's too).

Besides specifying auxiliary secondaries you can also specify an overturn on the primary (for deflection coils which would otherwise require a >1500 V HOT) and influence the tuning of the EHT secondary, to determine the EHT internal impedance. And finally you might specify a built-in EHT capacitor or bleeder resistor and various types of clicked-on potmeter modules (perhaps with a second focus voltage for DAF).

Typical Flyback Schematic

This diagram shows a typical flyback that might be found in a direct view color television or computer monitor. Resistances are included for illustrative purposes only and may be quite different on your flyback!

The high voltage section on the right may actually be constructed as a voltage multiplier rather than a single winding with multiple HV diodes. The rectifiers or multiplier, and/or focus/screen divider may be external to the flyback transformer in some models.

Flyback transformers used in black-and-white TVs and monochrome computer monitors do not have a focus and screen divider network. Older ones do not include a high voltage rectifier either - it is external.

The ferrite core of a flyback transformer is constructed with a precision gap usually formed by some plastic spacers or pieces of tape. Don't lose them if you need to disassemble the core. The ferrite core is also relatively fragile, so take care.

The focus and screen divider network uses potentiometers and resistors (not shown) with values in the 10s to 100s of M ohms so they may not register at all on your multimeter. The high voltage rectifiers (CR1 to CR3 on this diagram) are composed of many silicon diodes in series and will read open on a typical VOM or DMM.

Note that there is no standardization to the color code. However, the fat wire to the CRT is most often red but could also be black. Of course, you cannot miss it with the suction cup-like insulator at the CRT anode end. The focus and/or screen connections may also be to pins rather than flying leads.

```
                                            +--|>|-----------o  HV to CRT
               _        1                 ::(   CR1             (25 to 30 kV,
              |   B+  o-------------+ ::(                       suction cup on
    Drive     |                      )::(                       fat red wire)
    winding <                        ):: +-------+
              |             1.32     )::         |
              |         2            ):: +--|>|--+
              |_  HOT o-------------+ ::(   CR2
```

```
             _        3             ::(
            |   50  o-------------+ ::(
            |                      ):: +-------+
            |         4    .11     )::         |
            |   35  o-------------+ :: +--|>|--+
 Various    |                      )::(   CR3  |
 auxiliary <               .28     )::(        /
 windings   |         5            )::(        \<-------o  Focus
            |   16  o-------------+ ::(        /          (3 to 10 kV,
            |                      )::(        \           orange wire)
            |         6    .12     )::(        |
            |_   0  o----------+--+ ::(        |
             _        7        |    :: +--+    /
            |   H1  o----------|--+ ::   |    \<-------o  Screen
CRT Heater <          8    .08 |   )::   |    /          (200 to 800 V,
            |_  H2  o----------+--+      |    \           brown wire)
                               |          |    |      9
                               |          +----|--------o  To CRT DAG
                               |               |            ground
                               +---------------+
```

Replacement Flyback Transformers

Unfortunately, you cannot walk into Radio Shack and expect to locate a flyback for your TV or monitor. It is unlikely the carrots at the counter will even know what a flyback is or recognize one if it hit them over the head (wherever that would be on a carrot). They will probably attempt to sell you a 6.3 V power transformer :-). Fortunately, there are other options:

- Original manufacturer - most reliable source but most expensive. Older models may not be available. This may be the only option for many TVs and monitors - particularly expensive or less popular models.

- Electronics distributors - a number of places including MCM Electronics, Dalbani, Premium Parts, and Computer Component Source, sell replacement flybacks. See the document: Notes on the Troubleshooting and Repair of Computer and Video Monitors for contact info. Many of these are actually original parts and are designated as such. However, there may be no way of knowing and you may end up with something that isn't quite compatible (see below). Thus, unless the catalog listing says 'original part', these may be no better than the sources below.

  Here is one apperently just for flybacks:

  - Component Technologies, 1-888-FLYBACK or 1-800-878-0540. email: fbtxformer@aol.com.

  and one that is mostly for flybacks:

  - CRC Components, 1-800-822-1272.

  some others:

  - Data Display Ltd, Canadian sub of CCS, 1-800-561-9903.
  - EDI (Electro Dynamics, Inc.) NY, 1-800-426-6423.
  - Global Semiconductors, 1-800-668-8776, Toronto.

  And, here's one for your semi-antique (1950s) needs:

  - Linear Electronics, Walthan, MA. Phone: 1-617-894-7300, Fax: 1-617-894-8890. (They also have vacuum tubes.)

- Generic replacements - these are sometimes available. ECG, NTE, ASTI, HR Diemen, for example, offer a line of replacement flybacks. Some of these sites include a cross reference to their replacement based on TV or monitor model and/or the part or house number on the flyback:

    - NTE (NTE Electronics, Inc)
    - ECG (Philips)
    - ASTI (ASTI Magnetics)
    - Flybacktransformer
    - Cactus Technology Corp.

  However, these may be of lower quality or not be quite compatible with your original. In an effort to minimize the number of distinct flyback models, some corners may be cut and one-size-fits-many may be the rule resulting in all sorts of problems. Here are a couple of possibilities:

    - The number of turns on one or more windings may not quite match your original meaning there will be lower or higher voltages from certain outputs and/or drive conditions (current, resonance) may be affected.

    - There may even be extra or missing connections - pins on the bottom or flying leads. It is essential to determine what must be done to make the flyback work in your equipment *before* applying power. Extra connections may need to be grounded or connected to some other points in the circuit. If this is not done, operation may not be correct or other parts may blow as current from these unconnected pins finds its own way to ground.

    - The flyback may simply be defective due to bad quality control, part number confusion, or mismarking. Internal circuitry such as the focus and screen(G2) divider could be improperly wired, configured for a different model, or omitted entirely. Such defects can be very tough to identify.

  Thus, marginal or erratic behavior might result from generic replacements greatly complicating your troubleshooting since without careful measurements there is no way of knowing whether the problem is due to the new flyback or a fault that still exists elsewhere. For some actual experiences, see the section: Cheap Flybacks - Beware.

(From: a-freak@freenet.de.)

HRdiemen is a manufacturer of replacement line output transformers and have several thousand types available. But the nicest thing is their online database where they have pinout and internal schematics including typical voltages of every of these transformers. Just type your original letters/numbers into the search box, then you get the replacement transformer type and a link to its internal construction.

Very helpful if you want to "recycle" an old transformer for a new circuit.

Javascript must be enabled for this to all happen automagically. If you prefer to work without javascript (like me, to avoid ad banners and other doubtful background activities), you can also directly access http://www.hrdiemen.es/data/esquemas/HR7491.gif or whatever number your transformer has.

Cheap flybacks - Beware

There have been reports of inexpensive replacement flybacks resulting in a variety of strange symptoms. I do not know how likely it is to have problems with these. In most cases, I would expect the replacement to drop right in and perform perfectly. However, I have heard of occasionally difficulties. I do not know which, if any, of the companies listed above sell such incompatible devices. However, it would be worth checking before buying if possible.

Here are several examples of incompatibility problems:

(From: Petercoe (petercoe@aol.com).)

There is some good and some bad to these flybacks. One thing I noticed is that the competition has caused the price of the name brands to drop.

However, these flybacks may not work right in all cases. I know I had to modify a circuit in a Sony to get the set to work right after using a low priced replacement. I also had a Goldstar which would only work with the original flyback."

(From: Michael Caplan (cy173@freenet.carleton.ca).)

The FBTs that I tried (three samples in two generic brands available here in Canada) all seem to be missing the required internal voltage divider. This was confirmed by comparison with a new oem Sony part. The OEM part exhibits the proper resistance measurement. It is through this resistance that the Hold Down voltage is derived. "No resistance = no Hold Down voltage", as far as I can see."

(From: Dave Moore (penguin@datastar.net).)

I recently put a cheapo sub flyback Hitachi P/N 243384 in a Hitachi model CT2647 26" tv.

Apart from inadequate horizontal deflection, the TV exhibited ringing like jail bar shadows on the left side of the screen and a bright area with retrace lines showing from top to bottom down the middle of the of the screen. At first I thought that this was the classic bad B+ filter to the crt board phenomena. But nope, filter good.

So I figured that it had to be a bad filter in the brightness limiter or to the video circuits. A quick round about with my trusty DS ESR meter did sniff out a weak cap in what seemed to be the brightness limiter circuit. Did this cure the problem? As John Belushi would say: Noooooooooooo. Well I recalled a similar problem that I had encountered while experimenting with the screen voltage on a Zenith TV. At one point I had removed a small disk capacitor on the screen supply trying to unload the shorted screen supply. Well the problem turned out to be the picture tube and after I cleared the screen short I noticed a similar phenomena to the one that I was presently experiencing (the bright area in the middle of the screen from top to bottom with retrace lines).

Well after I reconnected the little disk capacitor the problem went away. So!! I thinks to myself: The little disk cap on this Hitachi I'm working on must be bad. Well lo and behold - there is no disk cap on the hitachi. No place for one either. It was designed to not need one apparently.

So I put a .01 uf 1400 volt disk cap (cause it was handy) on the screen and voila! End of jail bars and retrace lines in middle of screen. I can only assume that the cheapie flyback was the cause. This makes me wonder if the lack of horizontal width might be symptomatic of this "cheapie" flyback also. I'll probably just parallel some capacitance on the HOT since I don't have much width to make up. I already adjusted B+ to the High Voltage section and at full clockwise position of the control the picture doesn't open up all the way. I left the control at mid position and played the set for a couple of hours. Everything's running cool.

(From: Gregory Danner (gdanner@advancenet.net).)

As far as "generic" flybacks, be prepared to do some slight adapting as far as mechanical installation. Sometimes new ones aren't the same diameter and height, and don't fit with existing metal support brackets, which may have to be cut away or bent. Sometimes the pins that go through the circuit board aren't aligned quite right, and may have to be bent and adjusted slightly to fit the board. Screen and focus controls may not be in the same physical position on the new flyback. But, overall, I would say that most of the generic flybacks I've used have worked out OK electronically.

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-- end V1.57 --

TV and Monitor Deflection Systems

Version 1.27

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

Acknowledgement

Special thanks to Jeroen H. Stessen (Jeroen.Stessen@philips.com) for his extensive contributions to this document. However, he does insist on the additional disclaimer that "I (he) will not be responsible for any unforeseen consequences resulting from following this advice".

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Introduction

Scope of This Document

TVs and most computer and video monitors depend on the use of similar (at least in concept) circuit configurations to generate several outputs:

* Current waveform required in the deflection yoke coils of the CRT for linear sweep of the electron beam to create a high quality (geometry and linearity) picture. This is close to a sawtooth but not quite.
* CRT High voltage (20 to 30 kV or more) required to accelerate the electron beam and provide high brightness

and sharp focus, as well as other related voltages - focus and screen (G2).

- Various auxiliary power and signals for other subsystems of the equipment (low voltage, CRT filament, feedback, etc.).

This document addresses the basic principles of operation of these types of deflection systems. While most people with any familiarity with TV or monitor operation or repair have some vague idea of how these circuits work (probably just enough to be dangerous), many are incorrect or at least very incomplete.

Most of this information applies to the horizontal deflection which operates at the higher frequency in a raster scan display (except for peculiar rotated portrait formats where the functions of the horizontal and vertical scan are interchanged.

Equipment which utilizes this circuitry includes TV (direct view as well 3-CRT and light valve projection types), computer and video monitors, tube based video cameras (e.g., vidicon), and other magnetically deflected CRT devices.

Vertical deflection circuits are much less complex due to the lower scan rate (e.g., 50 to 120 Hz V as compared to 15.734 kHz H for an NTSC TV or up to 120 kHz or more for a high resolution computer monitor). Most of the control and output drive circuitry is contained in a special vertical chip in modern equipment.

Deflection System Safety

The deflection components of an operating TV or monitor contains substantial power with high voltages and high currents. This circuitry in many TVs and some monitors is directly line connected (no isolation). There are often large high voltage filter capacitors on the B+ supply and these may retain a lethal charge for some time after the plug is pulled. The CRT HV capacitance can also retain a dangerous charge - possibly for weeks!

Read, understand, and follow the recommendations in the document: Safety Guidelines for High Voltage and/or Line Powered Equipment before attempting any TV or monitor repairs. See the specific documents: Notes on the Troubleshooting and Repair of Television Sets or Notes on the Troubleshooting and Repair of Computer and Video Monitors as appropriate for your equipment.

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Horizontal Deflection System Fundamentals

How Does the Horizontal Deflection Circuit Work?

Although there are many variations, the basic operation of the horizontal deflection/high voltage power supplies in most TVs, monitors, and other CRT displays is very similar.

For understanding the working of the deflection circuit regard the flyback transformer as an inductor. The airgap stores energy, some of which may be tapped off during flyback by secondary rectifiers (e.g., vertical deflection, signal circuits, and high voltage supplies) and non-rectified loads (e.g., filament supply) but these have hardly any influence on the basic working principles.

The scenario described below is only true in the steady state - the first few scans are different because the picture tube capacitance is still discharged. This represents a short-circuit at the secondary side of the flyback. It prevents proper demagnetizing, hence the core will go into saturation (unless special soft-start measures have been taken, like a B+ supply that comes up slowly). Generally, a hard start of the line deflection circuit represents a very heavy load on the HOT. This will happen after a picture tube flashover or if the B+ is connected suddenly (due to intermittent contact) and can mean instant death to the HOT due to secondary breakdown. See the section: More on HOT Failure.

Basic Deflection Circuit Operation

The following description is only the basics. For more information, see the article by David Sharples in "Electronics World", June 1996.

A very simplified circuit is shown below - many components needed to create a practical design have been omitted for clarity. First concentrate only on the portion of the schematic shown below to the left of the yoke components:

```
                         B+
                          o
                          |
                          +
                           )::
                Part of T2 )::
                   Flyback )::
                   Primary )::
                           )::
                          +
                          |
                          +-------+---------+----------+
                          |       |         |          |
         Horizontal       |       |         |          +
           Drive          | C     |         |           )::    (Horizontal
             T1       B |/      __|__      _|_          ):: L2  Deflection
         --+    +-------|       _/_\_      ---          )::     Yoke - HDY)
    Driver  )::(        |\        |   D1    | C1       +
    Stage   )::(     Q1   | E     | Damper  | Snubber _|_ C2
    (not    )::(     HOT  |       |         |         --- S-correction
     shown  )::(          |       |         |          |
         --+    +---------+---+---+---------+----------+
                             _|_
                              -
               B+ Return (may not be signal ground)
```

The current in the flyback primary and collector of the HOT are *not* equal. The horizontal deflection yoke, damper diode, HOT collector, snubber HV capacitor(s), and flyback primary all connect to the same point. We begin our adventure at the end of the scan - retrace - when the flyback period begins:

1. At the end of scan, current is flowing through the flyback primary to the HOT, Q1. At the start of the flyback period, Q1 turns off. (This must be done in a controlled manner - not just a hard shutoff to minimize stresses on the HOT - but that is another story). Since current in an inductor (the primary of the flyback has inductance) cannot change instantaneously, the current is diverted into the snubber capacitor, C1. The inductance of the flyback primary (T2) and C1 forms a resonant circuit so that the voltage climbs on C1 as the current goes down.

At its peak, this voltage will be 1000 V to 1500 V.

2. C1 now begins to discharge in reverse through the primary of T2 (back into the B+ supply - the filter capacitor will stabilize the B+ output) until its voltage (also C-E of the HOT) reaches 0.

3. If there were no damper diode (D1), this voltage would go negative and continue to oscillate as a damped sinusoid due to the resonant circuit formed by T2 and C1 (and the other components). However, D1 turns on as the voltage goes negative and diverts the current through it clamping the voltage near 0 (-Vf for the diode).

   Note that the damper diode D1 may have been built into the HOT T2 in the case of an inexpensive or small screen TV or even some monitors that don't have any circuitry for E/W correction.

   Steps (1) to (3) have accomplished the flyback function of quickly and cleanly reversing the current in T2 (and, as we will see, the deflection yoke as well). The full flyback (and yoke current) are now flowing through the forward biased damper diode, D1.

4. At the beginning of scan, the damper diode (forward biased) carries the bulk of the current from the yoke and flyback. The nearly constant voltage of the B+ across T2 results in a linear ramp of current now through the damper diode since it is still negative and decreasing in magnitude.

5. At approximately mid-scan, the current passes through zero and changes polarity from minus to plus. As it does so, the damper diode cuts off and the HOT picks up the current (with a voltage drop of +VCEsat). Current is now flowing out of the B+ supply.

   The base-drive to the HOT must have been switched on before this point! Timing is not very critical as long as it happens between the end of the flyback and the zero crossing of the summed current. The location of the zero crossing depends on the secondary load, notably the beam current. Larger beam current requires that the HOT be switched on earlier. The designer has to do some optimizing here...

6. During the second half of the scan, the HOT current ramps up approximately linearly. This is again due to the nearly constant voltage of B+ across the inductance of the flyback primary.

7. Near the end of scan, the HOT turns off and the cycle repeats.

   The HOT has a storage time between 3 us and 7 us, thus the base-drive is switched off earlier, in a controlled way to properly remove the charge carriers from the collector region in the HOT. The peak amplitude of the base current and the way it is decreased determine the ultimate dissipation in the HOT and are thus subject of heavy optimization. This is hampered by the fact that there is much spread in HOT parameters.

Thus, the current in the flyback (ignoring the yoke components) is a nearly perfect sawtooth. The ramp portion is quite linear due to the essentially constant B+ across the flyback primary inductance. The current waveform can be easily viewed on an oscilloscope with a high frequency current probe. See the section: Probing TV and Monitor Yoke Signals.

The voltage across the C-E of the HOT is a half sinusoid pulse during the flyback (scan retrace) period and close to zero at all other times (-Vf of the damper diode during the first half of scan; +VCEsat for the HOT during second half of scan).

Caution: Without a proper high frequency high voltage probe, it is not possible or safe to observe this point on an oscilloscope with full B+. However, where the equipment can be run on a Variac, this clean pulse waveform can be observed at very reduced B+. Excessive ringing or other corruption would indicate a problem in the flyback, yoke, or elsewhere.

Normally you would use a 100:1 probe suitable for 2 kV peak. You could always make your own voltage divider out of a couple of suitable resistors and use a regular 10:1 or 1:1 probe. Beware that also the capacitive division ratio must be correct because the line frequency is high enough to make it relevant.

The current through Q1+D1 is several amperes peak-peak. There's a lot of power circulating here, making this a *dangerous* circuit in every way!

The Deflection Yoke Connection

So, you ask: "Why can't the yoke just be placed in series or parallel with the flyback primary?". After all, the current is a nice sawtooth. Isn't that what we want?

There are several reasons including:

- The desired yoke current is not quite a sawtooth but includes two major corrections: S and E/W (described below). These cannot be applied easily with such a configuration.

- The flyback also generates the HV and secondary output voltages and the primary current might then be affected by these and change as a function of beam current (picture brightness) or audio level (although feeding the audio amplifiers from LOT windings is not common anymore).

Note that some TVs and monitors cut off power to the horizontal deflection circuits if the yoke connector is removed. This is a separate interlock and not a result of the B+ flowing through the yoke. Its purpose is to protect the circuitry and the CRT. With no deflection, the very bright spot in the center of the screen would quickly turn into a very dark permanent unsightly blemish. With appropriate precautions to avoid this costly situation, it is possible to power a monitor or TV with the yoke winding(s) disconnected to determine if a defective yoke is messing up the deflection system operation. See the documents: Notes on the Troubleshooting and Repair of Computer and Video Monitors or Notes on the Troubleshooting and Repair of Television Sets for additional information.

The yoke is placed across the C-E of the HOT in series with a capacitor (S-correction) and other components which in effect form a variable power supply (analogous to the constant B+) which is used to compensate for the various problems of scanning a nearly flat screen.

What are S and E/W or N/S Correction?

These terms actually refer to the various corrections to deal with what is normally called scan linearity and pincushion distortion. Most larger TVs and nearly all high quality monitors will have various user and internal controls to optimize the corrections for each scan rate (multiscan monitors).

And yes, E/W/N/S stand for directions. :)

Because the screen of most CRTs is relatively flat (even those not advertized as flat) and the electron gun is relatively close, any picture tube will naturally have serious linearity problems and pincushion distortion if there were no corrections applied. Near the *edges* and *corners* of the screen the spot will move faster because the same angular speed translates to a larger linear speed. This is simple trigonometry.

There are 3 ways of correcting N/S:

1. The design of the deflection coil (distribution of the windings). This is cheap and robust but it requires a huge design effort. Also, if for some reason the glue that holds the wires together gets soft then the geometry and convergence may be affected.

2. With permanent magnets. After the tube has been built it is switched on and some magnets are stuck on the back to improve geometry, convergence and or landing. This is very difficult but relatively cheap. I would expect it in better monitors.

3. With active N/S correction. A line-frequency complex waveform is injected as current into the raster deflection coil. This allows arbitrary correction of N/S waveforms, within the limitations of the waveform generator and the bandwidth of the system. This can be easy to adjust, or not, depending on the design, and it is most expensive of all. I would expect it in workstation monitors.

As for problems with N/S geometry, if there is an active circuit at all, then it would correct only 4-way symmetrical errors, so you would expect an error in all 4 corners. I don't know of any circuits that would affect only 1 corner. A magnet might affect only 1 corner, it might have dropped. A coil might have softened in 1 corner, due to heat. That would be beyond repair, I guess. But it is not very likely either. My guess is that the error has always been there, from the start and it was just noticed!

S-Correction Circuit Operation

The first correction to apply, in both directions, is S-correction. By simply putting a capacitor in series with each coil, the sawtooth waveform is modified into a slightly sine-wave shape (the top and bottom are somewhat squashed). This reduces the scanning speed near the edges. Linearity over the two main axis should now be good.

When we add in the yoke components (only the horizontal deflection coil and S-correction capacitor or S-cap are actually shown above) conditions are only slightly more complex:

First, consider what would happen if instead of the S-cap, the yoke were connected to B+ like the flyback. In this case, the total current would divide between the flyback primary and the yoke. It would still be a sawtooth as described above. Of course, component values would need to be changed to provide the proper resonant circuit behavior.

That's called 'tuning of the flyback capacitor', to achieve the proper duration of the flyback pulse, matching the blanking time of the video signal, and to achieve the proper peak flyback voltage, matching the Vces specification of the HOT with a reserve of about 20%. That's two conditions, requiring two degrees of design freedom. There are 3 freedoms: supply voltage, flyback capacitor and yoke inductance.

With the S-cap and yoke wired as shown above, the inductance of the yoke and S-cap form a low pass filter such that voltage on the S-cap will be a smoothed version of the pulses on the HOT collector (similar in effect to the B+ feeding the flyback but not a constant value). The average value of the S-cap voltage will be positive.

The S-capacitor together with the yoke inductance forms a resonant circuit whose frequency is tuned lower than the line frequency. It has the effect of modifying the sawtooth current into a sine-wave shape. This is called 'S-correction'. It reduces the scanning speed at the left and right edges of the screen.

The value of the S-cap can be selected so that the voltage varies in such a way as to squash the current sawtooth by the appropriate amount to largely compensate for the fact that the electron beam scans a greater distance with respect to deflection angle near the edges of the screen.

Think of it this way: When the scan begins, the yoke current is at the maximum value in the direction to charge the S-cap. The voltage across the S-cap is causing the current to decrease but the S-cap is also gaining charge so the rate of decrease is increasing. At the time the current passes through 0, the S-cap is charged to its maximum. The current now reverses direction retracing its steps. Got that! :-). This is another example of a portion of a resonant circuit. The voltage on the S-cap is varying by just the right amount to compensate for the geometry error.

Many CRTs, especially the flatter ones, have a need for geometry correction that goes beyond simple S-correction. Most tubes need inner pin-cushion correction, which is also called "dynamic S-correction". It is an adaptation of the diode modulator circuit, which is only found with tubes that need E/W (pin-cushion) correction in the first place. See the section: N/S and E/W Correction Circuit Operation.

Some tubes need more S-correction only at the extreme edges, this is called "higher-order S-correction". This requires another resonant circuit, tuned to a higher frequency, which is more difficult to implement. Most sets will not have such circuit.

Many tubes in the USA (with only 100 degrees deflection angle) are "raster-correction-free" so they will not have much correction circuitry other than basic S-correction. There will be no diode-modulator for E/W-modulation. Such sets will have larger remaining errors that tubes (with 110 degrees deflection angle) that need active correction to begin with.

For multiscan monitors, S-caps must be selected for each scan range since the timing varies with scan rate. These are only approximate corrections but good enough for most purposes. MOSFET or relay circuits take care that for each range of scanning frequencies the correct combination of S-correction capacitors is selected.

As an example, consider a multiscan monitor which supports VGA (31.4 kHz, 800x600 at 56 Kz (35 kHz), and 800x600 at 60 Hz (38 kHz):

For good geometry between 31, 35 and 38 kHz, two discrete values for the S-cap is barely enough. Actually a 3rd value optimized for 35 kHz would be better. If there is only one S-cap and it is optimized for 38 kHz, then at 31 kHz you will be using a too large angle of the sine (of the resonant frequency between the S-cap C and the deflection coil inductance). Possibly even > 180 degrees, making the current fold back. Apart from an obvious geometric distortion, there is also increased risk of HOT failure because you're operating too close to the resonant frequency.

Applications of CRTs in TVs are a lot less critical than computer monitors, so don't expect too much of them. It is simply not worth the money until more critical applications like WebTV come along. The market is not willing to pay for corrections to problems that most people would never notice (with typical TV pictures).

N/S and E/W Correction Circuit Operation

Then remain the N/S and E/W errors, meaning that near the corners the scanning speed is still too large.

To a large extent the N/S errors can be corrected by a suitable yoke coil design. For smaller tubes (90 to 100 degrees types) this is also possible for E/W errors. For larger tubes (110 degrees) or high quality tubes, electronic E/W correction is required. This is the well-known pincushion.

E/W correction is modulation (which implies multiplication) as a function of vertical beam position. The amplitude of the horizontal deflection current is modulated with a parabola waveform which is derived from the vertical deflection circuit. This squeezes the top and bottom lines back into the left and right screen borders.

N/S correction (if any) is a method of injection - addition of a high frequency waveform (harmonics of the line frequency) to the low-frequency field-deflection waveform.

This requires costly nasty circuitry which is better avoided.

This is how the diode modulator for E/W correction works:

```
           B+
            o
            | (Vb)
            +
             )::
  Part of T2 )::
     Flyback )::
     Primary )::
             )::
            +
            |                    <- Yoke components ->
            +-------+---------+---------+----------+
            |       |         |         |          |
            |       |         |         |          +
            |       |         |         |           )::    (Horizontal
            |     __|__      _|_        |           ):: L2  Deflection
            |     _/_\_      ---        |           )::     Yoke - HDY)
            |       |   D1    | C1      |          +
            |       | Damper  | Snubber |         _|_ C2
            |       |         |         |         --- S-correction
            |       |         |         |          |
            |       +---------+---------)----------+
            |       |         |         |(NC)      |
            |       |         |         |          +
            | C     |         |         |       L3 )::
        B |/      __|__      _|_       _|_   Bridge )::  L4
     -----|       _/_\_      ---       ---     coil )::  E/W Coil
          |\        |   D2    | C3      | C4       +     ::::         (Vm)
       Q1   | E     | Damper  | Snubber | Snubber  +----+^^^^+---+-----+-----
       HOT  |       |         |         |          |             |     |
            |       |         |         |     C5 _|_          +_|_   E \|B
            |       |         |         |  Bridge ---       C6 ---  Q2  |---
            |       |         |         |     cap  |             |   C /|
            |       |         |         |          |             |     |
            +-------+---------+---------+----------+-------------+-----+------
           _|_                                          E/W Amplifier (PNP)
            -
       B+ Return (may not be signal ground)
```

The deflection supply B+ gives a constant voltage Vb. At the output of the E/W amplifier there is a variable voltage Vm. Because there can not be an average voltage over any coil, the average voltage over the deflection circuit (L2 + C2) is Vb-Vm. The scanning width is proportional with this voltage Vb-Vm. By modulating Vm as a field-frequency parabola which is higher for the top and bottom lines it is achieved that the scanning width is reduced for the corners of the screen.

The required field-parabola waveform is derived from the field deflection circuit. Amplitude and DC-level are adjustable, for correcting pin-cushion distortion and setting the screen width. EHT is *not* influenced !

The E/W amplifier usually has a PNP emitter follower only, because it must only sink current and dissipate a bit of power. The coils L3 and L4 take care that the E/W amplifier sees no line-frequency. The "bridge" components L3 and C5 resemble the deflection coil with its S-correction capacitor and carry the large amplitude alternating current. L3+C5 are tuned to approximately the same frequency as L2+C2.

C1, C3 and C4 must be tuned so that EHT is independent of Vm and peak voltage over D2+C2 is high enough but not too high when Q2 is off. C4 is usually a small ceramic capacitor of approx. 1 nF mounted close to the HOT Q1, it also suppresses EMI. Flyback capacitors are critical components. Wrong types may overheat and burn. Bad contacts here or elsewhere in the deflection circuit may arc and also cause fire.

There are many variants to this circuit, e.g. for dynamic S-correction. Multi-sync monitors need added circuitry to make the EHT independent of the line frequency (if there is not a separate EHT supply, that is).

If the E/W modulator fails then you will see that the top and bottom lines will be much too wide. There are several parts that could have failed. It's usually not too difficult to find why there's no parabola. If you have partial loss of E/W modulation, notably in the extreme corners, then you should suspect the tuning of the 3 flyback capacitors that belong to the diode modulator circuit. That's a specialist job...

S-Correction Problems

- An open S-cap will result in no horizontal deflection - a vertical line.
- A shorted S-cap will likely load down the B+ possibly resulting in a blown fuse or other power supply components.
- An S-cap that changed value (or in the case of a multiscan monitor, selected to be the wrong value) will result in distortion at the left and right sides of the screen:
  - Too low: picture will be squashed towards edges.
  - Too high: picture will be stretched towards edges.

  Note that this is not the same as what is commonly called linearity which would likely affect only one side or gradually change across the screen.

Horizontal Linearity Correction

Since there is non-zero resistance associated with the components (mainly coil losses) in the yoke circuit (yoke winding, ESR of S-cap, etc.) the world is not quite as ideal as one would hope. Without compensation, this resistance would result in non-linearity of the picture - it would tend to be squashed on the right side as the resistance saps energy from the yoke circuit.

The waveform becomes a damped sinewave, which will be 'undamped' by restoring energy during the flyback.

One way to deal with this is to add a magnetically biased saturable inductor in series with the horizontal deflection yoke. This is called the linearity coil.

Its core is magnetically biased near the point of saturation such that the inductance decreeases with increasing current and this helps to stretch the right hand side of the scan. In other words, during the scan the coil saturates so that the inductance decreases. At the end of scan there is practically no voltage left over the linearity coil so that the deflection coil gets maximum voltage.

E/W Correction Problems

The common name for the adjustments is likely to be 'Pincushion Amp' and 'Pincushion Phase'. They are controlling the E/W correction circuits.

Pincushion Amp adjusts the amplitude of the correction signal.

Pincushion Phase adjusts where the correction is applied on the vertical scan.

- Failure of the E/W correction circuit will result in very noticeable pincushioning distortion of the vertical edges.
- Excessive E/W correction will result in barrel distortion of the vertical edges.
- A bad power supply derived from the flyback could also result in similar symptoms due to ripple or lack of power to the pincushion circuitry.

Differences Between N/S and E/W Correction Implementation

While the desired effects are symmetric - modulate the amplitude of one component of the deflection circuit (H or V) by the other (V or H), the implementations will differ substantially. The reasons should be obvious: The line frequency is much higher than the field frequency.

E/W correction is easy: the lower frequency modulates the higher frequency. This reduces to simple amplitude modulation. Well, simple in principle. The line circuit is a high-energy circuit. For this purpose the diode modulator circuit has been invented. It allows an energy exchange between the line deflection circuit and a pseudo deflection circuit.

N/S correction is difficult: the higher frequency modulates the lower frequency. It *can* be done with sort-of amplitude modulation by using a 'transductor'. This is not a transformer but a component with 2 coils and a saturable core where the (line frequency) current through 1 coil modulates the inductance of the other coil. If there are tuned parts in the circuit then the correction will be highly sensitive to line frequency variations.

It can also be done with a regular transformer, by injecting a strong signal (from an amplifier) with line frequency components into the field deflection circuit.

Either way, it's an expensive solution which should be avoided by designing the deflection coils in such a way that the picture tube needs no active N/S correction.

Several types of auxiliary power may be obtained from the flyback, somewhat as a byproduct of the deflections system operation. These may provide DC (using high speed rectifiers and small filter capacitors), or AC. Although not always well known, the coupling factor with the primary is decent for a flyback transformer and so there can be scan rectifiers as well as flyback rectifiers in the same system - and often are. Refer to the diagram, below:

- Scan power is obtained during the forward stroke as with a 'normal' transformer. Energy is transferred while the HOT/damper diode is conducting. The output rectifier is oriented so that current flows during scan time. (Dots on the transformer winding match.)

The scan rectifiers make no use of the stored magnetic energy, they load the primary directly during the scan part. They do not cause an increase of the stored magnetic energy so a heavy load is not a problem.

- Flyback power is obtained from the stored energy in the flyback transformer's inductance when the HOT shuts off. The output rectifier is oriented so that current flows at flyback time. (Dots on the transformer windings oppose.)

  The flyback rectifiers on the other hand (especially the EHT) draw from the stored magnetic energy. When the secondary load increases, the magnetization current will also increase. Ultimately this will cause saturation of the ferrite core. Excess beam current is a common cause for this and should be avoided by the beam current limiter. The advantage of a flyback rectifier is that it provides 7 times more volts per winding than a scan rectifier.

- AC power (usually only for the filament or a feedback signal) flows during both scan and flyback.

```
                  _  _
                   \/                                       _/\_
B+ ------+        +----|>|-----+---o +V1  B+ ------+        +----|>|-----+---o +HV
       o ):( o  Scan           |                 o ):(    Flyback        |
         ):(   Rectifier  _|_+                     ):(   Rectifier  _|_+
         ):(               ---                     ):(               ---
         ):(                |                      ):(                |
    _/\_  ):(               |                _/\_  ):( o              |
HOT ------+        +------------+          HOT ------+        +------------+
                              _|_                                       _|_
                               -                                         -
```

Here, V1 is just a typical example of an auxiliary supply derived from a scan rectifier and HV is the best known example of the use of a flyback rectifier. Since the deflection system runs at 15 kHz or higher, fast recovery diodes must be used as rectifiers. However, at these frequencies, the uF ratings of the filter capacitors can be quite small compared to power line (50/60 Hz) based systems.

EHT (High Voltage) Generation

The EHT (Extra High Tension or HV to the CRT) is generated from a secondary winding on the flyback transformer having several thousand turns of very fine wire. Being a flyback supply, the actual output voltage is many times what would be calculated based on turns ratios alone. The HV rectifier consists of a stack of silicon diodes with a total PIV rating of 50 kV or more.

Because the flyback pulse is so narrow, the rectifier diode will conduct only a short time. Thus the peak current in the winding will be quite high, resulting in a significant voltage drop when loaded. The internal impedance of the EHT source is in the order of 1 MOhm, so with a load of e.g. 1 mA the EHT will drop 1000 V = -3%. Usually the EHT voltage is far from stable, 10% drop is quite normal.

If the EHT voltage drops, then the electrons will be accelerated less and will move through the deflection field at a lower velocity. As a result they will be easier to deflect by the magnetic field, and the picture size will grow. Without special measures, brighter pictures will be larger. The measure is to feed some EHT information or beam current information to the deflection circuits, reducing the deflection current amplitude a bit for bright pictures. For horizontal deflection this is done by the E/W modulator. This is called anti-breathing.

Sets with raster correction free picture tubes don't have an E/W modulator. There the correction may be done by means of a power resistor in series with the B+ supply. A large beam current causes more power consumption, this lowers the B+ supply voltage and thus reduces the line deflection current. That also reduces the EHT even further, but the deflection current has a stronger effect on the picture width than the EHT. Better methods exist too.

The EHT information is also used to protect the flyback transformer from overload. As the load increases, the average primary current rises. Ultimately it may reach a level where the transformer core may go into saturation. This causes large peak currents in the HOT which might lead to destruction. To prevent this, some EHT information is fed to the contrast controller, to automatically reduce the picture brightness whenever the white content is too much. This is called the average beam current limiter.

A failure in the video path, like a video output amplifier stuck at 0 V, causes a high beam current that will not react to the contrast controller. In that case the beam current limiter will not work and the set should switch off automatically, usually within a few seconds after applying power. When the cathodes heat up, you'll see an even picture with diagonal retrace lines and then it will switch off.

The Difference Between the Ideal and the Real

Don't expect to find the circuits shown above staring you in the face when you get your Sams' Photofact or service manual. There are a semi-infinite number of variations on this basic theme. Some of them will, to put it mildly, appear quite obscure (or to put it more positively, creative) at first.

You may see all sorts of additional passive components as well as transformers for generating additional voltages not provided by the flyback. There may be diodes in places you would think would be impossible. Therefore, to really understand even approximately how each design works may require some head scratching but the basic operation of them all seems to be very similar.

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Horizontal Output Transistor (HOT) Information

Why are There So Many Different HOTs?

I find it fascinating (ok, well at least interesting) that after 20 years of designing totally solid state TVs and monitors, HOTs have not become jelly bean parts. Why does every new design insist on a unique HOT? I don't believe this is simply due to increased requirements like wider deflection angles or (for computer monitors) higher scan rates.

Actually there is still some progress going on :-).

TV's for Europe DO get higher scan rates, you know. Our entire high-end range runs on 31250 Hz. Sets with VGA capability often run even higher. 100 Hz HDTV was supposed to run on 62500 Hz but that is a big technological problem as you might imagine.

Larger screen sizes (32" 16:9, 33" 4:3) do tend to have less sensitive deflection coils, so the peak-peak amps go up. Combined with the higher scan rate this often means that some new transistor must be found, even if it is only a higher rated selection from an existing type. There are also 1700 V Vce types next to the regular 1500 V.

And in USA it is known that setmakers (like ourselves) have standard transistors marked with a different type number, to prevent repairmen from putting in just any would-be replacement type. For a fact, it IS risky to put in the wrong replacement, the faulty drive conditions may destroy it early. So try and avoid this.

To comfort you, the BU508 is still widely used!

HOT Specs and Substitution

Refer the article on deflection circuit design by David Sharples (Electronics World & Wireless World, June 1996).

Every line transistor has its own requirements for:

- Amount of base drive current, especially the Ib at end-of-scan.
- Waveform of base drive current (rising, steady, falling)
- Speed of reduction base drive current at switch-off.

The most effort goes into the optimization of the magnitude of the base drive current. The problem is: gain spread. In the ideal world, all transistors would come from the factory with exactly the same gain. In the real world, this isn't the case - it isn't even close. You have to find *one* optimum drive so that neither the high-gain nor the low-gain type will dissipate too much power taking into consideration the variations in other circuit components as well. There used to be other spread factors influencing the dynamic transistor parameters but fortunately, these have been mostly eliminated by better process control.

- Overdriving causes a slow switch-off behavior, some collector current keeps flowing during the beginning of the flyback and will cause dissipation.

- Underdriving causes bad saturation, the collector voltage will start to rise before the flyback should start. This too causes dissipation.

Either condition is easily observed with an oscilloscope, a current probe and a 1:100 voltage probe (be sure to calibrate it for high frequency response!).

The dissipation as a function of the base drive current is a more-or-less parabolic function with a global minimum. The minimum will be different for high-gain and low-gain types. By measuring the curves for both extreme types and combining them, an optimum drive for the random type will be found, with a figure for the worst-case dissipation.

All this will only be true if you insert a device which is a member of the population spread for which you optimized the base drive. If you just insert a random other device (different type, same type but different brand, same type and brand but much older/newer batch) then all bets are off. Dissipation may be way too high, with early failure as a result (and possibly a distorted picture geometry due to excess damping of the waveform).

It is certainly not possible to substitute a standard HOT (BU508) in place of a more advanced type (in >> 15 kHz applications like a monitor). It is also a very bad idea to substitute a BU508 in place of a much lighter type like a BUT11 (used in <= 17" sets). It will fail!

With horizontal output transistors, it is *not* true that 'bigger is better'. If you substitute a heavier transistor (more amps, more volts, more watts, faster switching, whatever) for a lighter one, then there is a very big chance that it will fail earlier, not later. The reason is that the drive conditions will now be wrong (most likely underdrive) and the transistor will overheat from too high conduction losses (Ic * Vce,sat). So do yourselves a favour and get a correct replacement type.

If cost weren't an issue, transistors and other parts could be hand selected (and some are in any case). But, you wouldn't be able to buy a monitor for $200 if that were required!

Is there a Universal HOT Replacement for TVs?

WARNING: As noted elsewhere in this document, the following approach is much less likely to work with long term (or even more than a few millisecond) reliability in high performance computer monitors.

(From: Chris Jardine (cjardine@wctc.net).)

I shouldn't say this, but, the TV repair shop I worked for a number of years ago stocked 1 universal Horizontal Output Transistor 2SC1308K or NTE238. This worked in almost every set out there that used a transistor and not SCR's (RCA, etc.). This may not be the best way of substituting, but, these 2 part numbers seem to have fairly high gain, power capability, voltage ratings, current ratings, etc. These characteristics made it a good substitute and when you buy 100 at a time you would get a really good price.

This may not work in your case, but, my $.02

Is There a Universal HOT Replacement for Monitors?

> "Would anyone like to comment on BU508's, they should be to the same spec. and born equal. My experience has been that different manufacturers BU508's behave differently. One make will fry and last about 3 weeks, put in a different make, no circuit change, and it runs cool, and is still running 3 years later. Price doesn't seem to be a guide, a $1 one may run cool and have no mfr. code, while a branded one might cost a lot more and run hot."

Yes, here you have the problem exactly!

There is such a thing as component spread. Base drive must be optimized for the whole range of gain within a type. That range can be so large that at the limits of the spread the dissipation can still be too large. The reason is that the device with the largest gain will be overdriven, causing a tail in the current at switch-off, whereas the device with the smallest gain will be underdriven, causing it not too saturate enough. Each condition can be easily viewed on the 'scope. By varying the base drive you can minimize dissipation.

Normally one basedrive is set for the entire population, accepting the variation in dissipation and its upper limit. Sometimes the variation is so large that this will not be acceptable. But this is unlikely for a BU508 in a 16 kHz application. Substituting it with a similar type from a different brand with different parameter spread may indeed cause it to dissipate too much and thus fail early. This has nothing to do with price or quality, just with a different optimum base drive. If base drive has been optimized for a brand with low parameter spread then it can be that the heatsink may have correctly been selected smaller...

Since you live in the UK, you should definitely read David Sharples' article in Electronics World (was it June 1996 ?). He literally optimizes base drive for a living.

Typical Types of HOTs Used in Monitors

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14", SVGA (38 kHz)           A-types: BU2508AF, 2SC4830,  2SC5148.

                             D-types: BU2508DF, 2SC4762,  2SC4916,  2SC5149,
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                                    2SC4291,  2SC5250.

15", XVGA (64 kHz)           A-types: BU2520AF, BU2522AF, 2SC3885A, 2SC3886A,
                                      2SC4757,  2SC4758,  2SC5129,  2SC4438,
                                      2SC4770,  2SC4743,  2SC5067,  2SC5207,
                                      2SC5251,  2SC5002.

                             D-types: BU2520DF, 2SC3892A, 2SC3893A, 2SC4531,
                                      2SC4763,  2SC4124,  2SC4769,  2SC5296,
                                      2SC4742,  2SC4744,  2SC4927,  2SC5003.

                           C
                           o                      C o--+--+
                           |                           |  |
                         |/                          |/  _|_
                    B o--|                 B o--+--------|   /_\ Dd
                         |\                     |        |\    |
                           |                    |   Rd     |   |
                           o                    +--/\/\----+--+--o E
                           E

                 A-Type without damper      D-Type with Damper
```

Note that transistors with built-in damper diodes also are likely to have a base to emitter resistor of about 50 ohms - keep this in mind when testing a HOT with a multimeter - that 50 ohm resistor will look like a shorted junction on the diode test scale.

In nearly all the above cases, the devices will plug-in substitute for each other within a category.

For designs with larger screen sizes (and higher frequencies) the device selection is not so straightforward as some designs which split the horizontal deflection and high voltage generation circuitry.

Continuous dissipation is hardly ever the cause of failure. Failure is usually due to some infrequent transient condition. For multi-frequency monitor designs of 1991-1994 mode-change was/is a big killer. When repairs are made it is wise to cycle through a mode-change sequence. Delays of about 1 min. between changes should be used, shorter delays can cook the device.

- As a rule, once an engineer has a bad experience with mode change he takes greater care in the small-signal circuitry of his next design. This has led to mode change, in general, becoming more benign in the last couple of years. However, in Taiwan & Korea there is a high turn round of engineering staff and some, shall we say, less than perfect designs do still reach production.

- To "cook" a device by mode changing would take at least 30 mins. of continuous changing with a delay of about 20 seconds between each change.

- If a device fails during such a sequence the old spit test is good indicator of why a device fails. That is, a drop of spit on the HOT immediately after failure can tell us a lot: if it sizzles, then the device has probably cooked, if it doesn't then the device failed instantly after one stressful cycle. Frontiers of technology it is isn't but it is a useful technique.

- If you do get failures which haven't been caused by the HOT "cooking" I have no easy solution, sorry!

- Winfield Hill's comments reflect the experiences of many. School physics teaches that bipolar's are current driven and MOSFET's are voltage driven. In practice, of course, this is a gross over-simplification. A MOSFET in deflection would, as we say in the north of England, have to be a "bloody big bugger". For example, a 1500V MOSFET that behaved as a BU2508 would have to be nearly twice the size and at least twice the price. Getting 10V on all the gate cells of such a big chip requires a lot of charge to be injected (i.e., current) and then removed (reverse current); much like a bipolar drive.

Varieties of BU508 HOTs

(From: J. G. Simpson (ccjs@cse.bris.ac.uk).)

BU508 series seem to come in a number of variants, I haven't sorted out the specification for each listed variant, but have found that it's worth trying replacements by different manufacturers. Also if the device is on a grounded piece of metal as heatsink try adding another radiator (twisted vane is my preference). Some TV manufacturers introduce post production mods to change resistance values to provide more drive into the base, this may be in the base or emitter. Scope the waveform for parasitic high frequency oscillation and check that the waveform looks clean. Check voltage rails, supply and derived, and that the set is not over scanning. Check all the components around the horizontal output stage, it may be the manufacturer. had a duff batch of some component (often a capacitor that goes OC) that keeps failing which then stresses the BU508.

Why Do Apparently Similar or Better HOTs Sometimes Run Hot and Blow?

It is often surprising that replacing a horizontal output transistor with one that has overall better specifications does not work out - it may run hot and fail.

There is more to characterizing a transistor than just maximum voltage, current, and power dissipation.

One important parameter is current gain: Too low a gain for a particular operating point may result in incomplete turn-on during scan resulting in high dissipation. You want the transistor to be in the fully saturated state. A larger HOT is more likely to have a lower current gain.

If you read the app notes put out by the manufacturers like Motorola you will also find that fast turn off based drive (negative step) is actually not what you want since this traps excess carriers in the high resistivity collector region which leads to continued conduction and heating. The ideal waveform also provide adequate drive during scan but not excessive overdrive and is thus an increasing ramp to account for the increasing collector current during scan.

Characteristics like this are not dealt with by the basic specs but can differ substantially among otherwise similar transistors.

Also see the section: HOT Specs and Substitution.

Storage Time of HOTs

Storage time differs between transistor types, there's parameter spread within a type (lower Hfe gain gives shorter storage time and v.v.) and it depends on load (higher beam current or larger deflection amplitude due to E/W modulation gives shorter storage time).

Variations in storage time would translate into horizontal position errors of the picture. That's why the base-drive to the HOT is generated by a PLL that measures the phase of the output of the HOT, which is the flyback pulse at the collector. This PLL is called the PHI-2. It keeps a constant phase relation between the sync at the input and the flyback pulse. As a result, you will see the base-drive pulse shifting in time as a function of HOT load, this is normal.

Most deflection processors generate a base-drive pulse with a constant duty-cycle. This means that also the switch-on moment of the HOT will vary with the load. This makes it extra difficult to optimize the base-drive because there is only a limited time interval where the HOT may be switched on and that interval is shorter with high beam current load. On-time is typically between 50% and 55%, depending on the IC.

The feedback of the flyback pulse to the PHI-2 PLL is not perfect because the shape of the pulse distorts as a function of beam current. This will give a dynamic geometry error. It is compensated by feeding a certain amount of EHT information to the PLL.

Typical HOT Dissipation

Just measuring the actual power dissipation in a HOT is not trivial due to the nasty shapes of the voltage and current waveforms. You can't do this with your DMM! A couple of ways of doing this are:

- Monitor the voltage and current waveforms for the HOT. Integrate the instantaneous measured V*I over the duration of one scan line and multiply by the horizontal scan rate.
- Mount the HOT and a fixed power resistor on identical heat sinks so that their thermal enviroments are the same. Then, adjust the current through the resistor (and thus its power dissipation) so that the temperature rise of the heat sinks for the two are equal.

Here are some measured values for TV HOTs with optimized drive:

(From: David, a Philips application engineer).

```
14-21", 16 kHz: About 1 W      (some have the HOT running in free-air)
21-36", 16 kHz: Less than 2 W  (some new large CRT's only need 9 A p-p)
25-36", 32 kHz: Less than 4 W  (dissipation really is prop. to frequency)
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I am sure I don't need to tell you that the dissipation varies with the type of HOT used and the drive.

Why MOSFETs are Not Generally Used for HOTs

One would think that with a MOSFET's high impedance voltage drive and other desirable characteristics, they would have displaced bipolar transistors for horizontal deflection circuits. Why not?

True, a MOSFET is much much much easier to drive. In modern switched-mode power supplies they reign, rightfully so. They are effective and rugged.

But in line deflection things are not so easy. I'll give you 4 reasons:

1. The flyback pulse is regularly 1200 V peak, allowing for margins you need a 1500 V device. There are few or no FETs available for that. In a small set, a 1000 or 1200 V device may be usable. With effort, the deflection circuit impedance may be re-scaled for greater current and lower voltage.
2. The conduction losses (Vds = Id * Rds) of a FET are quite high, this not only is wasteful dissipation but it also affects the linearity of the picture (it's a damped sine-wave, going slower and slower).

3. For the same power losses a FET needs a much bigger silicon area, also FETs are made in a more advanced process, with IC-like features, this translates directly into greater cost! They are several times more expensive.

4. A FET has no storage time, hence it has no storage-time modulation, which is a disadvantage because that would help to improve the natural stability of the control of the phase of the line deflection.

And these are just some major reasons, there are minors too. We have looked into it time and again and still the bipolar wins!

Optimizing Base Drive for HOTs

It is interesting that the problem of base drive optimization receives a fair bit of attention, either for allowing a (non-compatible) replacement HOT to survive or for rebuilding a fixed frequency monitor to a different scan frequency. I wish there was an easy way to teach the average hobbyist a method to do this himself.

The recipe itself isn't all to difficult: mostly we change the value of the power resistor that feeds the line drive circuit until the temperature of the HOT heatsink is at minimum. Too much basedrive current increases the switching losses, too little basedrive current increases the conduction losses. The optimum is somewhere in the middle. All you need is a handful of power resistors and a thermometer on the heatsink.

If you need to optimize for a general HOT type (as opposed to one single sample) then you kindly ask the manufacturer to provide some limit case samples (lowest and highest hFE found) and find a basedrive that satisfies both extremes. Of course you must select a slightly larger heatsink. So far so good. The difficult bit is when you find that you need to change other components in the drive circuit as well, like the spread inductance of the driver transformer, a damping resistor, a duty cycle of a drive signal etc. And of course you may find that the HOT you planned to use is entirely unsuitable for this application ...

Anyway, it's never a case of just 'drive it hard'.

What is This Diode Across My HOT?

It is called a damper diode and is essential to proper operation of the TV's or monitor's horizontal deflection as well as to the continued life and happiness of the HOT. Using an HOT with an internal damper is OK even if there is a separate one in the circuit. The other way around (leaving it out entirely) will likely result in instant - i.e., single scan - destruction of the HOT. This is because in modern deflection system designs, the damper carries the horizontal yoke current for a significant portion of the scan. If it is not present, the HOT will be forced to try to eat this current - in reverse - across C-E.

The damper is a special high voltage fast recovery type of diode - a 1N400x type will not work in its place.

BTW, many of these HOTs have a D after the part number to indicate that they have the internal damper and include a B-E resistor (which may confuse transistor testing) of about 50 ohms. However, the D is not a sure indication of an internal damper - nor is its absence an indication of a lack thereof. The entire part number must be checked to be sure.

What is This Funny Capacitor (or Capacitors) Across My HOT?

These may go by the name flyback, high voltage, snubber, or deflection capacitors. When the HOT is shut off, the current flowing in the inductance of the flyback primary and horizontal deflection yoke cannot be stopped instantly. These capacitors provide a place for this current to go and is part of a tuned circuit (in combination with the flyback and yoke) which needed to accomplish the flyback function.

If this capacitor is open or missing, excessive flyback voltage will result probably killing the HOT. If the HOT does not fail, the result will likely be greatly increased high voltage. Should the X-ray protection circuitry not shut down the deflection, there could be internal or external arcing and/or destruction of components like the flyback or tripler.

For proper operation and continued safety, only proper exact replacements should be used for these parts.

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Horizontal Output Transistor Failure and Testing

HOTs Keep Blowing (or Running Excessively Hot)

Unfortunately, these sorts of problems are often difficult to definitively diagnose and repair and will often involve expensive component swapping.

You have just replaced an obviously blown (shorted) horizontal output transistor (HOT) and an hour (or a minute) later the same symptoms appear. Or, you notice that the new HOT is hotter than expected:

Would the next logical step be a new flyback (LOPT)? Not necessarily.

If the set performed normally until it died, there are other possible causes. However, it could be the flyback failing under load or when it warms up. I would expect some warning though - like the picture shrinks for a few seconds before the poof.

Other possible causes:

1. Improper drive to horizontal output transistor (HOT).

   - A too weak drive (or a HOT with a too low Hfe) causes Vce(sat) to be too large, giving conduction losses.

   - A too strong drive (or a HOT with a too high Hfe) causes it to switch off too slowly, giving switching losses.

   Base drive should be optimized to balance between these 2 losses. Check driver and HOT base circuit components. Dried up capacitors, open resistors or chokes, bad connections, or a driver transformer with shorted windings can all affect drive waveforms.

2. Excessive voltage (B+) on HOT collector - check low voltage regulator (and line voltage if this is a field repair), if any.

3. Defective safety/flyback capacitors or damper diode around HOT. (Though this usually results in instant destruction with little heating).

4. New transistor not mounted properly to heat sink - probably needs mica washer and heat sink compound.

5. Replacement transistor not correct or inferior cross reference. Sometimes, the horizontal deflection is designed based on the quirks of a particular transistor. Substitutes may not work reliably.

   Well, you can always *try* to optimize the base drive by changing the value of the power resistor that feeds the drive circuit at the primary of the drive transformer. But you're on your own here! Clearly label what you have done or else your name will be mud if the unit ever needs to be repaired by someone else in the future.

6. And, of course, bad connections in the drive or output circuitry can be the cause of almost any sort of failure! The HOT should not run hot if properly mounted to the heat sink (using heatsink compound). It should not be too hot to touch (CAREFUL - don't touch with power on - it is at over a hundred volts with nasty thousand volt spikes and may be line connected - discharge power supply filter caps first after unplugging). If it is scorching hot after a few minutes, then you need to check the other possibilities.

   However, it is possible that the deflection circuit is just poorly designed in the first place and it has always run hot (though it is unlikely to have always been scorching hot). There is no way to know for sure without a complete analysis of the circuit - not something that is a realistic possibility. In this case, the addition of a small fan may make a big difference in HOT survival.

   It is also possible that a defective flyback - perhaps one shorted turn - would not cause an immediate failure and only affect the picture slightly. This would be unusual, however. See the document: Testing of Flyback (LOPT) Transformers.

   Note that running the set with a series light bulb may allow the HOT to survive long enough for you to gather some of the information needed to identify the bad component.

Base Drive and Hot HOTs

One common cause of a HOT running excessively hot is wrongly dimensioned base drive. This may be due to problems in the drive circuit due to bad components (often a capacitor) or as a result of poor design. There is usually easy evidence if you look at the rising edge of the collector voltage. If it rises too early, before the end of the scan, then the transistor is underdriven and there will be excess conduction losses. If it rises too late, or rather when there is still a lot of collector current during the flyback, then the transistor is overdriven and there will be excess switching losses. The condition can be varied by playing with the power resistor that supplies the line drive circuit. It would be appropriate to vary this as a function of parameter spread within one type of transistor. This is not necessary for 16 kHz deflection because there is sufficient margin for error.

Other deviations may be due to an inappropriate waveform of the base current. It should not fall too quickly because the HOT needs time for recombination of electron-hole pairs. This is typical of high voltage transistors which have a very wide and high-impedance collector-base region, difficult to control. Setting this right is the one-time responsibility of the TV designer. It can be disturbed by a wrong transistor substitution of course, so check whether a correct type has been mounted. That's what I mean when I say that a bigger HOT is not better. A BU508 requires a totally different base drive from a BUT12.

Also see the section: Optimizing Base Drive for HOTs.

HOTs Blowing at Random Intervals

The HOT may last a few months or years but then blow again.

However, a combination of mode switching, loss of sync during bootup, running on the edge of acceptable scan rates, and frequent power cycles, could test a monitor in ways never dreamed of by the designers. A TV may suffer from similar failures due to repeated power cycling, video input selection, or channel changing. It may take only one scan line that is too long to blow the HOT. Newer horizontal processor chips are quite smart about preventing HOT killing signals from reaching the horizontal driver but they may not be perfect.

On the other hand, the cause may be along the lines of those listed in the section: HOTs Keep Blowing (or Running Excessively Hot) and just not as obvious - blowing in a few days or weeks instead of a few seconds but in this case, the HOT will likely be running very hot even after only a few minutes.

Another possible cause for random failures of the HOT are bad solder connections in the vicinity of the flyback and HOT (very common due to the large hot high power components) as well as the horizontal driver and even possibly the sync and horizontal oscillator circuits, power supply, or elsewhere.

Preventing Random HOT Failures

As noted above, a bigger HOT is not necessarily the answer. A selection of the same HOT for 1700 V breakdown voltage may help but is not an option outside the design lab. Sometimes very exotic HOT type numbers occur, which are really a selection from a standard type, used for statistical failure analysis.

A separate EHT supply (only in the most expensive monitors) would also help to save the deflection transistor, but might kill its EHT twin. Of course, not an option in the field.

Soft-start circuits make a biiig difference, but are an inherent part of the design, not an afterthought.

The chance of failure may also be a function of an unspecified transistor parameter, so sometimes the mere swapping of a HOT may solve it permanently.

And, if in the unlikely event it is an EMI problem (like a cellular phone lying on top or the set) then obviously the cause must be eliminated. A layout change is a better remedy but out of reach of a repair shop.

More on HOT Failure

> "I'm sure this has been discussed before, but I have worked on several monitors lately with shorted HOT's, replacing that one part has fixed all of them, and I have not had a reoccurrence yet. Does something cause HOT's to blow, or do they just short occasionally for no reason?"

Actually, we know fairly well why HOTs blow, at least in television. They almost always fail from secondary breakdown, not from average dissipation. Secondary breakdown occurs instantly if the combination of voltage and current is too high, even for only 1 line period.

Usually this happens due to a hard-start condition of a flyback converter. In case of a CRT display this usually applies to the high voltage output which is loaded by the built-in capacitance of the tube. When the FBT starts to charge that capacitance it sees a short-circuit. This causes the core of the FBT to go into saturation and the primary current rises to a multiple of what it should be.

When the HOT switches off such a large current it breaks down. That is, some HOTs break down. Most are better than spec and survive. If it survives the first hard start it will likely survive many.

Such situation occurs most likely after a picture tube flashover, when the EHT capacitance has been shorted. After about 3 line periods the current through the HOT becomes too high. Only a soft-start method can really prevent it but it is a bit hard to design a circuit.

Other causes for HOT failure may be false drive pulses, e.g. due to a bad sync input (not likely for a monitor with a slow line PLL) or due to EMI. It should not happen, but it will. Some manufacturers have better designers than others. Ahem...

Saga on Swapping of HOTs

(From: Malik (M.Dad@mmu.ac.uk).)

The prologue:

I have in for repair a Tatung monitor model CM14UAE. Originally it was dead this fault was quickly remedied by replacing the line output transistor which was 'dead short', causing the power supply to shut down.

Now the transistor I replaced seems to get a hell of a lot hotter than it should, when it gets to a certain temperature after about half an hour the width begins to collapse at which point I quickly switched off. If I switched off for a few seconds and back on again I would get the width back but again it quickly began to collapse.

Things you need to know:

The LOP stage is independent from the EHT transformer. i.e. there is a separate transformer for the EHT (and A1 supplies etc) with its own transistor and a separate line output only transformer with its own transistor.

I have also tried substituting the efficiency diode, still no joy. I have also replaced the EW transistor and its driver.

To me it seems that the transistor is not being switched properly, although the waveforms do look OK.

Original line output device 2SC3893A, which I replaced with a BU508DF (European equivalent according to the books. I also tried a 2SC3883 which used for the same job in other SVGA monitors. Both give the same problem,

I will be trying to get the original transistor in case this is the problem but I don't think it will make a difference.

And the conclusion:

Anyway after all that headache I finally received through the post the original 2SC3893A. I fitted this and left the monitor on test. Sigh of relief, the problem has gone away.

It seems the timing on this device differs from all the others I tried. The transistor runs at a reasonable temperature even after a few hours use.

The moral of this story is, use original line output transistors. Unless you are 100% sure the replacement works in its place. Don't rely too much on equivalent books, these should be used as a guide. The book I looked at specified the BU508DF as a direct replacement for a 2SC3893A, but as I know now it doesn't work properly.

The HOT should not run too hot to touch. If the replacement sizzles, it won't last long and is probably deficient in some specification. If the monitor or TV appears to work normally otherwise, try an exact replacement HOT if available before swapping other expensive parts like the flyback (LOPT). For testing, however, a substitute can usually be used - with a series light bulb and Variac.

Brief Comments on Testing the HOT

For a TV or monitor with no blown fuses that will not start, here are two quick checks to see if the HOT is good and has power and drive:

- HOT tests - check across each pair of pins for shorts (preferably removed from the circuit board). No junction should measure less than 50 ohms or so. Lower readings almost certainly indicate a bad HOT. If in-circuit, however, the reading between base and emitter will be near zero due to the secondary of the driver transformer. See the document: Basic Testing of Semiconductors. Don't be confused by internal damper diodes and B-E resistors.

- Power - measure across the collector to emitter with a multimeter (with the HOT removed or if there is no deflection, this is safe with it in place). There should be solid B+, typically about 100 to 160 V (for TVs, 115 VAC sets - possibly higher for 220 VAC sets), 60 to 170 V or higher for auto-scan monitors. If this is missing, either there is a problem with the power supply or the emitter fusable resistor has blown (probably in addition to the HOT) and there is no return for your voltmeter. If it is pulsing, the power supply may be cycling on overvoltage - the HOT may be good in this case but there is no base drive.

- Drive: put an oscilloscope on the base - there should be pulses around .7 V for most of the scan and probably going negative a couple volts at least for retrace. Specific timing will depend on the actual scan rate. If drive is weak or missing, If drive is weak or missing, determine how it is derived as there may be a problem in the startup power supply or deflection IC.

WARNING: Use an isolation transformer for the oscilloscope tests (and whenever you are probing a TV in general)!!! This part of the circuit, in particular, is usually line connected. See the document: Safety Guidelines for High Voltage and/or Line Powered Equipment.

Testing of Replacement HOTs

The following is useful both to confirm that a substitute replacement HOT is suitable and that no other circuit problems are still present. However, single scan line anomalies (particularly when changing channels and/or where reception is poor with a TV or when switching scan rates and/or when no or incorrect sync is present with a monitor) resulting in excessive voltage across the HOT and instant failure are still possible and will not result in an HOT running excessively hot.

- Function - Confirm that the monitor or TV behaves EXACTLY as you expect. Look for any sign of changes in picture width and other aspects of geometry that might indicate a less than happy horizontal deflection system.

- Temperature - After letting the unit run for a while, unplug the unit and confirm that the voltage on the HOT collector is near zero (discharge the power supply filter capacitors if it is not) and see how hot the HOT is. Note: Unplugging without switching of off may result in the capacitors discharging faster if the unit has a soft (logic controlled) on/off switch. Careful, the HOT may be really hot - start at the far end of the heat sink and work your way towards the transistor case. Obviously, a temperature probe (insulated!) would be better as it would be able to make measurements while the HOT is powered. You can also use a cheap thermometer for this purpose - attach its sensor to the heat sink near the HOT.

(From: Raymond Carlsen (rrcc@u.washington.edu).)

After installing a replacement HOT in a TV set or monitor, I like to check the temperature for awhile to make sure the substitute is a good match and that there are no other problems such as a weak H drive signal. The input current is just not a good enough indicator. I have been using a WCF (well calibrated finger) for years. For me, the rule of thumb, quite literally, is: if you can not hold your finger on it, it's running too hot, and will probably fail prematurely. Touching the case of the transistor or heat sink is tricky....

Metal case transistors will be connected to the collector and have a healthy pulse (>1,200 V peak!) and even with plastic case tab transistors, the tab will be at this potential. It is best to do this only after the power is off and the B+ has discharged. In addition, the HOT may be hot enough to burn you.

A better method is the use of an indoor/outdoor thermometer. I bought one recently from Radio Shack for about $15 (63-1009). It has a plastic 'probe' on the end of a 10' cable as the outdoor sensor. With a large alligator clip, I just clamp the sensor to the heat sink near the transistor and set up the digital display near the TV set to monitor the temperature. The last TV I used it on was a 27" Sanyo that had a shorted H. output and an open B+ resistor. Replacement parts brought the set back to life and the flyback pulse looked OK, but the transistor was getting hot within 5 minutes... up to 130 degrees before I shut it down and started looking for the cause. I found a 1 uF 160 volt cap in the driver circuit that was open. After replacing the cap, I fired up the set again and monitored the heat sink as before. This time, the temperature slowly rose to about 115 degrees and stayed there. I ran the set all day and noticed little variation in the measurement. Test equipment doesn't have to cost a fortune.

Oscillation or Ringing at HOT Base?

> "Could this be happening because I'm using the wrong HOT?"

At these relatively low frequencies your scope probe is probably not suspect, although you should keep loops small and not underestimate the effect of high dV/dt inside the line transformer.

First, how do we know if the oscillations were already there with the original HOT ? I suppose you have never measured that ...

Second, it is NEVER a good idea to replace a HOT with just any other type because there can be significant differences which are not at all visible in the spec. Even for specialists it's quite difficult to optimize the drive conditions for a new HOT type. You're on your own here.

Third, some oscillations are normal because the inductance of the base drive transformer does form part of a damped resonant circuit. Usually these oscillations show after switching OFF the HOT and they can be a problem if the negative Vbe is insufficient during the flyback pulse and the transistor might be turned back on, which would kill it. As a rule of thumb, Vbe should be -2 V during flyback, but there are exceptions. Depending on the HOT type, some damping resistor may have to be applied. I've never heard of oscillations during HOT ON.

If the collector waveforms (V and I) seem OK and the HOT does not overheat then maybe you shouldn't worry too much. But do check at high beam current too (max. brightness on a white picture) because then the HOT must be switched on earlier to provide the magnetizing current to the line transformer too.

(From: Alan McKinnon (a.mckinnon@pixie.co.za).)

I've run into this kind of thing several times recently on different sets, this is what I've found:

1. Do you have a damper resistor (about 30 or so ohms) across B-E of the HOT. It can go open circuit, causing weird stuff.

2. Check the supply feed resistor into the transformer of the line drive circuit. These can go high, especially

if it's a high value resistor dropping a supply of 120 odd volts down to 30 or so.

3. Check all small resistors and caps in the line drive circuit, take then out and measure them, in circuit reading are funny in this area.

4. Try a new drive transformer.

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Additional Deflection System Information

Web Resources on Deflection Systems

Here is an article originally from Sencore: Understanding the TV Horizontal Output Stage. I have archived it at Sam's Copy of Sencore's Understanding the TV Horizontal Output Stage in case the link dies. While specifically written for television sets, most of it also applies to monitors.

Why are Nearly All Horizontal Driver Circuits Transformer Coupled?

Almost every TV and monitor in the universe uses a small high frequency transformer to couple the drive signal from the horizontal oscillator to the horizontal output transistor base. There are several reasons why this is so popular:

- One (probably secondary) reason is that this provides one of the isolation barriers between a line-connected HOT and flyback primary and the signal circuits of the TV.

- A more important rational is that a transformer is nice easy way of impedance matching the horizontal driver circuit (100s to 1000s of ohms) to the few ohm input impedance of the horizontal output transistor base which requires upwards of several amps for proper drive. A typical driver transformer may be in the 5-10:1 turns ratio representing 25-100:1 impedance ratio.

- A byproduct of all this is that it is unlikely for a faulty driver stage to kill the HOT. Unlikely but not impossible.

However, there are apparently some smaller TVs that use a direct coupled drive scheme but these are definitely the exception.

S-Correction Circuits on Multi-Scan Monitors

(Quoted text from a curious but frustrated tinkerer/technician.)

> "Hi there. Recently, I've encountered this circuit (or ones similar to it) several times in VGA monitors and I'd like to know what it's purpose is.

```
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                |D                    |                  |
               _+--+                  |                  |
            G||   __|__              _|_              __|__
     S0 ----||   _/_\_  IRF620       ___  .64 uF       _\_/_
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```
       ||_   |                |                 |
          +--+                |                 |
          |S        .64 uF    |B                |
Ground o--+-----------||------+---o * See Text  +------o To +76 V
          |S                A |C                |
         _+--+                |                 |
      G||  __|__             _|_              __|__
S1 ----||  _\_/_ IRF620      ___ .64 uF       _/_\_
       ||_   |                |                 |
          +--+                |                 |
          |D                  |                 |
          +-------------------+-----------------+
```

The IRF620's are N channel Enhancement Mode MOSFETs.

8. The connection at this point is to the HOT collector via the horizontal deflection yoke (HDY), width, and linearity coils."

You will probably find that 0, 1, or 2 of the MOSFETs will be turned on (S0, S1 set to ground or +15 V (typical) depending on the scan rate. This would introduce varying amounts of S-correction (E/W) depending on the horizontal scan rate.

The diodes are probably for clamping and protection. The MOSFETs are used as switches. You, in effect, get 1, 2, or 3 x .64 uF between the yoke return (the point marked '*') and ground.

This circuit is from an auto-scan computer monitor where it switches the effective S-correction capacitor to one of 3 possible values depending on scan rate.

Note that this approach is used both in multi-scan and auto-scan monitors. The multi-scan (largely obsolete technology though still used in some specific applications) has two or more discrete line frequencies and the auto-scan has a whole range of available frequencies. You would not guess this from the discrete switching of the S-correction capacitors. Obviously, the S-correction is optimized only for 3 frequencies and approximated for all others. This is generally good enough (even) for auto-scan.

The internal diodes anti-parallel to the MOSFET (A to S, K to D) are important to set the DC voltage over the extra S-capacitors to a reasonable value before they are first switched in. At lower line frequencies the extra capacitors are permanently switched on.

For each given scan frequency there is only one correct value for the S-correction capacitor. If you limit your circuit to only 3 discrete values (like 0.64, 1.28 and 1.92 uF) then the horizontal geometry can be optimized for only 3 scan frequencies.

Somewhere between these 3 frequencies there will be 2 switch-over points where more S-correction capacitance is added by the switches. Generally, around these border frequencies the geometry will be worst (because whatever the position of the switch, there will be an error one way or the other) and it would be wise to switch over near some little-used frequencies and thus optimize for the much-used frequencies like 31, 38, 48 and 64 kHz. For the other scan frequencies, the geometry will then be only approximately correct. Luckily, S-correction is not very critical.

For any given scan frequency, the position of the MOSFET switches is constant: either on or off. These are not used in a switched mode.

There *will* be one or two other MOSFET switches that switch at a line scan rate in order to take care of the correct dependency of the (average) supply voltage and E/W voltage in function of the scan frequency.

There is a difference in the horizontal deflection circuit of a TV versus an auto-scan monitor. In the diode bridge of a TV, the deflection circuit is in the upper half of the bridge and the "bridge circuit" is in the lower half of the circuit. The E/W amplifier *sinks* current from the centre node (and dissipates). The VB supply voltage is constant.

In the diode bridge of a auto-scan monitor, the deflection circuit is in the lower half of the bridge. This makes the S-correction capacitor grounded and thus easier variable (without need for level shifters, opto-couplers, etc). The E/W amplifier *sources* current into the centre node. The VB supply voltage is made variable, linearly proportional to the line frequency, by means of a switched-mode down-converter topology. The same topology is also used for the E/W amplifier, which now actually delivers power to the circuit. With this topology you can have a constant (even regulated) EHT and a constant deflection current amplitude, independent of the line frequency.

> "In another similar monitor, this circuit had completely self-destructed and taken out a few other things too (fire). The monitor shuts down immediately unless the HOT is disabled or connections A, B, and C are *all* broken (no other combination works). It almost seems like it's used to accommodate or change the horizontal frequency for different video modes. For some reason, the monitor is now powering up so seems like it might be an intermittent short somewhere."

By disconnecting A,B,C you effectively take the coils of the horizontal deflection yoke (HDY) out of the circuit. By disabling the line transistor (HOT) there remains only DC voltage over the bridge- and S-correction capacitors. Either way there is no voltage over the HDY. I would suspect a short or arcing in the deflection coil. Just a wild guess, though.

There is enough energy present in the deflection circuit (also in the HDY) to create a very nice fire, let there be no doubt about that. A loose contact in series with this circuit is potentially fatal.

More on Horizontal Driver Circuits

Usually, the primary voltage is *constant* when the driver transistor is ON and thus the HOT is OFF. Then when the driver switches OFF, the stored magnetic energy switches the HOT to ON.

This is called non-simultaneous base drive, which is most common. The primary voltage that you see then is mostly a transformed version of the secondary voltage, over the series base impedance. The voltage at HOT=ON is not forced from the primary side.

Usually the "cold" side of the primary of the driver transformer is connected via a power resistor and filtering electrolytic capacitor to the B+. The R determines the average voltage and thus the base drive current. Higher R means less base drive and vice-versa. Varying the value of this resistor is the first choice for minimizing the power dissipated in the HOT.

The filtered DC voltage at the cold side is (typically) a little over 1/2 * V(B+). Then when the driver switches off the voltage at the hot side (of the primary) will be higher, but typically not higher than V(B+). But how high exactly is a coincidence.

Why do Some Monitors Fail if Driven at the Wrong Horizontal Frequency?

I think it *should* not have failed. It is the purpose of the deflection processor to guard that the line deflection never runs at a forbidden frequency. It is possible that such protection is not good enough, that when the PLL is not in lock it might generate a very irregular line drive. That can prove to be immediately fatal to a line transistor. All it takes is one line length that is too long, followed by a flyback pulse that is too high, and it's all over. Second breakdown, terminal.

Trying a too high line frequency is usually not harmful, generally your EHT will be too low and your deflection current amplitude too. The HOT might eventually die from overheating due to bad drive conditions, but otherwise any decent monitor should be able to withstand it. In the better cases it simply refuses to sync on an illegal frequency.

1. While increasing the frequency of the horizontal drive *all other factors being equal* should not result in HOT death, all other factors are not always equal. The sync circuits may select an improper set of voltages, the drive waveform (as mentioned) may be insufficient, etc.

2. The sync may lock to a submultiple so the drive may be at 1/2 H resulting in a too long on-time and poof.

As noted, this can be a one shot affair - absolutely no warning. My recommendation remains to attempt if at all possible to obtain the specs for any monitor you intend to use.

Tweaking the Deflection Rates in a Fixed Frequency Monitor

Pulling a fixed frequency monitor by more than a few percent will likely be a problem. I know this is not the answer you were looking for but getting a new inexpensive video card may be a better solution.

If not, you are looking for an adjustment called horizontal oscillator, horizontal frequency, or horizontal hold. If you do tweak, mark everything beforehand just in case you need to get back to the original settings. There is some risk - changing it too far may result in damage either immediate or down the road - I have no idea.

Here is a discussion about modifying a monitor to run at other scan rates than for which it was originally designed (in this case, a lower one):

> "I would like to convert IBM XGA2 (39.4 kHz JH) monitors (9515, 9518) to work at VGA (31.4 kHz H) rates.
>
> I have the schematics, and with datasheets/application notes from chipmakers' websites altering the scan-frequencies and the mode-switching logic has been relatively straightforward.
>
> That's as regards the 'small-signal' bits (and frame output), to leave a 39.4 kHz scan for 75 fps graphics and provide 31.5 kHz for the 400-line DOS text (VGA startup) mode, and 350-line graphics.
>
> *But* the HOTs blow up at 31.5 kHz: after a while in the first of a number of 9515s, almost instantly in 9518. The corpses and heatsinks are very hot, as in 'high temperature' as well as function :-(("

Blowing up the HOT after minutes is due to bad base drive, or (much more rare) due to LOT core saturation. Blowing up a HOT immediately is due to too high collector pulse.

> "The base drive looks fine on a 'scope as regards holding the HOTs (or now an experimentally-substituted forward diode) firmly saturated for the longer 'on' time, and then sharply/cleanly

> turning them off."

There's more to a good base drive than just 'looking fine' on a scope. The aim is to minimize the dissipation in the HOT. This requires just the right amount of base current and reducing it in a particular manner at the end of each line. (A process that we call 'de-holing', removing all the holes from the high-impedance collector region, this must not go too fast.)

- Too little base drive current will cause the collector voltage to start rising too early, before the beam has reached the right end of the screen. The HOT goes out of saturation too early, causing dissipation.

- Too much base drive current will cause the collector current to reduce too slowly during the beginning of flyback. The HOT goes out of saturation too late, also causing dissipation.

Usually for lower line frequency you need a bit more base drive.

> "I have only a rather vague mental picture of how a LOPT works. I think that, as a load on the HOT, it is almost purely inductive from turn-on (though not from the EHT-generating turn-off)."

If there are secondary scan-voltage rectifiers then they add to the load during (beam) scan. Otherwise it is always inductive. During flyback, the flyback capacitor and the secondary flyback rectifiers cause the characteristic flyback pulse shape.

> "Hence I suppose that the longer 'on' period allows the current to increase to a higher (and destructive) level."

Not the higher current in itself is destructive, but the increased magnetic energy is. During flyback, 1/2*L*I^2 is converted to 1/2*C*V^2 in the flyback capacitor. More energy means more voltage over the HOT. Over 1500 V peak it will be destroyed immediately.

> "If magnetic saturation were to be reached, it would even look more like a dead short than an inductance."

That's true, but it occurs mainly due to excess beam current. Secondary flyback load causes the primary scan current to rise.

> "My questions are twofold: (1) how correct is my understanding?"

Fair enough. You can get a fair idea by running simulations with ideal circuit models. But to understand what happens inside a HOT you need very advanced models. Which don't even exist (yet)!

> "(2) More to the point, what solution is there?"

You're doing a good job guessing. I'll let you continue.

> "One that springs to mind is to reduce the voltage of the HOT's supply, something like proportionally to the increase in 'on' time, so that the peak current is back to what it is at the higher frequency."

Exactly. Peak current and more importantly peak voltage, because then also the EHT will be kept constant.

> "This would be a non-trivial task, both to provide a second voltage (at quite high current) and to switch between them."

Maybe not trivial but a lot easier than you think.

> "Though some multi-frequency monitors have such multiple (switched) supplies, I don't think all do: what alternatives can be adopted? How does one calculate in this area, or is it (unfortunately) a matter of having LOPTs intended for the purpose?"

The LOPT must be optimized for the higher line frequency and the corresponding short flyback duration. For lower line frequencies, you want to reduce the B+ voltage so that it is proportional to the line time. This is in fact very easy if you use a switched-mode down-converter (is that called a 'buck'?) and you make the on-time of the switch *constant*. Now the line frequency may be varied over a wide and continuous range. This gives near constant EHT too.

On other monitors, a voltage determined by the detected scan rate is returned to the power supply in place of the usual zener reference to adjust its output.

You can use an extra filter coil to provide constant B+ to the line deflection circuit or you can use the LOPT primary for that. There are some subtle problems with which I will not bother you.

It may be necessary to reduce base drive current for line frequencies beyond a certain value.

The 'only' other thing left to do is to keep geometry correct for the various display modes. Mainly by switching in more or less S-correction capacitance (using FETs or even relays).

Don't assume that you will be able to re-invent the multi-scan monitor on your own. I think you will find that you have insufficient resources to do that.

Honestly.

That's quite a difference (a factor of 2.6)! Forget it. That's more work than even an expert would be willing to spend on a single prototype. Usually the lower impedance is intended for a higher line deflection frequency, so that requires a total redesign.

I don't know of any simple impedance transformation trick to operate the coil at a regular line frequency (with up-transformed impedance) except for sinewave deflection where I once succeeded in doing that. But this is sawtooth deflection, not so easy. Sorry.

Yoke and Interlocks

> **"I was asked a question today that I never thought of much before. If you remove the yoke (unplug it) from a TV or monitor is the high voltage still present and if so can this cause damage to the set. Thanks"**

The answer is an unqualified maybe on all counts.

Some have an interlock so you lose power to the deflection/set if the yoke is unplugged - found that out on a Magnavox chassis that would not do anything without the yoke connections.

Those that continue to have power may result in damage - at the very least, if the HV is present, you will be drilling a hole in the center of the screen since deflection will be absent. The horizontal deflection will be detuned possibly resulting in overheating, excess HV, etc.

If you do try this, I recommend using a Variac and carefully monitoring the CRT for presense of a very bright spot (which will turn into a very dark spot quite quickly) as well as an excessively hot HOT.

BTW, disconnecting the yoke may be desirable to troubleshoot a horizontal deflection/high voltage if the yoke is suspect. If the yoke is loading the deflection output due to shorted turns, disconnecting it may allow high voltage to come up - just go slow and nothing will blow.

(From: Stefan Huebner (Stefan_Huebner@rookie.fido.de).)

Some yoke plugs have a jumper wire to remove +B from the flyback when pulling it. But this may still damage the SMPS since they are not all build for running without a minimum load. Some yoke plugs only have the four yoke wires connected; in those sets HV will build up when the plug is pulled and you may even destroy something in the flyback area (most likely the HOT) because the horizontal deflection yoke is an essential part of the flyback circuitry (exception: some monitors, foe example Eizo, which have separate HOTs for the flyback and the horizontal yoke).

Why the Yoke is Needed to Keep the Horizontal Deflection System Happy

If you unplug the yoke (even if there is no interlock), while the system may still work to some extent, performance will be poor. High voltage will be reduced and parts may overheat (and possibly blow up).

- **One reason to do this at all is as a quick test to determine if the yoke is defective. While the resulting waveforms will not be totally correct, they should be much better than with a shorted yoke installed and there may be enough HV to get a spot on the screen. Caution: It may be quite bright. See the documents: Notes on the Troubleshooting and Repair of Computer and Video Monitors or Notes on the**

Troubleshooting and Repair of Television Sets for more info and precautions.

- Another more fun reason is if it is desired to use the flyback subsystem of a defunct TV, monitor, or computer terminal as a stand-alone high voltage power supply - but details are left as an exercise for the highly motivated (and cautious!) student. See the document: Salvaging Interesting Gadgets, Components, and Subsystems for more exciting details.

WARNING: High voltages and possibly line voltage present at HOT, yoke, flyback outputs, and elsewhere!

Of course, just removing the yoke doesn't work. The flyback capacitor is tuned for the presence of both inductances: line transformer and deflection coil. If you remove the deflection coil then the remaining primary transformer inductance is about 5 times as large. So, rule-of-thumb, you would have to decrease the flyback capacitor by a factor of approximate 5. But that's not all:

Without the deflection coil, a lot less current runs through the horizontal output transistor. So, in all likelihood, it will now be overdriven. So you need to reduce the basedrive. But that's not all:

If you remove the picture tube capacitance and the deflection coil then all peak energy demand must be delivered from the primary winding of the line transformer. Even the shortest peak load will cause saturation. The parallel deflection coil will at least lend some temporary energy, and the picture tube capacitance does an even better job. A good high-voltage source without the benefit of a deflection coil is more expensive...

If you *must* get rid of the 'ugly' deflection coil, then you may want to replace it with an equivalent 'pretty' coil. But:

- It must be able to carry the peak current without saturation (a deflection coil has such a huge air gap that it can not possibly ever saturate, but a smaller coil can).

- It must have a low enough dissipation so you might have to wind it with litz-like wire (multi-stranded isolated), do not underestimate the losses in high-frequency coils, mostly due to skin- and proximity-effect.

- Yes, it can be done, good luck.

And you might want to add a discrete high-voltage capacitor. How to isolate the wiring (corona discharge!) is left as an exercise to the reader... (We pot them in convenient blocks).

Probing TV and Monitor Yoke Signals

Due to the particular nature of the signals on the deflection yoke, special techniques must be used to safely view them on a scope. Note that the following also applies to some extent to deflection signals in tube-type video cameras and other similar devices as well.

You cannot put a ground clip on either pole of the line yoke, because one side carries the flyback pulses which are approx. 1000 Vpp and the other side carries the S-correction voltage which may be 100 V average with a (?) 50 Vpp line parabola. Both signals are at line frequency (15.75 kHz and up). You need a 100:1 oscilloscope probe for the 1000 Vpp signal! The field coil carries lower voltages (order of 50 Vpp max) and at field frequency (50 to 120 Hz).

Usually you connect the scope ground to a large heatsink, unless that carries a warning label that it is not grounded... ALWAYS check first to identify a proper ground and use an isolation transformer for safety since even this may not be the same as the power line ground.

If you have a current probe for your scope, this can be used to monitor the various current waveforms. I have used my Tektronix current probe to view the yoke current on TVs. The rendition of the horizontal deflection current waveform is quite good. However, the vertical suffers from severe distortion due to the low frequency cutoff of this probe.

You can build a not-very-fantastic (but quite usable) current problem using a split ferrite core of the type used on keyboard and monitor cables (preferably one that snaps together). The following will work:

- Wrap seven turns of insulated wire around one half of the core.

- Solder a 2.2 ohm resistor across the two leads to act as a load.

- Connect to the vertical input of your scope via a coaxial cable or probe.

You can experiment with the number of turns and load resistor value for best results.

To use your fabulous device, insert one and only one of the current carrying wires inside the ferrite core and clamp the two halves together.

For a typical TV horizontal deflection yoke, this results in about a .3 V p-p signal. The shape was similar to that from my (originally) expensive Tektronix current probe. Enjoy the show! Due to its uncompensated design, this simple probe will not work well (if at all) for low frequency signals.

Breathing Compensation

Breathing is a change in picture size caused by a variation of the EHT voltage due to varying beam current loading. The EHT has a typical output impedance of (approx.) 1 M Ohm. Average beam current varies between 0 and 2 mA, so the voltage drops by 2 kV (from 30 kV), or worse. At lower EHT, the electron beam is easier to deflect, so the picture size will increase.

Brighter picture -> higher beam current -> lower EHT -> larger picture. That's the law of physics.

The breathing can be compensated by decreasing the deflection current amplitude as a function of the beam current. A voltage called "EHT-info" is generated from the beam current as delivered by the line transformer. This is fed to the deflection circuit for feed-forward correction. For horizontal deflection this means feeding it to the East-West modulator.

And here's the catch for you Americans: many USA sets don't have an East-West modulator! Most picture tubes (for the USA) with 90 or 100 degrees deflection don't need (much) pin-cushion correction, so there is no fundamental need for the East-West modulator and so there is also no correction possibility for the anti-breathing. There are other options for corrections, like creating a deliberate higher output impedance for the V+ deflection supply etc., but these are passive measures which will lack accuracy.

Sets with 110 degrees deflection angle (common in Europe) will need active East-West correction and should also perform adequate anti-breathing. Although that is still difficult enough, I should know...

The LD/DVD "Video Essentials" contains test pictures to check your breathing performance. It advises you a simple counter- measure: reduce the beam current by lowering the contrast setting ! This will also improve the sharpness (less spot blooming) and increase the lifetime of the picture tube (less burn-in of the phosphors). But you need to darken the room because the picture will obviously be much darker... (http://www.videoessentials.com/)

Circuit Simulation of the Deflection System?

If it were that easy... You could use any regular circuit simulation like Spice or Microcap. The real problem is in obtaining the device models, particularly the horizontal output transistor and the line transformer. Initially you could start with ideal components (switch, inductor) and see if you've got the basic component values right. That will give you some basic insight into the working of the circuit, but it is then that the real fun starts. For example, storage time modulation of the HOT is essential for the Phi-2 PLL response... I don't think you will find any realistic device models for power transistors, so you will have to breadboard and actually measure...

Jurb's Comments on HOT Troubleshooting

(From: JURB6006 (jurb6006@aol.com).)

The base current is hard to read, but the HDT (Horizontal Drive Transistor) collector waveform can give you a readable picture of it. When you put a scope probe on the base of the HOT, the reading is almost useless, it tells you more about a parameters of the HOT than whether or not it has sufficient drive.

The reason for this phenomenon is the same as the reason they use a transformer to drive the HOT in the first place. A complimentary pair of transistors would do the job just fine, as long as they don't need the isolation. If the chassis uses an SMPS, it would be cheaper except for one thing. The HOT itself.

Even though the transformer steps down quite a bit, it is still a current source. As many linear amplifying stages we see using discreet components, the fact that a bipolar transistor device is current driven gets obscured.

The HDT collector voltage waveform can tell many things. When the base of the HOT is disconnected it will become what looks like the upper left quadrant of a circle. When loaded with that junction it looks more like a square wave. There is a hump at the beginning of the top, maybe about a 120 kHz component, that's the lag of the base current through whatever components and stray inductance. Then the top roses at a slower rate, that's when the collector current is ramping in the HOT.

Without linearity problems, it's probably turning on good enough. A good piece of the on time of the HOT is during trace. The major problem I have found is the turnoff time. Apparently if enough forward bias is applied, a pretty good negative spike is developed for turnoff of the HOT. If you can scope the HOT collector, you will see this as a rounding of the end of the pulse. When that top of about a 70 Khz sine wave hits the baseline, you want a sharp corner on it. If that part of the waveform is rounded, the HOT will fail. (transistor)

The only effect this has on the raster, if you can underscan it you can see a slight compression at the left side. Also depending on the exact design of the H sweep circuit, you might not even see that, and even if you had spikes between the pulses, the pincushion circuit might isolate them enough so you don't see it in the raster.

Horizontal Deflection Circuit from Small TVs and Monitors

(From: Carlos Marques (c_finos@hotmail.com).)

This is another common horizontal deflection system, used mainly in small TVs and monitors. This method of horizontal deflection has a high value decoupling non-polar capacitor (4.7 uF typically) across the HOT in series with the yoke. The collector of the HOT is also connected to the FBT, at a tap which joins two windings. One of the windings connects to the positive supply, and the other connects to a diode which is connected to ground. Sometimes this diode has a small capacitor in parallel with it. I have seen this configuration many times, and I don't understand it very well, mainly the flyback process.

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Notes on the Troubleshooting and Repair of Television Sets

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

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DISCLAIMER

Working inside a CRT-based television set, or computer or video monitor can be lethal from line-connected and high voltage power supplies as well as CRT implosion. Read and follow ALL of the safety guidelines found in Safety Guidelines for High Voltage and/or Line Powered Equipment and the section: SAFETY, below. If in doubt about your abilities or experience, leave repair and internal adjustments to a professional.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Introduction

Television at the crossroads

Television in substantially its present form has been with us for nearly 50 years. It is a tribute to the National Television Standards Committee (NTSC) that the color television standards agreed upon in the early 1950s have performed remarkably well making quite efficient use of valuable radio spectrum space and the psychovisual characteristics of the human eye-brain system. However, HDTV (High Definition TV) will supplant and ultimately replace the current standards. We will all come to expect its superior resolution, freedom from noise and ghosting, and pure CD sound. Yet, the perceived quality of TV broadcasts and cable will never likely be the major issue with most consumers. Content will continue to be the biggest problem.

It is likely that in roughly 15 years, HDTV - digitally processed and transmitted as 1s and 0s - will completely replace the current system. Acceptance in the marketplace is by no means assured but with the merging of TV and computers - with the Internet as a driving force - it would seem that the days of the stand-alone analog TV set are numbered.

Television receiver fundamentals

The basic color television receiver must perform the same functions today as 40 years ago. (Since B/W is a subset of the color standard, most references in this document will be for color except as noted). A studio video monitor includes all of the functions of a television receiver except the tuner and IF (which rarely fail except for bad connections or perhaps lightning strikes to the antenna or cable connection). Therefore most of the repair information in this document is applicable to both TVs and studio monitors. Modern computer monitors share many similarities with TVs but the multisync and high scan rate deflection circuitry and more sophisticated power supplies complicates their servicing.

As of this writing, the majority of TVs are still based on the Cathode Ray Tube (CRT) as the display device. Tiny pocket sets, camcorder viewfinders, and the like have started using LCD (Liquid Crystal Display) panels but these are still inferior to the CRT for real time video. There has always been talk of 'the picture on the wall' display and these are now appearing as large screen plasma panel displys but their cost is still high compared to even projection TVs using CRTs. The reason is simple economics - it is really hard to beat the simplicity of the shadow mask CRT. Of course, prices will drop as the technology matures.

Projection - large screen - TVs, on the other hand, are able to take advantage of a novel development in integrated micromachining - the Texas Instruments Inc. Digital Micromirror Device (DMD), now called DLP for "Digital Light Processing". This is basically an integrated circuit with a tiltable micromirror for each pixel fabricated on top of a static memory - RAM - cell. This technology would permit nearly any size projection display to be produced and would therefore be applicable to HDTV. Since it is a reflective device, the light source can be as bright as needed. This technology is already appearing in commercial high performance projectors and is competing for use in totally digital movie theaters to replace the film projector and has begun appearing in high-end consumer projection TV sets - yet.

> (From: Kurk MacKay (kurk_mackay@telus.net).)
>
> "DMD TVs have been on the marketplace for about a year now. The DMD is more commonly referred to as DLP (Digital Light Processing) in the marketplace. From what I've heard Samsung has had a DLP TV on the consumer marketplace as of last year in the US and this year here in Canada. My boss was looking at buying one so we went around to view them. The picture quality looks to be between the LCD projection and Plasma. I believe the current Samsung uses a color wheel but they are working on a three color independent system.
>
> For more info or if you want to buy one, see DLP TV Showcase."

As noted, the plasma panel flat screen display has been around for several years in high-end TVs, typically in the 42 inch diagonal range. However, they are very expensive ($5,000 to $15,000 as of Winter, 2003), and their life expectancy may be limited due to the gradual degradation of the active pixel cells - which occurs faster than for a CRT. The physical resolution is also still low enough that visible discrete pixels may be objectionable to some viewers. However, there is little doubt that this or a similar technology will eventually replace the direct view CRT and 3-tube projection TVs in the mid to large screen sizes in the not too distant future.

The remainder of this document concentrates on CRT based analog TVs since these still dominate the market and realistically, these are the only type where there is a good chance of repair without access to specialized test equipment and parts. I wouldn't recommend any sort of attempt at repair of flat screen TVs or monitors - no matter what the size - beyond checking for bad connections, dead power supplies, or other obvious problems. The chance of success is vanishingly small and it's very likely that even with great care, damage could occur to the panels or circuitry.

TV repair

Unlike VCRs or CD players where any disasters are likely to only affect your pocketbook, TVs can be dangerous. Read, understand, and follow the set of safety guidelines provided later in this section whenever working on TVs, monitors, or other similar high voltage equipment.

If you do go inside, beware: line voltage (on large caps) and high voltage (on CRT) for long after the plug is pulled. There is the added danger of CRT implosion for carelessly dropped tools and often sharp sheetmetal shields which can injure if you should have a reflex reaction upon touching something you should not touch. In inside of a TV or monitor is no place for the careless or naive.

Having said that, a basic knowledge of how a TV set works and what can go wrong can be of great value even if you do not attempt the repair yourself. It will enable you to intelligently deal with the service technician. You will be more likely to be able to recognize if you are being taken for a ride by a dishonest or just plain incompetent repair center. For example, a faulty picture tube CANNOT be the cause of a color television only displaying shows in black-and-white. The majority of consumers probably do not know even this simple fact. Such a problem is usually due to a bad capacitor or other 10 cent part.

This document will provide you with the knowledge to deal with a large percentage of the problems you are likely to encounter with your TVs. It will enable you to diagnose problems and in many cases, correct them as well. With minor exceptions, specific manufacturers and models will not be covered as there are so many variations that such a treatment would require a huge and very detailed text. Rather, the most common problems will be addressed and enough basic principles of operation will be provided to enable you to narrow the problem down and likely determine a course of action for repair. In many cases, you will be able to do what is required for a fraction of the cost that would be charged by a repair center.

Should you still not be able to find a solution, you will have learned a great deal and be able to ask appropriate questions and supply relevant information if you decide to post to sci.electronics.repair. It will also be easier to do further research using a repair text such as the ones listed at the end of this document. In any case, you will have the satisfaction of knowing you did as much as you could before taking it in for professional repair. With your new-found knowledge, you will have the upper hand and will not easily be snowed by a dishonest or incompetent technician.

Repair or replace

If you need to send or take the TV to a service center, the repair could easily exceed half the cost of a new TV. Service centers may charge up to $50 or more for providing an initial estimate of repair costs but this will usually be credited toward the total cost of the repair (of course, they may just jack this up to compensate for their bench time).

TV prices have been dropping almost as fast as PC prices. Therefore, paying such prices for repair just may not make sense. Except for picture tube problems, most TV faults can be corrected without expensive parts, however. Keeping a 5 year old TV alive may be well worthwhile as basic TV performance and important features have not changed in a long time.

If you can do the repairs yourself, the equation changes dramatically as your parts costs will be 1/2 to 1/4 of what a professional will charge and of course your time is free. The educational aspects may also be appealing. You will learn a lot in the process. Thus, it may make sense to repair that old clunker for your game room or beach house. (I would suggest the kid's room but most TV watching just rots the brain anyhow so a broken TV may be more worthwhile educationally than one that works.)

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TV Receivers 101

Subsystems of a television set

A TV set includes the following functional blocks:

1. Low voltage power supply (some may also be part of (2).) Most of the lower voltages used in the TV may be derived from the horizontal deflection circuits. Sometimes, there is a separate switching power supply but this would be the exception. Rectifier/filter capacitor/regulator from AC line provides the B+ to the switching power supply or horizontal deflection system. Degauss operates off of the line whenever power is turned on (after having been off for a few minutes) to demagnetize the CRT.

2. Horizontal deflection. These circuits provide the waveforms needed to sweep the electron beam in the CRT across and back some 15,734 times per second (for NTSC). The horizontal sync pulse from the sync separator locks the horizontal deflection to the video signal.

3. Vertical deflection. These circuits provide the waveforms needed to sweep the electron beam in the CRT from top to bottom and back 60 times per second (for NTSC). The vertical sync pulse from the sync separator locks the vertical deflection to the video signal.

4. CRT high voltage (also part of (2).) A modern color CRT requires up to 30 kV for a crisp bright picture. Rather than having a totally separate power supply, nearly every TV on the planet derives the HV (as well as many other voltages) from the horizontal deflection using a special transformer called a 'flyback' or 'Line OutPut Transformer (LOPT) for those of you on the other side of the lake.

5. Tuner, IF, AGC, video and audio demodulators. Input is the antenna or cable signal and output are baseband video and audio signals. There is usually someplace inside the TV where line level video and audio are present but it may not be accessible from the outside of the cabinet unless you paid for the more expensive model with the A/V option. Very often, the tuner is a shielded metal box positioned on the bottom right (as viewed from the front) separate from the main circuit board. Sometimes it is on the main circuit board. The IF section may be in either place.

   On older or cheap TVs with a knob tuner, this is usually mounted to the front panel by itself. There are usually separate boxes for the VHF and UHF tuners.

6. Chroma demodulator. Input is the baseband video signal. Outputs are the individual signals for the red, green, and blue video to the CRT.

7. Video drivers (RGB). These are almost always located on a little circuit board plugged directly onto the neck of the CRT. They boost the output of the chroma demodulator to the hundred volts or so needed to drive the cathodes of the CRT.

8. Sync separator. Input is baseband video. Output is horizontal and vertical sync pulses to control the deflection circuits.

9. Audio amplifier/output. The line level audio is amplified to drive a set of speakers. If this is a stereo TV, then these circuits must also perform the stereo demultiplexing.

10. System control. Most modern TVs actually use a microcontroller - a fixed program microcomputer to perform all user interface and control functions from the front panel and remote control. These are becoming increasingly sophisticated. However, they do not fail often. Older TVs use a bunch of knobs and switches and these are prone to wear and dirt.

Most problems occur in the horizontal deflection and power supply sections. These run at relatively high power levels and some components run hot. The high voltage section is prone to breakdown and arcing as a result of hairline cracks, humidity, dirt, etc.

The tuner components are usually quite reliable unless the antenna experiences a lightning strike. However, it seems that even after 20+ years of solid state TVs, manufacturers still cannot reliably solder the tuner connectors and shields so that bad solder connections in these areas are common even in new sets.

Why projection TVs are not just normal TVs in big boxes

In order to achieve the necessary brightness with a large display format, three separate monochrome CRTs are used with optics to combine the three images properly at the screen. This creates an entire set of additional problems in design.

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The average projection TV has about twice as many parts as its direct-view counterpart. Some of the extra parts are essential for projection because CRT projection tubes require dynamic convergence. The other extra parts have to do with the fact that a more expensive TV also should have some extra features, like Dolby ProLogic sound, a satellite tuner and such.

Generally, the electronics are based on a standard chassis that is also used for direct-view CRT television. Even the deflection circuits require minor adaptations at most. The high-voltage circuit is different because the EHT, focus and G2 voltages must be distributed over 3 CRTs. So this requires a special high-voltage part, which also includes an EHT capacitor and bleeder.

There will be 3 CRT panels with video amplifiers. Because of the extremely high brightness, projection tubes will burn the phosphor screen immediately in fault conditions so a protection circuit is essential.

And last but certainly not least, there is the dynamic convergence panel. The heart is a waveform generator IC, often of a Japanese brand but nowadays there's also a digital variant by Philips. The old-fashioned way requires many many potentiometers to program the waveforms. Then there's 5 or 6 convergence amplifiers and a corresponding extra power supply. And usually this is where the single deflection circuits are distributed to the 3 CRTs. At the same time the deflection currents are sensed for the protection circuits.

Designing a PTV from a DVTV requires several man-years of work. In the factory, a special corner is devoted to the assembly. There you'll find specially educated people and the speed of the assembly line is a lot lower than usual. It requires many more adjustments, e.g. 3 optical and 3 electrical focus adjustments and then convergence.

For more information on TV technology

The books listed in the section: Suggested references include additional information on the theory and implementation of the technology of television standards and TV receivers.

Philips/Magnavox used to have a very nice on-line introduction to a variety of consumer electronics technologies. Although their site has disappeared - and even people who work for them have no clue - I have now recovered several of the articles including those on TVs, VCRs, camcorders, satellite reception, and connections. See the Introductory Consumer Electronics Technology Series.

Also see:

- NTSC Television Tutorials by Williamson Labs has many diagrams with a bit of text on their site. It looks like they are really trying to sell stuff including a CDROM but the graphics are worth checking out.

On-line tech-tips databases

A number of organizations have compiled databases covering thousands of common problems with VCRs, TVs, computer monitors, and other electronic equipment. Most charge for their information but a few, accessible via the Internet, are either free or have a very minimal monthly or per-case fee. In other cases, a limited but still useful subset of the for-fee database is freely available.

A tech-tips database is a collection of problems and solutions accumulated by the organization providing the information or other sources based on actual repair experiences and case histories. Since the identical failures often occur at some point in a large percentage of a given model or product line, checking out a tech-tips database may quickly identify your problem and solution.

In that case, you can greatly simplify your troubleshooting or at least confirm a diagnosis before ordering parts. My only reservation with respect to tech-tips databases in general - this has nothing to do with any one in particular - is that symptoms can sometimes be deceiving and a solution that works in one instance may not apply to your specific problem. Therefore, an understanding of the hows and whys of the equipment along with some good old fashioned testing is highly desirable to minimize the risk of replacing parts that turn out not to be bad.

The other disadvantage - at least from one point of view - is that you do not learn much by just following a procedure developed by others. There is no explanation of how the original diagnosis was determined or what may have caused the failure in the first place. Nor is there likely to be any list of other components that may have been affected by overstress and may fail in the future. Replacing Q701 and C725 may get your equipment going again but this will not help you to repair a different model in the future.

Please see the document: On-Line Tech-Tips Databases for the most up to date compilation of these resources for TVs, VCRs, computer monitors, and other consumer electronic equipment.

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CRT Basics

Note: Most of the information on TV and monitor CRT construction, operation, interference and other problems. has been moved to the document: TV and Monitor CRT (Picture Tube) Information. The following is just a brief introduction with instructions on degaussing.

Color CRTs - shadow masks and aperture grills

All color CRTs utilize a shadow mask or aperture grill a fraction of an inch (1/2" typical) behind the phosphor screen to direct the electron beams for the red, green, and blue video signals to the proper phosphor dots. Since the electron beams for the R, G, and B phosphors originate from slightly different positions (individual electron guns for each) and thus arrive at slightly different angles, only the proper phosphors are excited when the purity is properly adjusted and the necessary magnetic field free region is maintained inside the CRT. Note that purity determines that the correct video signal excites the proper color while convergence determines the geometric alignment of the 3 colors. Both are affected by magnetic fields. Bad purity results in mottled or incorrect colors. Bad convergence results in color fringing at edges of characters or graphics.

The shadow mask consists of a thin steel or InVar (a ferrous alloy) with a fine array of holes - one for each trio of phosphor dots - positioned about 1/2 inch behind the surface of the phosphor screen. With most CRTs, the phosphors are arranged in triangular formations called triads with each of the color dots at the apex of the triangle. With many TVs and some monitors, they are arranged as vertical slots with the phosphors for the 3 colors next to one another.

An aperture grille, used exclusively in Sony Trinitrons (and now their clones as well), replaces the shadow mask with an array of finely tensioned vertical wires. Along with other characteristics of the aperture grille approach, this permits a somewhat higher possible brightness to be achieved and is more immune to other problems like line induced moire and purity changes due to local heating causing distortion of the shadow mask.

However, there are some disadvantages of the aperture grille design:

- weight - a heavy support structure must be provided for the tensioned wires (like a piano frame).

- price (proportional to weight).

- always a cylindrical screen (this may be considered an advantage depending on your preference.

- visible stabilizing wires which may be objectionable or unacceptable for certain applications.

Apparently, there is no known way around the need to keep the fine wires from vibrating or changing position due to mechanical shock in high resolution tubes and thus all Trinitron monitors require 1, 2, or 3 stabilizing wires (depending on tube size) across the screen which can be see as very fine lines on bright images. Some people find these wires to be objectionable and for some critical applications, they may be unacceptable (e.g., medical diagnosis).

Degaussing (demagnetizing) a CRT

Degaussing may be required if there are color purity problems with the display. On rare occasions, there may be geometric distortion caused by magnetic fields as well without color problems. The CRT can get magnetized:

- if the TV or monitor is moved or even just rotated.

- if there has been a lightning strike nearby. A friend of mine had a lightning strike near his house which produced all of the effects of the EMP from a nuclear bomb.

- If a permanent magnet was brought near the screen (e.g., kid's magnet or megawatt stereo speakers).

- If some piece of electrical or electronic equipment with unshielded magnetic fields is in the vicinity of the TV or monitor.

Degaussing should be the first thing attempted whenever color purity problems are detected. As noted below, first try the internal degauss circuits of the TV or monitor by power cycling a few times (on for a minute, off for at least 20 minutes, on for a minute, etc.) If this does not help or does not completely cure the problem, then you can try manually degaussing.

Note: Some monitors have a degauss button, and monitors and TVs that are microprocessor controlled may degauss automatically upon power-on (but may require pulling the plug to do a hard reset) regardless of the amount of off time. However, repeated use of these 'features' in rapid succession may result in overheating of the degauss coil or other components. The 20 minutes off/1 minute on precedure is guaranteed to be safe. (Some others may degauss upon power-on as long as the previous degauss was not done within some predetermined amount of time - they keep track with an internal timer.)

Commercial CRT Degaussers are available from parts distributors like MCM Electronics and consist of a hundred or so turns of magnet wire in a 6-12 inch coil. They include a line cord and momentary switch. You flip on the switch, and bring the coil to within several inches of the screen face. Then you slowly draw the center of the coil toward one edge of the screen and trace the perimeter of the screen face. Then return to the original position of the coil being flat against the center of the screen. Next, slowly decrease the field to zero by backing straight up across the room as you hold the coil. When you are farther than 5 feet away you can release the line switch.

The key word here is ** slow **. Go too fast and you will freeze the instantaneous intensity of the 50/60 Hz AC magnetic field variation into the ferrous components of the CRT and may make the problem worse.

WARNING: Don't attempt to degauss inside or in the back of the set (near the CRT neck. This can demagnetize the relatively weak purity and convergence magnets which may turn a simple repair into a feature length extravaganza!

It looks really cool to do this while the CRT is powered. The kids will love the color effects (but then lock your degaussing coil safely away so they don't try it on every TV and monitor in the house!).

Bulk tape erasers, tape head degaussers, open frame transformers, and the "butt-end" of a weller soldering gun can be used as CRT demagnetizers but it just takes a little longer. (Be careful not to scratch the screen face with anything sharp. For the Weller, the tip needs to be in place to get enough magnetic field.) It is imperative to have the CRT running when using these whimpier approaches, so that you can see where there are still impurities. Never release the power switch until you're 4 or 5 feet away from the screen or you'll have to start over.

I've never known of anything being damaged by excess manual degaussing as long as you don't attempt to degauss *inside* or the back of the set - it is possible to demagnetize geometry correction, purity, and static converence magnets in the process! However, I would recommend keeping really powerful bulk tape erasers-turned-degaussers a couple of inches from the CRT.

If an AC degaussing coil or substitute is unavailable, I have even done degaussed with a permanent magnet but this is not recommended since it is more likely to make the problem worse than better. However, if the display is unusable as is, then using a small magnet can do no harm. (Don't use a 20 pound speaker or magnetron magnet as you may rip the shadow mask right out of the CRT - well at least distort it beyond repair. What I have in mind is something about as powerful as a refrigerator magnet.)

Keep degaussing fields away from magnetic media. It is a good idea to avoid degaussing in a room with floppies or back-up tapes. When removing media from a room remember to check desk drawers and manuals for stray floppies, too.

It is unlikely that you could actually affect magnetic media but better safe than sorry. Of the devices mentioned above, only a bulk eraser or strong permanent magnet are likely to have any effect - and then only when at extremely close range (direct contact with media container).

All color CRTs include a built-in degaussing coil wrapped around the perimeter of the CRT face. These are activated each time the CRT is powered up cold by a 3 terminal thermister device or other control circuitry. This is why it is often suggested that color purity problems may go away "in a few days". It isn't a matter of time; it's the number of cold power ups that causes it. It takes about 15 minutes of the power being off for each cool down cycle. These built-in coils with thermal control are never as effective as external coils.

Note that while the monochrome CRTs used in B/W and projection TVs and mono monitors don't have anything inside to get magnetized, the chassis or other cabinet parts of the equipment may still need degaussing. While this isn't likely from normal use or even after being moved or reoriented, a powerful magnet (like that from a large speaker) could leave iron, steel, or other ferrous parts with enough residual magnetism to cause a noticeable problem.

See the document: TV and Monitor CRT (Picture Tube) Information for some additional discussion of degaussing tools, techniques, treatments for severe magnetization from lightning strikes, and cautions.

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TV Placement And Preventive Maintenance

General TV placement considerations

Proper care of a TV does not require much. Following the recommendations below will assure long life and minimize repairs:

- Subdued lighting is preferred for best viewing conditions but I will not attempt to tell you how to arrange your room!

- Locate the TV away from extremes of hot and cold. Avoid damp or dusty locations if possible. (Right you say, keep dreaming!)

- Allow adequate ventilation - TVs use more power than any of your other A/V components. Heat buildup takes its toll on electronic components. Leave at least 3 inches on top and sides for air circulation if the entertainment center does not have a wide open back panel. Do not pile other components like VCRs on top of the TV if possible (seebelow).

- Do not put anything on top of the TV that might block the ventilation grill in the rear or top of the cover. This is the major avenue for the convection needed to cool internal components.

- If possible, locate the VCR away from the TV. Some VCRs are particularly sensitive to interference from the TV's circuitry and while this won't usually damage anything, it may make for less than optimal performance due to RF interference. The reverse is sometimes true as well.

  In addition, modern VCRs are NOT built like the Brooklyn Bridge! The weight of a TV or stereo components could affect the VCR mechanically, messing up tape path alignment or worse.

- If possible, locate your computer monitor away from the TV. Interaction of the electromagnetic fields of the deflection systems may result in one or both displays jiggling, wiggling, or vibrating.

- Locate loudspeakers and other sources of magnetic fields at least a couple of feet from the TV. This will minimize the possibility of color purity or geometry problems.

- Make sure all input-output video and audio connections are tight and secure to minimize intermittent or noisy pictures and sound. Use proper high quality cable only long enough to make connections conveniently.

- Finally, store video cassettes well away from all electronic equipment including and especially loudspeakers. Heat and magnetic fields will rapidly turn your priceless video collection into so much trash. The operation of the TV depends on magnetic fields for beam deflection. Enough said.

Preventive maintenance

Preventive maintenance for a TV is pretty simple - just keep the case clean and free of obstructions. Clean the screen with a soft cloth just dampened with water and at most, mild detergent. DO NOT use anything so wet that liquid may seep inside of the set around the edge of the picture tube - you could end up with a very expensive repair bill when the liquid shorts out the main circuit board lurking just below. If the set has a protective flat glass faceplate, there is usually an easy way (on newer sets with this type of protection) of removing it to get at the inner face of the CRT. Clean both the CRT and the protective glass with a soft damp cloth and dry thoroughly. If you have not cleaned the screen for quite a while, you will be amazed at the amount of black grime that collects due to the static buildup from the high voltage CRT supply.

In really dusty situations, periodically vacuuming inside the case and the use of contact cleaner for the controls might be a good idea but realistically, you will not do this so don't worry about it.

Warning about using a TV as a computer or video game display

> "I remember a while back (about 10 years) most home computers used to hook up to televisions. I seem to

> remember them having some effect on the TV though. I think they made the TV go blurry after a while. I was just wondering what these computers used to do to the televisions to mess them up like that. I thought a TV signal was a TV signal."

The problem was screen burn. Since computers of that era were mostly text and video games tended to use fixed patterns for scenery, patterns tended to be burned into the phosphor such that they were noticeably darker and less sensitive in those areas. This was exacerbated by the tendency to run those devices at very high brightness levels.

Modern computers and video games should not be nearly as much of a risk since the displays are so much more varied and dynamic. Nevertheless, setting the brightness at a moderate level would be prudent.

However, projection sets with their much higher intensity CRTs may still be susceptible to screen burn and the manufacturer will likely NOT cover the cost of repairs. There is probably a disclaimer to this effect in the warranty.

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TV Troubleshooting

SAFETY

TVs and computer or video monitors are among the more dangerous of consumer electronic equipment when it comes to servicing. (Microwave ovens are probably the most hazardous due to high voltage at high power.)

There are two areas which have particularly nasty electrical dangers: the non-isolated line power supply and the CRT high voltage.

Major parts of nearly all modern TVs and many computer monitors are directly connected to the AC line - there is no power transformer to provide the essential barrier for safety and to minimize the risk of equipment damage. In the majority of designs, the live parts of the TV or monitor are limited to the AC input and line filter, degauss circuit, bridge rectifier and main filter capacitor(s), low voltage (B+) regulator (if any), horizontal output transistor and primary side of the flyback (LOPT) transformer, and parts of the startup circuit and standby power supply. The flyback generates most of the other voltages used in the unit and provides an isolation barrier so that the signal circuits are not line connected and safer.

Since a bridge rectifier is generally used in the power supply, both directions of the polarized plug result in dangerous conditions and an isolation transformer really should be used - to protect you, your test equipment, and the TV, from serious damage. Some TVs do not have any isolation barrier whatsoever - the entire chassis is live. These are particularly nasty.

The high voltage to the CRT, while 200 times greater than the line input, is not nearly as dangerous for several reasons. First, it is present in a very limited area of the TV or monitor - from the output of the flyback to the CRT anode via the fat HV wire and suction cup connector. If you don't need to remove the mainboard or replace the flyback or CRT, then leave it alone and it should not bite. Furthermore, while the shock from the HV can be quite painful due to the capacitance of the CRT envelope, it is not nearly as likely to be lethal since the current available from the line connected power supply is much greater.

Safety guidelines

These guidelines are to protect you from potentially deadly electrical shock hazards as well as the equipment from accidental damage.

Note that the danger to you is not only in your body providing a conducting path, particularly through your heart. Any involuntary muscle contractions caused by a shock, while perhaps harmless in themselves, may cause collateral damage - there are many sharp edges inside this type of equipment as well as other electrically live parts you may contact accidentally.

The purpose of this set of guidelines is not to frighten you but rather to make you aware of the appropriate precautions. Repair of TVs, monitors, microwave ovens, and other consumer and industrial equipment can be both rewarding and economical. Just be sure that it is also safe!

- Don't work alone - in the event of an emergency another person's presence may be essential.

- Always keep one hand in your pocket when anywhere around a powered line-connected or high voltage system.

- Wear rubber bottom shoes or sneakers.

- Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current, or get caught in moving parts.

- Set up your work area away from possible grounds that you may accidentally contact.

- Know your equipment: TVs and monitors may use parts of the metal chassis as ground return yet the chassis may be electrically live with respect to the earth ground of the AC line. Microwave ovens use the chassis as ground return for the high voltage. In addition, do not assume that the chassis is a suitable ground for your test equipment!

- If circuit boards need to be removed from their mountings, put insulating material between the boards and anything they may short to. Hold them in place with string or electrical tape. Prop them up with insulation sticks - plastic or wood.

- If you need to probe, solder, or otherwise touch circuits with power off, discharge (across) large power supply filter capacitors with a 2 W or greater resistor of 100 to 500 ohms/V approximate value (e.g., for a 200 V capacitor, use a 20K to 100K ohm resistor). Monitor while discharging and verify that there is no residual charge with a suitable voltmeter. In a TV or monitor, if you are removing the high voltage connection to the CRT (to replace the flyback transformer for example) first discharge the CRT contact (under the suction cup at the end of the fat HV wire). Use a 1M to 10M ohm 5 W or greater wattage (for its voltage holdoff capability, not power dissipation) resistor on the end of an insulating stick or the probe of a high voltage meter. Discharge to the metal frame which is connected to the outside of the CRT.

- For TVs and monitors in particular, there is the additional danger of CRT implosion - take care not to bang the CRT envelope with your tools. An implosion will scatter shards of glass at high velocity in every direction. There are several tons of force attempting to crush the typical CRT. While implosion is not really likely even with modest abuse, why take chances? However, the CRT neck is relatively thin and fragile and breaking it would be very embarrassing and costly. Always wear eye protection when working around the back side of a CRT.

- Connect/disconnect any test leads with the equipment unpowered and unplugged. Use clip leads or solder temporary wires to reach cramped locations or difficult to access locations.

- If you must probe live, put electrical tape over all but the last 1/16" of the test probes to avoid the possibility of an accidental short which could cause damage to various components. Clip the reference end of the meter or scope to the appropriate ground return so that you need to only probe with one hand.

- Perform as many tests as possible with power off and the equipment unplugged. For example, the semiconductors in the power supply section of a TV or monitor can be tested for short circuits with an ohmmeter.

- Use an isolation transformer if there is any chance of contacting line connected circuits. A Variac(tm) is not an isolation transformer! The use of a GFCI (Ground Fault Circuit Interrupter) protected outlet is a good idea but will not protect you from shock from many points in a line connected TV or monitor, or the high voltage side of a microwave oven, for example. (Note however, that, a GFCI may nuisanse trip at power-on or at other random times due to leakage paths (like your scope probe ground) or the highly capacitive or inductive input characteristics of line powered equipment.) A fuse or circuit breaker is too slow and insensitive to provide any protection for you or in many cases, your equipment. However, these devices may save your scope probe ground wire should you accidentally connect it to a live chassis.

- Don't attempt repair work when you are tired. Not only will you be more careless, but your primary diagnostic tool - deductive reasoning - will not be operating at full capacity.

- Finally, never assume anything without checking it out for yourself! Don't take shortcuts!

Warning about disconnecting CRT neck board

Some manufacturers warn against powering a TV or monitor CRT without the CRT neck board connected. Apparently, without something - anything - to drain the charge resulting from the current flow due to residual gas ions inside the CRT, the shortest path may be through the glass neck of the tube to the yoke or from the pins outside the CRT to whatever is nearby. There aren't many ions in a modern CRT but I suppose a few here, a few there, and eventually they add up to enough to cause a major disaster at least on some CRTs.

This is probably not a problem on small CRTs but for large ones with high high voltages and high deflection angles where the glass of the neck is very thin to allow for maximum deflection sensitivity, the potential does exist for arcing through the glass to the yoke to occur, destroying the CRT.

There is really no way to know which models will self destruct but it should be possible to avoid such a disaster by providing a temporary return path to the DAG ground of the CRT (NOT SIGNAL GROUND!!) via the focus or G2 pins preferably through a high value high voltage rated resistor just in case one of these is shorted.

This probably applies mostly to large direct-view TVs since they use high deflection angle CRTs but it won't hurt to take appropriate precautions with video and computer monitors as well.

Troubleshooting tips

Many problems have simple solutions. Don't immediately assume that your problem is some combination of esoteric complex convoluted failures. For a TV, it may just be a bad connection or blown fuse. Remember that the problems with the most catastrophic impact on operation like a dead TV usually have the simplest solutions. The kind of problems we would like to avoid at all costs are the ones that are intermittent or difficult to reproduce: the occasional interference or a TV that refuses to play 'StarTrek Voyager'.

If you get stuck, sleep on it. Sometimes, just letting the problem bounce around in your head will lead to a different more successful approach or solution. Don't work when you are really tired - it is both dangerous (especially with respect to TVs) and mostly non-productive (or possibly destructive).

Whenever working on precision equipment, make copious notes and diagrams. You will be eternally grateful when the time comes to reassemble the unit. Most connectors are keyed against incorrect insertion or interchange of cables, but not always. Apparently identical screws may be of differing lengths or have slightly different thread types. Little parts may fit in more than one place or orientation. Etc. Etc.

Pill bottles, film canisters, and plastic ice cube trays come in handy for sorting and storing screws and other small parts after disassembly. This is particularly true if you have repairs on multiple pieces of equipment under way simultaneously.

Select a work area which is wide open, well lighted, and where dropped parts can be located - not on a deep pile shag rug. The best location will also be relatively dust free and allow you to suspend your troubleshooting to eat or sleep or think without having to pile everything into a cardboard box for storage.

Another consideration is ESD - Electro-Static Discharge. Some components (like ICs) in a TV are vulnerable to ESD. There is no need to go overboard but taking reasonable precautions such as getting into the habit of touching a **safe** ground point first.

WARNING: even with an isolation transformer, a live chassis should **not** be considered a safe ground point. When the set is unplugged, the tuner shield or other signal ground points should be safe and effective.

A basic set of precision hand tools will be all you need to disassemble a TV and perform most adjustments. These do not need to be really expensive but poor quality tools are worse than useless and can cause damage. Needed tools include a selection of Philips and straight blade screwdrivers, socket drivers, needlenose pliers, wire cutters, tweezers, and dental picks. For adjustments, a miniature (1/16" blade) screwdriver with a non-metallic tip is desirable both to prevent the presence of metal from altering the electrical properties of the circuit and to minimize the possibility of shorting something from accidental contact with the circuitry. A set of plastic alignment tools will be useful for making adjustments to coils and RF transformers.

A low power (e.g., 25 W) fine tip soldering iron and fine rosin core solder will be needed if you should need to disconnect any soldered wires (on purpose or by accident) or replace soldered components. A higher power iron or small soldering gun will be needed for dealing with larger components.

CAUTION: You can easily turn a simple repair (e.g., bad solder connections) into an expensive mess if you use inappropriate soldering equipment and/or lack the soldering skills to go along with it. If in doubt, find someone else to do the soldering or at least practice, practice, practice, soldering and desoldering on a junk circuit board first! See the document: Troubleshooting and Repair of Consumer Electronic Equipment for additional info on soldering and rework techniques.

For thermal or warmup problems, a can of 'cold spray' or 'circuit chiller' (they are the same) and a heat gun or blow dryer come in handy to identify components whose characteristics may be drifting with temperature. Using the extension tube of the spray can or making a cardboard nozzle for the heat gun can provide very precise control of which components you are affecting.

For info on useful chemicals, adhesives, and lubricants, see "Repair Briefs, an Introduction" as well as other documents available at this site.

Program to aid in diagnosing TV set problems

I haven't actually tried this so no warranties. :)

(From: Joe Janecka a0010631@airmail.net).)

I cranked out a little program for diagnosing TV problems and posted it at:

- TV Diagnostics Page.

It's not the complete answer, but it can get you started.

Test equipment

Don't start with the electronic test equipment, start with some analytical thinking. Your powers of observation (and a little experience) will make a good start. Your built in senses and that stuff between your ears represents the most important test equipment you have.

However, some test equipment will be needed:

- Multimeter (DMM or VOM) - This is essential for checking of power supply voltages and voltages on the pins of ICs or other components - service literature like the Sams' Photofacts described elsewhere in this document include voltage measurements at nearly every circuit tie point for properly functioning equipment. The multimeter will also be used to check components like transistors, resistors, and capacitors for correct value and for shorts or opens. You do not need a fancy instrument. A basic DMM - as long as it is reliable - will suffice for most troubleshooting. If you want one that will last for many years, go with a Fluke. However, even the mid range DMMs from Radio Shack have proven to be reliable and of acceptable accuracy. For some kinds of measurements - to deduce trends for example - an analog VOM is preferred (though some DMMs have a bar graph scale which almost as good).

- Oscilloscope - While many problems can be dealt with using just a multimeter, a 'scope will be essential as you get more into advanced troubleshooting. Basic requirements are: dual trace, 10-20 MHz minimum vertical bandwidth, delayed sweep desirable but not essential. A good set of proper 10X/1X probes. Higher vertical bandwidth is desirable but most consumer electronics work can be done with a 10 MHz scope. A storage scope or digital scope might be desirable for certain tasks but is by no means essential for basic troubleshooting.

  I would recommend a good used Tektronix (Tek) or Hewlett Packard (HP) scope over a new scope of almost any other brand. You will usually get more scope for your money and these things last almost forever. Until recently, my 'good' scope was the militarized version (AN/USM-281A) of the HP180 lab scope. It has a dual channel 50 MHz vertical plugin and a delayed sweep horizontal plugin. I have seen these going for under $300 from surplus outfits. For a little more money, you can get a Tek 465 or 465B (newer version but similar specifications) 100 Mhz scope ($200 to $600, sometimes cheaper on eBay or elsewhere but there is more risk than buying from a reputable dealer). I have now acquired a Tek 465B and that's what I use mostly these days. The HP-180 is still fine but I couldn't pass up a really good deal. :) The Tek 465/B or other similar model will suffice for all but the most demanding (read: RF or high speed digital) repairs.

- A video signal source - both RF and baseband (RCA jacks). Unless you are troubleshooting tuner or video/audio input problems, either one will suffice. RF sources include a pair of rabbit ears or an outdoor antenna, a cable connection, or a VCR with a working RF modulator. This will be more convenient than an antenna connection and will permit you to control the program material. In fact, making some test tapes using a camcorder or video camera to record static test patterns will allow you full control of what is being displayed and for how long.

- Color bar/dot/crosshatch signal generator. This is a useful piece of equipment if you are doing a lot of TV or monitor repair and need to perform CRT convergence and chroma adjustments. However, there are alternatives that are almost as good: a VHS recording of these test patterns will work for TVs. A PC programmed to output a suitable set of test patterns will be fine for monitors (and TVs if you can set up the video card to produce an NTSC/PAL signal. This can be put through a VCR to generate the RF (Channel 3/4) input to your TV if it does not have direct video inputs (RCA jacks).

Incredibly Handy widgets

These are the little gadgets and homemade testers that are useful for many repair situations. Here are just a few of the most basic:

- Series light bulb for current limiting during the testing of TVs, monitors, switching power supplies, audio power amplifiers, etc. I built a dual outlet box with the outlets wired in series so that a lamp can be plugged into one outlet and the device under test into the other. For added versatility, add a regular outlet and 'kill' switch using a quad box instead. The use of a series load will prevent your expensive replacement part like a horizontal output transistor from blowing if there is still some fault in the circuit you have failed to locate.

- A Variac. It doesn't need to be large - a 2 A Variac mounted with a switch, outlet and fuse will suffice for most tasks. However, a 5 amp or larger Variac is desirable. If you will be troubleshooting 220 VAC equipment in the US, there are Variacs that will output 0-240 VAC from a 115 VAC line (just make sure you don't forget that this can easily fry your 115 VAC equipment.) By varying the line voltage, not only can you bring up a newly repaired TV gradually to make sure there are no problems but you can also evaluate behavior at low and high line voltage. This can greatly aid in troubleshooting power supply problems. Warning: a Variac is not an isolation transformer and does not help with respect to safety. You need an isolation transformer as well.

- Isolation transformer. This is very important for safely working on live chassis equipment. Since all modern TVs use a line connected power supply, it is essential. You can build one from a pair of similar power transformers back-to-back (with their highest rated secondaries connected together. I built mine from a couple of similar old tube type TV power transformers mounted on a board with an outlet box including a fuse. Their high voltage windings were connected together. The unused low voltage windings can be put in series with the primary or output windings to adjust voltage. Alternatively, commercial line isolation transformers suitable for TV troubleshooting are available for less than $100 - well worth every penny.

- Variable isolation transformer. You don't need to buy a fancy combination unit. A Variac can be followed by a normal isolation transformer. (The opposite order also works. There may be some subtle differences in load capacity.).

CAUTION: Keep any large transformer of this type well away from your monitor or TV. The magnetic field it produces may cause the picture to wiggle or the colors to become messed up - and you to think there is an additional problem!

- Degaussing coil. Make or buy. The internal degaussing coil salvaged from a defunct TV doubled over to half it original diameter to increase its strength in series with a 200 W light bulb for current limiting will work just fine. Or, buy one from a place like MCM Electronics - about $15 for one suitable for all but the largest TVs. Also, see the section: Degaussing (demagnetizing) a CRT.

Safe discharging of capacitors in TVs and video monitors

It is essential - for your safety and to prevent damage to the device under test as well as your test equipment - that large or high voltage capacitors be fully discharged before measurements are made, soldering is attempted, or the circuitry is touched in any way. Some of the large filter capacitors commonly found in line operated equipment store a potentially lethal charge.

This doesn't mean that every one of the 250 capacitors in your TV need to be discharged every time you power off and want to make a measurement. However, the large main filter capacitors and other capacitors in the power supplies should be checked and discharged if any significant voltage is found after powering off (or before any testing - the CRT capacitance in a TV or video monitor, for example, can retain a dangerous or at least painful charge for days or longer!)

The technique I recommend is to use a high wattage resistor of about 5 to 50 ohms/V of the working voltage of the capacitor. This isn't critical - a bit more or less will be fine but will affect the time it takes to fully discharge the capacitor. The use of a current limiting resistor will prevent the arc-welding associated with screwdriver discharge but will have a short enough time constant so that the capacitor will drop to a low voltage in at most a few seconds (dependent of course on the RC time constant and its original voltage).

Then check with a voltmeter to be double sure. Better yet, monitor while discharging (not needed for the CRT - discharge is nearly instantaneous even with multi-M ohm resistor).

Obviously, make sure that you are well insulated!

- For the main capacitors in a TV or monitor power supply which might be 400 uF at 200 V, this would mean a 5K, 10W resistor. RC = 2 seconds. 5RC = 10 seconds. A lower wattage resistor can be used since the total energy in not that great. If you want to be more high tech, you can build the capacitor discharge circuit outlined in the companion document: Capacitor Testing, Safe Discharging, and Other Related Information. This provides a visible indication of remaining charge and polarity.

- For the CRT, use a several M ohm resistor good for 30 kV or more (or a string of lower value resistors to obtain this voltage rating). A 1/4 watt job will just arc over! Discharge to the chassis ground connected to the outside of the CRT - NOT SIGNAL GROUND ON THE MAIN BOARD as you may damage sensitive circuitry. The time constant is very short - a ms or so. However, repeat a few times to be sure, then use a shorting clip as these capacitors have a way of recovering a painful charge if left alone - there have been too many stories of painful experiences from charge developing for whatever reasons ready to bite when the HV lead is reconnected.

  Note that if you are touching the little board on the neck of the CRT, you may want to discharge the HV even if you are not disconnecting the fat red wire - the focus and screen (G2) voltages on that board are derived from the CRT HV.

  WARNING: Most common resistors - even 5 W jobs - are rated for only a few hundred volts and are not suitable for the 25 kV or more found in modern TVs and monitors. Alternatives to a long string of regular resistors are a high voltage probe or a known good focus/screen divider network. However, note that the discharge time constant with these may be a few seconds. Also see the section: Additional information on discharging CRTs.

  If you are not going to be removing the CRT anode connection, replacing the flyback, or going near the components on the little board on the neck of the CRT, I would just stay away from the fat red wire and what it is connected to including the focus and screen wires. Repeatedly shoving a screwdriver under the anode cap risks scratching the CRT envelope which is something you really do not want to do.

Again, always double check with a reliable voltmeter!

Reasons to use a resistor and not a screwdriver to discharge capacitors:

1. It will not destroy screwdrivers and capacitor terminals.

2. It will not damage the capacitor (due to the current pulse).

3. It will reduce your spouse's stress level in not having to hear those scary snaps and crackles.

Additional information on discharging CRTs

You may hear that it is only safe to discharge from the Ultor to the Dag. So, what the @#$% are they talking about? :-).

(From: Asimov (mike.ross@juxta.mnet.pubnix.ten).)

'Dag' is short for Aquadag. It is a type of paint made of a graphite pigment which is conductive. It is painted onto the inside and outside of picture tubes to form the 2 plates of a high voltage filter capacitor using the glass in between as dielectric. This capacitor is between .005uF and .01uF in value. This seems like very little capacity but it can store a substantial charge with 25,000 volts applied.

The outside "Dag" is always connected to the circuit chassis ground via a series of springs, clips, and wires around the picture tube. The high voltage or "Ultor" terminal must be discharged to chassis ground before working on the circuit especially with older TV's which didn't use a voltage divider to derive the focus potential or newer TV's with a defective open divider.

CAUTION: The Dag coating/springs/clips/etc. may not be the same as signal ground on the mainboard. Discharging to that instead could result in all sorts of expensive blown components. Discharging between the CRT anode cap and Dag should be low risk though it is best to use a HV probe or properly rated high value resistor.

For more details, see the document: [TV and Monitor CRT (Picture Tube) Information](#).

Removing the CRT HV connector

WARNING: Make sure the CRT has been discharged FIRST!

The rubber part is usually not glued down so it can be lifted rather easily. However, there may be some silicone type grease between the rubber boot (that looks like a suction cup) and the CRT glass to seal out dust.

A metal clip with a spring keeping it spread out attaches inside the button.

While there are a variety of types of clips actually used, pushing the connector to one side and/or squeezing it in the appropriate direction (peel up one side of the rubber to inspect) while gently lifting up should free it. Probably :-).

The clip (when removed) and CRT button look sort of like this:

```
                       ||======= HV Cable
                       /\
               Clip   |  |
          (Removed)  _|  |_
                                (No DAG coating in vicinity of HV connector)
        ____________.-    -.____________
  CRT   ____________|______|____________ Glass
                  Metal Button
```

Replacement is done in reverse order!

This isn't rocket science and excessive force should not be needed! :-)

Safe troubleshooting techniques for line powered TVs

TVs are particularly dangerous with respect to troubleshooting due to the fact that a substantial portion of their circuitry - sometimes all of it - is directly line connected. Even if your are working in a totally unrelated area like the sound circuits, awareness of the general design and location of the line-connected circuits can prove to be a life saver.

These designs may take several forms:

> Separate switchmode power supply (SMPS). In this case, only the primary side of the power supply is line connected. The remainder of the TV is usually isolated from the line by the high frequency transformer and

feedback device (transformer or optoisolator) of the switchmode power supply.

1. On-board SMPS - a portion of the circuitry on the mainboard is directly line-connected. In the best case, this is restricted to the area around the power cord connections and well marked on both top and bottom but don't count on it. Again, the rest of the TV may be isolated but avoiding hazardous areas is more difficult especially in cramped quarters.

2. Flyback derived power supply - a non-isolated linear (usually) power supply provides B+ to the horizontal deflection (and startup circuit). All other system power is derived from secondary windings on the flyback transformer. Similar comments to (2) above apply.

(1) to (3) may be found in TVs with A/V inputs and outputs.

4. Full hot chassis - a bridge rectifier/filter capacitor/linear regulator provides some voltages including B+. The flyback secondaries provide the remaining voltages. All share a common return which is at the intersection of two of the diodes of the bridge rectifier. There is no isolation.

   This type of design will usually not be found in a TV where there are external connections (other than the RF antenna/cable connector which can be capacitively isolated and you may actually get an AC reading or even sparks between the RF shield and an earth ground due to this capacitance.)

   WARNING: Never attempt to add A/V inputs or outputs to such a TV as the signals and shields will be electrically live.

   However, some TVs with A/V inputs/outputs actually had a live chassis and used an isolated means of coupling the signals from/to the external jacks:

   (From: Bill Coffel (bc@datamix.com).)

   The late 70's and early 80's Sony CVM 1250/1750/2150 (12"/17"/21") monitors (TV) have a HOT chassis. In fact they are kV-1201/1701/2101 TV sets in larger cabinet With a 3 prong plug!!!! The inputs and outputs are isolated via opto couplers and transformers on an additional circuit board (about 6" by 8" and powered by a small transformer) the connector panel is the only part grounded via the third prong.

   If someone thinks its not a live chassis they are in for quite a shock.

Always use an isolation transformer, whatever kind of design is used in the equipment you are troubleshooting. There are very few situations in which an isolation transformer will hurt. If you use it automatically, you will never have a chance to screw up.

Identify the appropriate ground point (return) for your multimeter or scope. These should be marked in the Sams' Photofact or service manual. There may be several such returns such as: non-isolated, signal, and CRT. Selecting the wrong one - even momentarily connecting to it - can ruin your whole day.

If you are not using an isolation transformer (a no-no), connecting your scope to the wrong ground point can result in (1) blown fuses and/or blown parts, and a very dangerous situation and (2) readings that don't make sense generally with distorted power line frequency signals of high amplitude.

- Use the non-isolated ground (A) (with your isolation transformer on the TV *only* for measurements of voltage on the line-connected power supply.

- Use the signal ground (B) for all measurements of tuner, IF, video, and sound circuits.

Whenever you get a reading or waveform that is grossly wrong, confirm that you are using the proper ground point! Note that failures of fusable resistors in the *return* of the HOT or power supply chopper or elsewhere can also result in points that should be near ground floating at unexpected voltage levels.

The general arrangement of components for a typical TV using a linear B+ supply with isolated auxiliary supplies for the signal circuits is shown below including the (linear) line-connected power supply, horizontal deflection output (drive, horizontal output transistor, flyback), and a typical Aux power supply output.

```
    Line fuse   Main bridge                            Part of flyback
          _      rectifier    +----------+  B+           transformer
    H o--_ --+------|>|---+---|          |-----------------+            Aux 1
             |            |   | Filter,  |                  ):: +--|>|--+--o
             |  +---|>|---+   | REG, etc.|                  )::(       _|_
  115 VAC    |  |             |          |                  )::(       ---
             +--|---|<|---+   +----------+             +---+ ::(        |
                |         |         |     H-drive      |        +-------+ B
 +-> N o---------+---|<|---+---------+   transformer  |/ C             __|__
 |                                A _|_       || +----|    Horizontal   -_-
 +-> G - Power line earth ground   ///        ||(     |\ E Output      Signal
        via building wiring         ^        ||(       |  Transistor  ground
                                    |        || +------+  (HOT)
                                    '               A _|_
                             Non-isolated return --> ///
                              (connected points)
```

For this power supply, what if?:

1. You connect your scope ground clip to the non-isolated ground (A) and you are *not* using an isolation transformer?

   Answer: you blow the line fuse and/or melt your scope probe ground lead. Other parts may be damaged as well. In effect, you have just shorted across the bottom diode of the bridge.

2. You attempt to monitor a video signal with your scope ground connected to the non-isolated ground (A)?

   Answer: you see only a highly distorted power line waveform of roughly 100 V p-p In effect, you are measuring across one of the diodes of the bridge rectifier, stray capacitance, etc.

The series light bulb trick

When powering up a TV (or any other modern electronic devices with expensive power semiconductors) that has had work done on any power circuits, it is desirable to minimize the chance of blowing your newly installed parts should there still be a fault. There are two ways of doing this: use of a Variac to bring up the AC line voltage gradually and the use of a series load to limit current to power semiconductors.

Actually using a series load - a light bulb is just a readily available cheap load - is better than a Variac (well both might be better still) since it will limit current to (hopefully) non-destructive levels.

What you want to do is limit current to the critical parts - usually the horizontal output transistor (HOT). Most of the time you will get away with putting it in series with the AC line. However, sometimes, putting a light bulb directly in the B+ circuit will be needed to provide adequate protection. In that location, it will limit the current to the HOT from the main filter capacitors of line connected power supplies. This may also be required with some switchmode power supplies as they can still supply bursts of full (or excessive) current even if there is a light bulb in series with the AC line.

Actually, an actual power resistor is probably better as its resistance is constant as opposed to a light bulb which will vary by 1:10 from cold to hot. The light bulb, however, provides a nice visual indication of the current drawn by the circuit under test. For example:

- Full brightness: short circuit or extremely heavy load - a fault probably is still present.

- Initially bright but then settles at reduced brightness: filter capacitors charge, then lower current to rest of circuit. This is what is expected when the equipment is operating normally. There could still be a problem with the power circuits but it will probably not result in an immediate catastrophic failure.

- Pulsating: power supply is trying to come up but shutting down due to overcurrent or overvoltage condition. This could be due to a continuing fault or the light bulb may be too small for the equipment.

Note: for a TV or monitor, it may be necessary (and desirable) to unplug the degauss coil as this represents a heavy initial load which may prevent the unit from starting up with the light bulb in the circuit.

The following are suggested starting wattages:

- 40 W bulb for VCR or laptop computer switching power supplies.
- 100 W bulb for small (i.e., B/W or 13 inch color) TVs.
- 150 to 200 W bulb for large color or projection TVs.

A 50/100/150 W (or similar) 3-way bulb in an appropriate socket comes in handy for this but mark the switch so that you know which setting is which!

Depending on the power rating of the equipment, these wattages may need to be increased. However, start low. If the bulb lights at full brightness, you know there is still a major fault. If it flickers or the TV (or other device) does not quite come fully up, then it should be safe to go to a larger bulb. Resist the temptation to immediately remove the series light bulb totally from the circuit at this point - I have been screwed by doing this. Try a larger one first. The behavior should improve. If it does not, there is still a fault present.

Note that some TVs and monitors simply will not power up at all with any kind of series load - at least not with one small enough (in terms of wattage) to provide any real protection. The microcontroller apparently senses the drop in voltage and shuts the unit down or continuously cycles power. Fortunately, these seem to be the exceptions.

Getting inside a TV

You will void the warranty - at least in principle. There are usually no warranty seals on a TV so unless you cause visible damage or mangle the screws, it is unlikely that this would be detected. You need to decide. A TV still under warranty should probably be returned for warranty service for any covered problems except those with the most obvious and easy solutions. Another advantage of using warranty service is that should your problem actually be covered by a design change, this will be performed free of charge. And, you cannot generally fix a problem which is due to poor design!

Getting into a TV is usually quite simple requiring the removal of anywhere from 4 to 16 Philips or 1/4" hex head screws - most around the rear edge of the cabinet or underneath, a couple perhaps in the middle. Disconnect the antenna and/or antenna or cable wiring first as it may stay with catch on the rear cover you are detaching. Reconnect whatever is needed for testing after the cover is removed.

As you pull the cover straight back (usually) and off, make sure that no other wires are still attached. Often, the main circuit board rests on the bottom of the cover in some slots. Go slow as this circuit board may try to come along with the back. Once the back is off, you may need to prop the circuit board up with a block of wood to prevent stress damage and contact with the work surface.

Most TVs can still be positioned stably on any of three sides (left, right, bottom) even without the rear cover. However, some require the cover for mechanical strength or to not easily fall over. Be careful- larger TVs, in particular, are quite heavy and bulky. Get someone to help and take precautions if yours is one of the unstable variety. If need be, the set can usually safely be positioned on the CRT face if it is supported by foam or a folded blanket.

Reassemble in reverse order. Getting the circuit board to slide smoothly into its slots may take a couple of attempts but otherwise there should be no surprises.

Specific considerations before poking around inside a TV or monitor

Both electrical and mechanical dangers lurk:

- Main filter capacitor(s). This is the most dangerous (not the HV as you would expect). Fortunately, these capacitors will normally discharge in a few minutes or less especially if the unit is basically working as the load will normally discharge the capacitors nearly fully as power is turned off. With TVs, the main filter capacitor is nearly always on the mainboard. Monitors are more likely to have a separate power supply module.

  However, you should check across this capacitor - usually only one and by far the largest in the set - with a voltmeter and discharge as suggested in the section: Safe discharging of capacitors in TVs and video monitors if it holds more than a few volts (or wait longer) before touching anything.

  Some of these are as large as 1,000 uF charged to 160 V - about 13 w-s or a similar amount of energy as that stored in an electronic flash. This is enough to be potentially lethal under the wrong circumstances.

- High Voltage capacitor formed by the envelope of the CRT. It is connected to the flyback transformer by the fat (usually red) wire at the suction cup (well, it looks like one anyhow) attached to the CRT. This capacitor can hold a charge for quite a while - weeks in the case of an old tube type TV!

  If you want to be doubly sure, discharge this also. However, unless you are going to be removing the HV connector/flyback, it should not bother you.

  The energy stored is about 1 w-s but if you touch it or come near to an exposed terminal, due to the high voltage, you will likely be handed *all* the energy and you *will* feel it. The danger is probably more in the collateral damage when you jump ripping flesh and smashing your head against the ceiling.

  Some people calibrate their jump based on voltage - about 1 inch/V. :-).

  There will be some HV on the back of the circuit board on the neck of the CRT but although you might receive a tingle but accidentally touching the focus or screen (G2) pins, it is not likely to be dangerous.

- CRT implosion risk. Don't hammer on it. However, it is more likely that you will break the neck off the tube since the neck is relatively weak. This will ruin your whole day and the TV or monitor but will likely not result in flying glass everywhere. Just, don't go out of your way to find out.

- Sharp sheet metal and so forth. This is not in itself dangerous but a reflex reaction can send your flesh into it with nasty consequences.

Dusting out the inside of a TV

The first thing you will notice when you remove the cover is how super dusty everything is. Complements to the maid. You never dreamed there was that much dust, dirt, and grime, in the entire house!

Use a soft brush (like a new paintbrush) and a vacuum cleaner to carefully remove the built up dust. Blowing off the dust will likely not hurt the TV unless it gets redeposited inside various controls or switches but will be bad for your lungs - and will spread it all over the room. Don't turn anything - many critical adjustments masquerade as screws that just beg to be tightened. Resist the impulse for being neat and tidy until you know exactly what you are doing. Be especially careful around the components on the neck of the CRT - picture tube - as some of these are easily shifted in position and control the most dreaded of adjustments - for color purity and convergence. In particular, there will be a series of adjustable ring magnets. It is a good idea to mark their position in any case with some white paint, 'white out', or a Magic Marker so that if they do get moved - or you move them deliberately, you will know where you started.

Troubleshooting a TV with the mainboard disconnected

There are times when it is desirable to remove the chassis or mainboard and work on it in a convenient location without having to worry about the equipment which will simulate the critical functions but this is rarely an option for the doit-yourselfer.

My approach is usually to do as much work as possible without removing the main board and not attempt to power it up when disconnected since there are too many unknowns. Professionals will plug the chassis into a piece of equipment which will simulate the critical functions.

Note that if you have a failure of the power supply - blown fuse, startup, etc., then it should be fine to disconnect the CRT since these problems are usually totally unrelated. Tests should be valid.

However, if you really want to do live testing with the main board removed, here are some considerations. There are usually several connections to the CRT and cabinet:

- Deflection yoke - since the horizontal coils are part of the horizontal flyback circuit, there could be problems running without a yoke. This could be anything from it appearing totally dead to an overheating or blown horizontal output transistor. There may be no problems. Vertical and any convergence coils may or may not be problems as well.

- CRT video Driver board - pulling this should not usually affect anything except possibly video output and bias voltages.

- CRT 2nd anode - without the CRT, there will be no capacitor to filter the high voltage and you would certaily want to insulate the HV connector **real** well. I do not know whether there are cases where damage to flyback could result from running in thie manner, however.

- Front panel controls - disconnecting these may result in inability to even turn the set on, erratic operation, and other unexpected behavior.

- Degauss - you just won't have this function when disconnected. But who cares - you are not going to be looking at the screen anyhow.

- Remote sensor - no remote control but I doubt that the floating signals will cause problems.

- Speakers - there will be no audio but this should not cause damage.

If you do disconnect everything, make sure to label any connectors whose location or orientation may be ambiguous. Most of the time, these will only fit one way but not always.

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TV Adjustments

These include both controls accessible to the user (and often not understood) as well as internal adjustments that may need to be touched up due to the aging of components or following a repair.

User picture adjustment

For general viewing, subdued lighting but not total darkness is probably best. However, for most dramatic impact, a darkened environment may be preferred. Make the following adjustments under the expected viewing conditions.

Tune to a strong channel or play a good quality tape.

Turn the brightness, contrast, and color controls all the way down. Center the tint control (NTSC, may not be present on PAL sets).

Increase the brightness until a raster is just visible in the darkest (shadow) areas of the picture and then back off until it **just** disappears.

Increase the contrast until the desired intensity of highlights is obtained.

Since brightness and contrast are not always independent, go back and forth until you get the best picture.

Initially adjust the color control for pastel shades rather than highly saturated color. Set the tint control for best flesh tones. Then, increase the color control to obtain the desired degree of color saturation.

Internal adjustments

All of the service adjustments are accomplished either using controls inside the set (though some may be accessible by holes in the rear of the cabinet). These are usually pots on the mainboard and CRT neck boards, or in newer TVs, mostly via a service menu accessed from the remote or by using a manufacturer specific computer interface.

A Web site with some information on the general objectives of video and color setup procedures for both direct view and projection TVs is Tru-line Video Technologies.

- Where actual pots are present, they may be labeled on the circuit boards or identified by a sticker on the TV's cover. Otherwise, the service manual or Sams' for the set will be required unless their function of the relevant pot is obvious.

- For service menus accessed via the remote control, service information is almost a necessity since adjustment procedures vary widely and it is all too easy to totally mess things up - even to the point of inflicting serious and expensive damage to the set.

For information on accessing the service menus if used on your model, see the section: Setup adjustments lost - TV service codes. However, even if the access procedure is known, get the service manual or Sams'!

- If a computer interface is required, you can most probably forget about attempting to adjust anything unless you find a friendly shop to provide the adapter and walk you through the procedure. Why would they want to do this? Because they know you there is a good chance that you will have to pay them to unscramble the mess you created!

Focus adjustment

On a decent TV, you should be able to make out the individual scanning lines. If they are fuzzy, especially in bright areas, then focus may need to be adjusted.

The focus pot is usually located on the flyback transformer or on an auxiliary panel nearby. Where there are two adjustment knobs on the flyback transformer, the top one is generally for focus and the bottom one is for G2.

The focus wire usually comes from the flyback or the general area or from a terminal on a voltage the multiplier module (if used). It is usually a wire by itself going to the little board on the neck of the CRT.

Let the set warm up for at least half an hour. Display a good quality signal. Turn the user color control all the way down and the brightness and contrast controls all the way up. This will be the worst case. Adjust the focus control for best overall sharpness - you may not be able to get it perfect everywhere - center as well as corners. If best focus is at one end of the focus pot's range and still not good enough, there may be a problem in the focus divider, focus pot, or some related component.

Adjustment of the internal SCREEN and color controls

The screen should be adjusted with a white pattern (snow from the tuner should do or turn the user COLOR control all the way down to get a black and white picture). Put the set in Service mode (horizontal line) if it has such a switch in the back or inside. If not, just use the raster in a darkened room. Adjust screen for a dim white line (raster). If the line is not white at its dimmest point, you will need to adjust the drive and cutoff controls for R, G, & B.

Alternatively, you can use the following procedure:

Turn R, G, and B screen (or background) controls down. Now turn color control fully counterclockwise -- off. Now turn up red screen until the screen just shows a red hue. Now turn red gun down until red tint just goes away. Now do the same with the green and blue screen controls. Now adjust the two DRIVE controls for the best black and white picture. That`s all there is to it. I don`t like to work with just a thin "SETUP" line. Cartoons seem to be the best thing to have on while doing the above procedure. You can also use just plain snow (no program) if you prefer. If you can obtain a good b@w pic. when you`re done, the tube is good and the set if most likely functioning properly. Be patient and go slow while watching the large mirror that you are using during this procedure. (LEE)

Optimal procedure for setting brightness/background and screen adjustments

For slight tweaks, the following is not necessary. However, if someone turned all the internal controls or if you are making significant changes that affect G2 (screen), then following the procedure below is desirable to achieve best performance and maximize life of the CRT.

The typical user controls - brightness and contrast can, of course, be set arbitrarily, depending on video content and ambient lighting conditions.

Set the user brightness and contrast controls in the middle for the following adjustments and let the set warm up for 20 minutes or so.

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

Now the screen control, that's another matter. It sets the voltage on the second grid of the electron guns, typically between +500 and +1000 V. You will want to use a well-isolated screwdriver for that if it is a naked potentiometer. In the old days there used to be 3 separate potentiometers for 3 G2s, now there is generally only one.

Its purpose is to set the cutoff voltage for the guns, i.e. the voltage between K and G1 at which the beam is just off. The higher you set the VG2, the higher VK - VG1 must be to cut off the beam.

If you set VG2 too low then your picture will be dark. You can compensate for that with the brightness control, which in effect will lower the VKs. A disadvantage is that you will not get optimum sharpness and peak brightness from your picture tube.

If you set VG2 too high then your picture will be bright. You can compensate for that with the brightness control, which in effect will raise the VKs. You might even get retrace lines which can usually not be made to disappear with the brightness control. Another disadvantage is that you will not get optimum LIFETIME from your picture tube. With a too high cutoff voltage the cathode (electron emitting surface) will wear out too soon.

You will need to see the picture tube specifications (or possibly the Sams' Photofact or service manual for the set --- sam) in order to find the correct setting for the cutoff voltage. This is measured as VK - VG1 (for each channel RGB) and is typically 130-160 V max. There will be spread between the 3 channels, typically the highest of the 3 measured values will be set against the upper limit.

The usual adjustment procedure is as follows:

- Use any low-level adjustments to set a black picture with all 3 cathode voltages at the specified level (e.g. 130 V) above the VG1 voltage (may be 0 V or 12 V or 20 V ?). (These are typically called RGB brightness, bias, or background level and are often on the little board on the neck of the CRT but not always --- sam).

- Adjust VG2 (screen) until one colour just starts too light up, turn it back down until the screen is just black again. (Occasionally, there are two G2 controls - one on the flyback and another on the CRT neck board or elsewhere. If so, they control are basically in series - leave the one on the flyback alone if the other one has enough range.)

- Now adjust 2 of the 3 low-level black controls until the other 2 colours just light up, and then back to black again.

- Select a white picture and use 2 low-level white (RGB drive or gain, also generally on the neck board --- sam) controls to set the proper colour temperature for white to your own taste.

- Check your black calibration again, may have to iterate a bit.

Color balance adjustment

Color balance needs adjustment if the highlights and/or shadows of a black and white picture (turn the color control all the way down) are not a perfectly neutral gray.

Note: Some TV designs (Zenith uses this in a few models) automatically balance CRT cathode drive by sensing emission from the red, green, and blue guns using a gray scale reference pulse outside the viewable picture. If this is the case with your set, there may be no user OR service adjustments :-(. A color balance problem in this case means either a failure of this circuitry or a CRT where the emission from the 3 cathodes is so unbalanced (usually due to one being much much weaker than the others) that compensation is not possible.

To adjust the color balance: Turn the color control all the way down so that you get what should be a B/W picture. Set the user brightness and contrast controls about mid-range. The tint control should not matter (if it does at this point, you have other chroma problems or an 'autocolor' switch is on limiting the range of some controls).

Adjust the sub-brightness controls (may be called color screen, background, or the like) so that the dark areas of the picture are just visible and neutral gray. Then, adjust the color gain controls until the brightest areas are neutral white but not so bright that there is 'color bleeding' in the highlights.

This should get you close. If something is still shifting after warmup and get some cold-spray or even a little blower and try to locate the component that is drifting. Most likely a transistor or capacitor.

More on 'Calibrating' TV color

If you don't know how to access the color and tint controls on your TV and are happy with green flesh tones and cartoon colors, you can skip this section. Most people can adjust their color and tint controls resulting in a reasonable hue and saturation. However, here are some ways of getting closer to perfection.

(From: Chris Johnson (wjohnson@palmnet.net).)

If you have access to a DVD player, get the 'Video Essentials' DVD and follow the directions.

If you have access to a LaserDisc player, get 'A Video Standard' and follow the directions.

But, here are a few quick pointers:

Back off the color control all the way on a program. Set the color balance for a true grey appearance without any bias toward red, green, or blue. (Or any other color.)

Max brightness should not be high enough that vertical lines (like the needle pulse on the test LD or DVD) don't bend.

On the test pattern with the multicolored bars, the large bars should have the following colors: white (actually grey, but fairly light), yellow, cyan, green, purple, red, blue.

The purpose of the narrow bars just below the large bars is to match up the tint balance. You do this with a blue filter, or killing the R and G guns. The narrow bars will be exactly the same intensity as the large bars above them, if the color and tint balance is correct.

Here's a quick trick if you're lucky enough to have a set with separate gun killer switches for R, G, and B guns: When properly set, the narrow bars will be the same intensity as the large bars above them, if you only turn one gun on at a time. First do red, then green, then blue. Go through the process once and you'll never forget what it looks like.

Last point: The pluge bar (in the lower right section of the color bar screen) should NOT be visible, being ten percent below black level. If you can see it, back off the brightness.

Remember:

- Brightness sets black level, it should ideally be as black as the screen itself, no more, no less.

- Contrast sets white level. Too bright and vertical lines start to bend.

  Using just these concepts, you can get REAL close to a proper alignment.

Most people set the color too high. News programs should NOT be as colorful as the movie 'Jingle All The Way'. (Which, by the way, is a real test of your TV's abilities.) Most people's faces should not be red.

You know you have it all set right when black clothing on people on TV has texture and depth to it, and also when purple and blue are two distinct colors. Some TV sets don't do that very well as shipped.

Horizontal position, size, and linearity adjustment

Horizontal position may be set via a switch or jumper, a pot, or (mostly in B/W TVs) a set of rings on the CRT neck.

Horizontal size should be set so that there is about 10-15 percent overscan left and right. This will allow ample margin for power line voltage fluctuations, component aging, and the reduction in raster size that may occur with some VCR special effects (fast play) modes.

Many sets no longer have any horizontal size adjustments and depend on accurate regulation of the voltage to the horizontal output stage to control horizontal size. There may be a B+ adjustment to perform first.

On those that do, the adjustment may either be done by setting the B+ voltage, by a pot, or a width coil in series with the horizontal deflection coils.

Modern sets do not generally have any linearity control but you may find this on older models. You will need to go back and forth between size and linearity as these adjustments are usually not independent.

Some of the newest sets control all these parameters via settings in non-volatile memory and use service menus accessed via the remote control for nearly all setup adjustments.

Vertical position, size, and linearity adjustment

Vertical position may be set via a switch or jumper, a pot, or (mostly in B/W TVs) a set of rings on the CRT neck.

Vertical size should be set so that there is about 10-15 percent overscan top and bottom. This will allow ample margin for power line voltage fluctuations, component aging, and the reduction in raster size that may occur with some VCR special effects (fast play) modes.

Some sets no longer have any vertical size adjustments and depend on the accurate regulation of the voltage to the vertical output stage to control vertical size.

On those that do, the adjustment is usually a pot in the vertical output circuitry. If your set has a linearity control, you will need to adjust this in conjunction with the size control as these are usually not independent.

Some of the newest sets control all these parameters via settings in non-volatile memory and use service menus accessed via the remote control for nearly all setup.

Pincushion adjustments

There may be two controls - amplitude and phase. Pincushion amplitude as its name implies, controls the size of the correction. Pincushion phase affects where on the sides it is applied. Don't expect perfection.

If the controls have no effect, there is probably a fault in the pincushion correction circuitry.

It is best to make these adjustments with a crosshatch or dot test pattern

Geometry adjustment

This refers to imperfections in the shape of the picture not handled by the pincushion and size adjustments. These types of defects include trapezoidal or keystone shaped raster and jogs or wiggles around the periphery of the raster. Unfortunately, one way these are handled at the factory is to glue little magnets to strategic locations on the CRT and/or rotate little magnets mounted on the yoke frame. Unless you really cannot live with the way it is (assuming there isn't something actually broken), leave these alone! You can end up with worse problems. In any case, carefully mark the position AND orientation of every magnet so that if this happens, you can get back to where you started. If the magnets are on little swivels, some experimenting with them one at a time may result in some improvement. Of course, it is best to obtain a service manual and follow its instructions.

Why is the convergence on my set bad near the edges

Very simple - nothing is quite perfect. Perfect convergence is not even necessarily possible in theory with the set of adjustments available on a typical TV. It is all a matter of compromises. Consider what you are trying to do: get three electron beams which originate from different electron guns to meet at a single point within a fraction of a mm everywhere on the screen. This while the beams are scanning at an effective writing rate of 20,000 mph across the face of a 27" CRT in a variable magnetic environment manufactured at a price you can afford without a second mortgage!

CRT purity and convergence problems

Purity assures that each of the beams for the 3 primary colors - red, green, and blue - strikes only the proper phosphor dots for that color. A totally red scene will appear pure red and so forth. Symptoms of poor purity are blotches of discoloration on the screen. Objects will change shades of color when the move from one part of the screen to another.

Convergence refers to the control of the instantaneous positions of the red, green, and blue spots as they scan across the face of the CRT so that they are as nearly coincident as possible. Symptoms of poor convergence are colored borders on solid objects or visible separate R, G, and B images of fine lines or images,

Note: It is probably best to face the set East-West (front-to-back) when performing any purity and convergence adjustments. Since you probably do not know what orientation will eventually be used, this is the best compromise as the earth's magnetic field will be aligned mostly across the CRT. This will minimize the possible rotation of the picture when the unit is moved to its final position but there may be a position shift. Neither of these is that significant so it probably doesn't really matter that much unless you are super fussy. Of course, if you know the final orientation of the TV in your entertainment center - and you don't expect to be redecorating, use that instead. Or, plan to do the final tilt and position adjustments after the set is in position - but this will probably require access to the inside!

First, make sure no sources of strong magnetic fields are in the vicinity of the TV - loudspeakers, refrigerator magnets, MRI scanners, etc. A nearby lightning strike or EMP from a nuclear explosion can also affect purity.

Cycle power a couple of times to degauss the CRT (1 minute on, 20 minutes off) - see the section: Degaussing (demagnetizing) a CRT. If the built in degaussing circuits have no effect, use an external manual degaussing coil.

Assuming this doesn't help, you will need to set the internal purity and/or convergence adjustments on the CRT. Modern CRTs usually use a combination of a series of magnetized moveable rings on the neck, and yoke position and orientation to set purity and convergence.

First, mark the positions of all adjustments - use white paint, 'White out', or a Magic Marker on the ring magnets on the neck of the CRT, the position and tilt of the deflection yoke, and any other controls that you may touch deliberately or by accident.

However, if your set is still of the type with a drawer or panel of knobs for these adjustments, don't even think about doing anything without a service manual and follow it to the letter unless the functions of all the knobs is clearly marked (some manufacturers actually do a pretty good job of this).

Note: some CRTs do not have any adjustable rings for purity (and static convergence). Either an internal structure in the neck of the CRT or an external 'permalloy' sleeve is permanently magnetized at the factory and there is not way of tweaking it in the field. However, it may be possible to use a normal set of magnet rings in addition to or in place of it to correct for purity or convergence problems due to loss of magnetism due to age or someone waving a 10 pound magnet near the CRT neck!

CRT purity adjustment

Purity on modern CRTs is usually set by a combination of a set of ring magnets just behind the deflection yoke on the neck of the CRT and the position of the yoke fore-aft. As always, mark the starting position of all the rings and make sure you are adjusting the correct set if rings!

Use the following purity adjustment procedure as a general guide only. Depending on the particular model TV, the following purity adjustment procedure may substitute green for red depending on the arrangement of the guns in the CRT. This description is based on the Sams' Photofact for the RCA CTC111C chassis which uses a slot-mask CRT. The procedures for dot-mask and Trinitron (aperture grille) CRTs will vary slightly. See you service manual!

Obtain a white raster (sometimes there is a test point that can be grounded to force this). Then, turn down the bias controls for blue and green so that you have a pure red raster. Let the set warm up for a minimum of 15 minutes.

Loosen the deflection yoke clamp and move the yoke as far back as it will go,

Adjust the purity magnets to center the red vertical raster on the screen.

Move the yoke forward until you have the best overall red purity.

Now, move the yoke forward until you have the best overall red purity. Tighten the clamp securely and reinstall the rubber wedges (if you set has these) to stabilize the yoke position. Reset the video adjustments you touched to get a red raster.

CRT convergence adjustment

In the good old days when TVs were TVs (and not just a picture tube with a little circuit board attached) there were literally drawers full of knobs for setting convergence. One could spend hours and still end up with a less than satisfactory picture. As the technology progressed, the number of electronic adjustments went down drastically so that today there are very few if any.

Unless you want a lot of frustration, I would recommend not messing with convergence. You could end up a lot worse. I have no idea what is used for convergence on your set but convergence adjustments are never quite independent of one another. You could find an adjustment that fixes the problem you think you have only to discover some other area of the screen is totally screwed. In addition, there are adjustments for geometry and purity and maybe others that you may accidentally move without even knowing it until you have buttoned up the set.

Warning: Accurately mark the original positions - sometimes you will change something that will not have an obvious effect but will be noticeable later on. So it is extremely important to be able to get back to where you started. If only red/green vertical lines are offset, then it is likely that only a single ring needs to be moved - and by just a hair. But, you may accidentally move something else!

If you really cannot live with it, make sure you mark everything very carefully so you can get back to your current state. A service manual is essential!

Convergence is set using a white crosshatch or dot test pattern. If you do not have a test pattern generator, any static scene (from a camcorder or previously recorded tape, for example) with a lot of fine detail will suffice. Turn the color control all the way down so you have a B/W picture.

Static convergence sets the beams to be coincident in the exact center of the screen. This is done using a set of ring magnets behind the purity magnets on the CRT neck.

From the Sams' for the RCA CTC111C: "adjust the center set of magnets to converge blue to green at the center of the screen. Adjust the rear set of magnets to converge red to green at the center of the screen." Your set may have a slightly different procedure.

Dynamic convergence adjusts for coincidence at the edges and corners.

On old tube, hybrid, and early solid state TVs, dynamic convergence was accomplished with electronic adjustments of which there may have been a dozen or more that were not independent. With modern sets, all convergence is done with magnet rings on the neck of the CRT, magnets glued to the CRT, and by tilting the deflection yoke. The clamp in conjunction with rubber wedges or set screws assures that the yoke remains in position.

From the Sams' for the RCA CTC111C: "Loosen the screws at the 6 o'clock and 10 o'clock positions to permit the yoke to be tilted vertically. Rock yoke up and down to converge the right and left sides of the screen. Tighten screw at 6 o'clock and loosen screw at 3 o'clock to permit the yoke to be tilted horizontally. Rock yoke from side to side to converge the top and bottom of the screen. Tighten screws at 3 o'clock and 10 o'clock."

Many sets simply use the main clamp which locks the yoke to the neck of the CRT in conjunction with rubber wedges between the yoke and the funnel of the CRT to stabilize the yoke position position.

Refer to your service manual. (Is this beginning to sound repetitious?)

For additional comments on convergence adjustments, see the sections: "Tony's notes on setting convergence on delta gun CRTs" and "Saga and General setup for large CRT TVs".

Tilted picture

You have just noticed that the picture on your fancy (or cheap) TV is not quite horizontal - not aligned with the front bezel. Note that often there is some keystoning as well where the top and bottom or left and right edges of the picture are not quite parallel - which you may never have noticed until now. Since this may not be correctable, adjusting tilt may represent a compromise at best between top/bottom or left/right alignment of the picture edges. You may never sleep again knowing that your TV picture is not perfect! BTW, I can sympathize with your unhappiness. Nothing is more annoying than a just noticeable imperfection such as this. However, since TVs always overscan, the only time you will really notice a minor tilt without going out of your way to look for it is if there is text or graphics near the edge of the screen.

There are several possible causes for a tilted picture:

1. Set orientation. The horizontal component of the earth's magnetic field affects this slgithly. Therefore, if you rotate the TV you may be able to correct the tilt. Of course, it will probably want to face the wall!

   Other external magnetic fields can sometimes cause a rotation without any other obvious effects - have you changed the TV's location? Did an MRI scanner move in next door?

2. Need for degaussing. Most of the time, magnetization of the CRT will result in color problems which will be far more obvious than a slight rotation. However, internal or external shields or other metal parts in the set could become magnetized resulting a tilt. More extensive treatment than provided by the built-in degaussing coil may be needed. Even, the normal manual degaussing procedure may not be enough to get close enough to all the affected parts.

3. You just became aware of it but nothing has changed. Don't dismiss this offhand. It is amazing how much we ignore unless it is brought to our attention. Are you a perfectionist?

4. There is an external tilt control which may be misadjusted. Newer Sony monitors have this (don't know about TVs) - a most wonderful addition. Too bad about the stabilizing wires on Trinitron CRTs. A digital control may have lost its memory accidentally. The circuitry could have a problem.

5. There is an internal tilt control that is misadjusted or not functioning. The existance of such a control is becoming more common.

6. The deflection yoke on the CRT has gotten rotated or was not oriented correctly at the time of the set's manufacture. Sometimes, the entire yoke is glued in place in addition to being clamped adding another complication.

   If the TV was recently bumped or handled roughly, the yoke may have been knocked out of position. But in most cases, the amount of abuse required to do this with the yoke firmly clamped and/or glued would have totally destroyed the set in the process.

   There is a risk (in addition to the risk of frying yourself on the various voltages present inside an operating TV) of messing up the convergence or purity when fiddling with the yoke or anything around it since the yoke position on the neck of the tube and its tilt may affect purity and convergence. Tape any rubber wedges under the yoke securely in place as these will maintain the proper position and tilt of the yoke while you are messing with it. (Don't assume the existing tape will hold - the adhesive is probably dry and brittle).

7. The CRT may have rotated slightly with respect to the front bezel. Irrespective of the cause of the tilt, sometimes it is possible to loosen the 4 (typical) CRT mounting screws and correct the tilt by slightly rotating the CRT. This may be easier than rotating the yoke. Just make sure to take proper safety precautions when reaching inside!

B/W TV size, position, and geometry adjustments

These tend to be a lot simpler and less critical than for color monitors or TV sets.

On a B/W TV you will probably see some of the following adjustments:

1. Position - a pair of rings with tabs on the neck of the CRT. There may be electronic position adjustements as well though this is not that common on small TVs.

2. Width and height (possibly linearity as well) controls. There may be some interaction between size and linearity - a crosshatch test pattern is best for this. Vertical adjustments are almost always pots while horizontal (if they exist) may be pots and/or coils. Size will normally be set for 5-10% overscan to account for line voltage fluctuations and

component drift. Confirm aspect ratio with test pattern which includes square boxes.

3. Geometry - some little magnets either on swivels around the yoke or glued to the CRT. If these shifted, the the edges may have gotten messed up - wiggles, dips, concave or convex shapes. There may be a doxen or more each mostly affecting a region around the edge of the raster. However, they will not be totally independent.

Check at extremes of brightness/contrast as there may be some slight changes in size and position due to imperfect HV regulation.

There may be others as well but without a service manual, there is no way of knowing for sure. Sams' often has folders for B/W TVs.

Just mark everything carefully before changing - then you will be able to get back where you started.

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Low Voltage Power Supply Problems

Low voltage power supply fundamentals

TVs require a variety of voltages (at various power levels) to function. The function of the low voltage power supply is to take the AC line input of either 115 VAC 60 Hz (220 VAC 50 Hz or other AC power in Europe and elsewhere) and produce some of these DC voltages. In all cases, the power to the horizontal output transistor of the horizontal deflection system is obtained directly from the low voltage power supply. In some cases, a variety of other DC voltages are derived directly from the AC line by rectification, filtering, and regulation. In other designs, however, most of the low voltages are derived from secondary windings on the flyback (LOPT) transformer of the horizontal deflection system. In still other designs, there is a separate switchmode power supply that provides some or all of these voltages. There are also various (and sometimes convoluted) combinations of any or all of the above.

There will always be:

1. A power switch, relay, or triac to enable main power.

2. A set of rectifiers - usually in a bridge configuration - to turn the AC into DC. Small ceramic capacitors are normally placed across the diodes to reduce RF interference.

3. One or more large filter capacitors to smooth the unregulated DC. In the U.S., this is most often a voltage around 150-160 V DC. In countries with 220 VAC power, it will typically be around 300-320 V DC.

4. A discrete, hybrid, or IC regulator to provide stable DC to the horizontal deflection system. Sometimes feedback from a secondary output of the flyback or even the high voltage is used. This regulator may be either a linear or switching type. In some cases, there is no regulator.

5. Zero or more voltage dividers and/or regulators to produce additional voltages directly from the line power. This relatively rare except for startup circuits. These voltages will not be isolated from the line.

6. A degauss control circuit usually including a thermistor or Posistor (a combination of a heater disk and Positive Temperature Coefficient (PTC) thermistor in a single package). When power is turned on, a relatively high AC current is applied to the degauss coil wrapped around the periphery of the CRT. The PTC thermister heats up,

increases in resistance, and smoothly decreases the current to nearly zero over a couple of seconds.

7. A startup circuit for booting the horizontal deflection if various voltages to run the TV are derived from the flyback. This may be an IC or discrete multivibrator or something else running off a non-isolated voltage or the standby power supply.

8. A standby power supply for the microcontroller and remote sensor. Usually, this is a separate low voltage power supply using a small power transformer for line isolation. However, some sets use other (probably cheaper) approaches. See below.

Always use an isolation transformer when working on a TV but this is especially important - for your safety - when dealing with the non-isolated line operated power supply. Read and follow the information in the section: Safety guidelines.

Standby power supplies

Where the TV has a remote control (which most do nowadays), there needs to be some source of voltage(s) for the remote receiver, microcontroller, and other circuitry that watch for the 'power on' commend. These sets are never totally off.

The standby supply may consist of:

- A low voltage power transformer feeding one or more sets of rectifiers, filter capacitors, and possibly regulators.

  A power surge could cause the primary of the transformer to open up. There may also be a thermal fuse under the outer layers of insulation which blew either due to overheating or a power surge. However, if the primary is open, it is best to replace the transformer rather than attempting repair it.

- One or more voltage dividers connected directly to the AC line feeding rectifiers, filter capacitors, and possibly regulators.

  Open resistors and dried up capacitors are common failures since the resistors are often not rated adequately and run hot, in close proximity to the capacitors.

- A portion of the main (switchmode) power supply that runs all the time.

  Failures could be almost anything that would affect normal operation of the power supply as well as problems with the control circuitry.

Typical TV power supply front end

The partial schematic below is similar to those found in the majority of TVs sold in countries with 110 to 120 VAC power. Many parts are not shown including the power switch or relay, RFI bypass capacitors across the rectifier diodes, and RFI line filter.

```
                                          Bypass resistor
     Line fuse    Main bridge  Fusable    +----/\/\-----+
           _       rectifier   resistor   |   +-----+   |
     H o--_ --+------|>|---+---/\/\--+---+---| REG |---+---+---o B+
              |            |         |       +-----+       |
              |  +---|>|---+      C1 _|_ Main    |         _|_ Regulator
   115 VAC    |  |           400 uF --- filter  |         --- output
```

```
              +--|---|<|---+  200 V  |  cap     |          |  capacitor
                 |         |         |          |          |
 +-> N o---------+---|<|---+---------+----------+----------+---o Non-isolated
 |                                                                  return
 +-> G - Power line earth ground via building wiring
```

- The line fuse is typically 2 to 4 A, usually a normal fast blow type. Even so, it may not blow as a result of faults down the line - the fusable resistor or regulator may fail first.

- The main bridge rectifier is often composed of 4 discrete diodes (similar to 1N400Xs) but may also be a single unit. Failures - usually shorted diodes - are common.

- The main filter capacitor can range in size from 200 to 800 uF or more at 200 to 250 V. THIS CAN BE LETHAL! A typical TV may continue to work at normal line voltage without any noticeable degradation in performance (hum bars, hum in sound, or shutdown) even if this capacitor is reduced in value by 75%. Its uF value is therefore not critical.

- The regulator is often an IC or hybrid module. Failures resulting in no or reduced output, or no regulation are common.

- The regulator output capacitor is needed for the B+ regulator to function properly. If this capacitor is reduced in value or develops a high ESR, regulation may fail resulting in instability, oscillation, or excessive B+ and shutdown.

- The regulator bypass resistor reduces the amount of current control needed of the regulator. Caution: even if the regulator has been pulled, the B+ line will have substantial voltage as a result of this resistor.

Totally dead set

This can be as simple as a bad outlet (including blown fuse or tripped circuit breaker due to some other fault), switched outlet and the switch is off, or bad cordset.

- Plug a lamp into the outlet to make sure it is live. If the lamp works, then the problem is the TV. It not, the outlet is defective or the fuse is blown or the circuit breaker is tripped. There is another very simple explanation that is sometimes overlooked: This is a switched outlet. You always wondered what that wall switch was for that didn't seem to do anything and you flipped randomly. :-) Well, now you know!

- Try wiggling the TV's cord both at the outlet (also push the wire toward the plug) and TV (also push the cord toward the TV) with the set on and/or while pressing the power-on button. If you can get a response, even momentarily, the cord likely has broken wires internally.

Beyond these basic causes, troubleshooting will be needed inside the set to determine what is defective. Also see the section: Intermittently dead set - bad cordset.

Intermittently dead set - bad cordset

There are two problems which are common with the line cord on appliances. Don't overlook these really simple things when troubleshooting your vacuum cleaner - or fancy electronic equipment! If wiggling the cord has an effect, then the following are likely causes:

- Repeated flexing results in the internal conductors breaking either at the plug or appliance end. If flexing the cord/squeezing/pulling results in the device going on and off, it is bad. If the problem is at the plug end, cut off the old plug a couple of inches beyond the problem area and replace just he plug. If the problem is at the appliance end, an entire new cordset is best though you can probably cut out the bad section and solder what remains directly to the mainboard.

In either case, observe the polarity of the cord wires - they will be marked in some way with a ridge or stripe. It is important that the new plug be of the same type (polarized usually) and that the cord is wired the same way.

- The prongs do not fit snugly into older worn outlets. This can usually be remedied by using a pointed tool like an awl or utility knife to spread apart the pair of leaves often used to form each prong of the plug. If the prongs are made of solid metal, it may be possible to spread them apart - widen the space between them. Alternatively, get a 3 to 2 prong adapter just to use as an intermediate connector. Spread the leaves of its prongs. However, a new outlet is best.

- Bad connections on the mainboard. As you flex the cord, it is also stressing the attachment to the mainboard and affecting some marginal solder joints.

It is important to deal with these symptoms as soon as possible as erratic power cycling can lead to much more serious and expensive problems down the road.

Power button on set is flakey

If the on/off (or other button) on the set itself behaves erratically but the remote control works fine, then it could be a dirty button or cable or other connections to the switch PCB, particularly if the buttons on the set itself are rarely used. There could possibly be a bad pullup resistor or something of that sort - but is it worth the effort to locate?

Why not just continue to use the remote? There is no reason to suspect that it will develop similar symptoms. However, there is some risk that if the button is dirty, you may find the TV coming on at random times in the middle of the night (of course!).

I think I have an older Sylvania that does that sort of thing - don't really know as I never use the power button on the set!

If power is controlled by a hard switch - a pull or click knob, or mechanical push-push switch and this has become erratic due to worn contacts, replacements are available but often only directly from the original manufacturer to physically fit and (where applicable) have the volume or other controls built in. As an alternative, consider mounting a small toggle switch on the side of the cabinet to substitute for the broken switch. This will almost certainly be easier and cheaper - and quite possibly, more reliable.

TV blows fuse

A blown fuse is a very common type of fault due to poor design very often triggered by power surges due to outages or lightning storms. However, the most likely parts to short are easily tested, usually in-circuit, with an ohmmeter and then easily removed to confirm.

Note that it *may be* useful to replace a fuse the *first* time it blows (though it would be better to do some basic checks for shorted components first as there is a small chance that having a fuse blow the second time could result in additional damage which would further complicate the troubleshooting process). However, if the new one blows, there is a real problem and the only use in feeding the TV fuses will be to keep the fuse manufacturer in business!

Sometimes, a fuse will just die of old age or be zapped by a power surge that caused no damage to the rest of the TV. However, it must be an EXACT replacement (including slo-blow if that is what was there originally). Else, there could be safety issues (e.g., fire hazard or equipment damage from too large a current rating) or you could be chasing a non-existent problem (e.g., if the new fuse is not slo-blow and is blown by the degauss circuit inrush current but nothing is actually wrong).

If the fuse really blows absolutely instantly with no indication that the circuits are functioning (no high pitched horizontal deflection whine (if your dog hides under the couch whenever the TV is turned on, deflection is probably working).) then this points to a short somewhere quite near the AC power input. The most common places would be:

- Degauss Posistor - very likely.
- Horizontal output transistor.
- Power supply regulator if there is one.
- Power supply chopper (switchmode) transistor if there is one.
- Diode(s) in main bridge
- Main filter capacitor(s).

You should be able to eliminate these one by one.

Unplug the degauss coil as this will show up as a low resistance.

First, measure across the input to the main power rectifiers - it should not be that low. A reading of only a few ohms may mean a shorted rectifier or two or a shorted Posistor.

- Test the rectifiers individually or remove and retest the resistance.

- Some sets use a Posistor for degauss control. This is a little cubical (about 1/2" x 3/4" x 1") component with 3 legs. It includes a line operated heater disk (which often shorts out) and a PTC thermister to control current to the degauss coil. Remove the posistor and try power. If the monitor now works, obtain a replacement but in the meantime you just won't have the automatic degauss.

If these test good, use an ohmmeter with the set unplugged to measure the horizontal output transistor. Even better to remove it and measure it.

- C-E should be high in at least one direction.
- B-E may be high or around 50 ohms but should not be near 0.

If any readings are under 5 ohms, the transistor is bad. The parts sources listed at the end of this document will have suitable replacements.

If the HOT tests bad, try powering the set first with your light bulb and if it just flashes once when the capacitor is charging, then put a fuse in and try it. The fuse should not blow with the transistor removed.

Of course, not much else will work either.

If it tests good, power the set without the transistor and see what happens. If the fuse does not blow, then with the good transistor (assuming it is not failing under load), it would mean that there is some problem with the driving circuits possibly or with the feedback from the voltages derived from the horizontal not regulating properly.

Look inside the TV and see if you can locate any other large power transistors in metal (TO3) cans or plastic (TOP3) cases. There may be a separate transistor that does the low voltage regulation or a separate regulator IC. Some TVs have a switchmode power supply that runs off a different transistor than the HOT. There is a chance that one of these may be bad. If it is a simple transistor, the same ohmmeter check should be performed.

If none of this proves fruitful, it may be time to try to locate a schematic.

A blown fuse is a very common type of fault due to poor design very often triggered by power surges due to outages or lightning storms. However, the most likely parts to short are easily tested, usually in-circuit, with an ohmmeter and then easily removed to confirm.

If you find the problem and repair it yourself, the cost is likely to be under $25.

Fuse blows or TV blows up when sync is disrupted

This is a problem which is not going to be easy to identify. One possibility is a drive problem. The messed up sync resulting from swtiching channels, or changing input connections might be resulting in an excessively long scan time for just one scan line. However, this may be enough to cause a current spike in the horizontal output circuit or an excessive voltage spike on the collector of the horizontal output transistor. Normally, the HOT current ramps up during scan. During flyback, the current is turned off. This current is normally limited and the voltage spike on the collector of the HOT is also limited by the snubber capacitors to a safe value. If scan time is too long, current continues to increase. At some point, the flyback core saturates and current goes way up. In addition, the voltage spike will be much higher - perhaps destructively so.

Troubleshooting these sorts of problems is going to be tough. However, a likely area to investigate would be:

- Drive circuitry for the HOT including the coupling components.

- The chip that generates takes the sync input and generates the horizontal drive signal.

- A bad low voltage regulator might permit the B+ to rise to excessive levels during black scenes (i.e., video mute during channel changing).

Internal fuse blew during lightning storm (or elephant hit power pole)

Power surges or nearby lightning strikes can destroy electronic equipment. However, most of the time, damage is minimal or at least easily repaired. With a direct hit, you may not recognize what is left of it!

Ideally, electronic equipment should be unplugged (both AC line and phone line!) during electrical storms if possible. Modern TVs, VCRs, microwave ovens, and even stereo equipment is particularly susceptible to lightning and surge damage because some parts of the circuitry are always alive and therefore have a connection to the AC line. Telephones, modems, and faxes are directly connected to the phone lines. Better designs include filtering and surge suppression components built in. With a near-miss, the only thing that may happen is for the internal fuse to blow or for the microcontroller to go bonkers and just require power cycling. There is no possible protection against a direct strike. However, devices with power switches that totally break the line connection are more robust since it takes much more voltage to jump the gap in the switch than to fry electronic parts. Monitors and TVs may also have their CRTs magnetized due to the electromagnetic fields associated with a lightning strike - similar but on a smaller scale to the EMP of a nuclear detonation.

Was the TV operating or on standby at the time? If it was switched off using an actual power switch (not a logic pushbutton or the remote control), then either a component in front of the switch has blown, the surge was enough to jump the gap between the switch contacts, or it was just a coincidence (yeh, right).

If the TV was operating or on standby or has no actual power switch, then a number of parts could be fried.

TVs usually have their own internal surge protection devices like MOVs (Metal Oxide Varistors) after the fuse. So it is possible that all that is wrong is that the line fuse has blown. Remove the cover (unplug it first!) and start at the line cord. If you find a blown fuse, remove it and measure across the in-board side of fuse holder and the other (should be the neutral) side of the line. The ohmmeter reading should be fairly high - well certainly not less than 100 ohms - in at least one direction. You may need to unplug the degaussing coil to get a reasonable reading as its resistance may be 25 or 30 ohms. If the reading is really low, there are other problems. If the resistance checks out, replace the fuse and try powering the TV. There will be 3 possibilities:

1. It will work fine, problem solved.

2. It will immediately blow the fuse. This means there is at least one component shorted - possibilities include an MOV, line rectifiers, main filter cap, regulator transistor, horizontal output transistor, etc. You will need to check with your ohmmeter for shorted semiconductors. Remove any that are suspect and see of the fuse now survives (use the series light bulb to cut your losses - see the section: The series light bulb trick.

3. It will not work properly or appear dead. This could mean there are open fusable resistors other defective parts in the power supply or elsewhere. In this case further testing will be required and at some point you may need the schematic.

If the reading is very low or the fuse blows again, see the section: TV blows fuse.

Fuse replaced but TV clicks with power-on but no other action

The click probably means that the power relay is working, though there could be bad contacts.

Since the fuse doesn't blow now (you did replace it with one of the same ratings, right?), you need to check for:

- Other blown fuses - occasionally there are more than one in a TV.

  Replace with one of exactly the same ratings.

- Open fusable resistors. These sometimes blow at the same time or in place of the fuses. They are usually low values like 2 ohms and are in big rectangular ceramic power resistor cases or smaller blue or gray colored cylindrical power resistors. They are supposed to protect expensive parts like the HOT but often blow at the same time.

If any of these are bad, they will need to be replaced with flameproof resistors of the same ratings (though you can substitute an ordinary resistor for testing purposes). Before applying power, check: Rectifier diodes, horizontal output transistor, regulator pass or chopper transistor (if present), and main filter capacitor for shorts.

An initial test with an ohmmeter can be done while in-circuit. The resistance across each diode and the collector to emitter of the transistors should be relatively high - a few hundred ohms at lest - in at least one direction (in-circuit). If there is a question, unsolder one side of each diode and check - should be in the Megohms or higher in one direction. Removed from the circuit, the collector-emitter resistance should be very high in one direction at least. Depending on the type, the base-emitter resistance may be high in one direction or around 50 ohms. If any reading on a semiconductor device is under 10 ohms - then the device most likely bad. Assuming that you do not have a schematic, you should be able to locate the rectifiers near where the line cord is connected and trace the circuit. The transistors will be either in a TO3 large metal can or a TOP3 plastic package - on heat sinks. The filter capacitor should eventually measure high in one direction (it will take a while to charge from your ohmmeter). It could still be failing at full voltage, however.

If you find one bad part, still check everything else as more than one part may fail and just replacing one may cause it to fail again.

Assuming everything here checks out, clip a voltmeter set on its 500 V scale or higher across the horizontal output transistor and turn the power on. Warning - never measure this point if the horizontal deflection is operating. it is ok now since the set is dead. If the voltage here is 100-150, then there is a problem in the drive to the horizontal output circuit. If it is low or 0, then there are still problems in the power supply or with the winding on the flyback transformer.

Other possible problems: bad hybrid voltage regulator, bad startup circuit, bad standby power supply (dried up filter capacitor, etc.) bad relay contacts as mentioned above. However, these probably would not have blown the fuse in the first place so are less likely.

Power-on tick-tick-tick or click-click-click but no other action

A variety of power supply or startup problems can result in this or similar behavior. Possibilities include:

- Lack of startup horizontal drive - see the section: Startup problems - nothing happens, click, or tick-tick-tick sound. The main regulator is cycling on overvoltage due to lack of load.

- Excessive load or faulty power supply cycling on its overcurrent protection circuit.

- High voltage shutdown, or some other system detecting an out of regulation condition. However, in this case, there should be some indication that the deflection and HV is attempting to come up - momentary whine, static on the screen, etc.

- A dried up main filter capacitor or other filter capacitor in the low voltage power supply that is producing an out-of-regulation condition until it warms up. A bad filter capacitor on the output of a series regulator may result in excessive voltage and subsequent shutdown.

- A problem with the microcontroller, relay or its driver, or standby power supply.

One possible test would be to vary the line voltage and observe the set's behavior. It may work fine at one extreme (usually low) or the other. This might give clues as to what is wrong.

Also see the section: Dead TV with periodic tweet-tweet, flub-flub, or low-low voltage.

No picture or raster and no sound

The screen is blank with no raster at all. There are indications that the channel numbers are changing in the display. This indicates that some of the low voltages are present but these may be derived from the standby supply.

Assuming there is no deflection and no HV, you either have a low voltage power supply problem, bad startup circuit, or bad horizontal output transistor (HOT) or other bad parts in the horizontal deflection.

Check for bad fuses.

(If you have HV as indicated by static electricity on the front of the screen and you hear the high pitched whine of the horizontal deflection when it is turned on, then the following does not apply).

1. Use an ohmmeter to test the HOT for shorts. If it is bad, look for open fusable resistors or other fuses you did not catch.

2. Assuming it is good, measure the voltage on the collector-emitter of the HOT (this is safe if there is no deflection). You should see the B+ - probably between 100 and 150 V.

3. If there is no voltage, you have a low voltage power supply problem and/or you have not found all the bad/open

parts.

4. If there is voltage and no deflection (no high pitched whine and no HV), you probably have a startup problem - all TVs need some kind of circuit to kick start the horizontal deflection until the auxiliary power outputs of the flyback are available. Some Zeniths use a simple multivibrator for this - a couple of transistors. Others power the horizontal osc. IC from a special line-derived voltage. The multivibrator type are sometimes designed to fail if someone keeps turning the set on and off (like kids playing) since the power rating is inadequate.

   Test the transistors if it is that type with an ohmmeter. If one is shorted, you have a problem. The usual way a TV service person would test for startup problems is to inject a signal to the base of the HOT of about 15.75 kHz. If the TV then starts and runs once this signal is removed, the diagnosis is confirmed. This is risky - you can blow things up if not careful (including yourself). See the section: Bypassing the Startup Circuit for details.

If you hear the high pitched whine of the deflection and/or feel some static on the scree, confirm that the horizontal deflection and high voltage are working by adjusting the SCREEN control (probably on the flyback). If you can get a raster then your problem is probably in the video or chroma circuits, not the deflection or high voltage.

Reduced width picture and/or hum bars in picture and/or hum in sound

The most likely cause is a dried up main filter capacitor. Once the effective capacitance drops low enough, 120 Hz (or 100 Hz in countries with 50 Hz power) ripple will make its way into the regulated DC supply (assuming full wave rectification).

Another likely cause of similar symptoms is a defective low voltage regulator allowing excessive ripple. The regulator IC could be bad or filter capacitor following the IC could be dried up.

Either of these faults may cause:

1. A pair of wiggles and/or hum bars in the picture which will float up the screen. For NTSC where the power line is 60 Hz but the frame rate is 59.94 Hz, it will take about 8 seconds for each bar to pass a given point on the screen. (On some sets, a half wave recitifier is used resulting in a single wiggle or hum bar).

2. Hum in the sound. This may or may not be noticeable with the volume turned down.

3. Possible regulation problems resulting in HV or total shutdown or power cycling on and off.

The best approach to testing the capacitors is to clip a good capacitor of approximately the same uF rating and at least the same voltage rating across the suspect capacitor (with the power off). A capacitor meter can also be used but the capacitor may need to be removed from the circuit.

Once the capacitors have been confirmed to be good, voltage measurements on the regulator should be able to narrow down the problem to a bad IC or other component.

Excessive B+ from fixed regulator like STR30123/STR30130/STR30135

These are fixed regulators that do fail but the problem may be elsewhere.

If the B+ goes to high, the X-ray protection circuitry may kick in and shut down the horizontal deflection.

If there is little or no load (horizontal deflection not running at all), all bets are off as well - the resistor that is likely across input-output will dominate and boost the voltage above the proper output for the regulator chip. Use a Variac to bring up the voltage to the TV. If the deflection does not start up at any voltage even with the B+ ramping up past its normal value, the problem is probably in the horizontal deflection/startup circuitry, not the regulator.

Some of these may go out of regulation if the output electrolytics are dried up. There might a a 10 uF 200 V or so electrolytic across the output to ground. Test it or substitute a known good one of about the same uF rating and at least equal voltage rating. If you can get the TV to work at reduced voltage using a Variac (but possibly with hum bars in the picture and hum in the audio), check the output capacitor.

Otherwise, it could be the regulator or one of its biasing components (sets current to B input - the voltage at this input should be close to the output voltage value). Also check to be sure the input voltage is solid - main filter capacitor is not dried up.

TV power cycling on and off

The power light may be flashing or if you are runing with a series light bulb it may be cycling on and off continuously. There may be a chirping or clicking sound from inside the set. (Note: using too small a series light bulb load during testing for the size of the TV may also result in this condition.)

If there is a low voltage regulator or separate switching supply, it could be cycling on and off if the horizontal output, flyback, or one of its secondary loads were defective.

Does this TV have a separate low voltage regulator and/or switching power supply or is it all part of the flyback circuit? For the following, I assume it is all in one (most common).

Some simple things to try first:

Verify that the main filter capacitor is doing its job. Excessive ripple on the rectified line voltage bus can cause various forms of shutdown behavior. An easy test is to jumper across the capacitor with one of at least equal voltage rating and similar capacitance (make connections with power off!).

Use a Variac, if possible, to bring up the input voltage slowly and see if the TV works at any point without shutting down. If it does, this could be an indication of X-ray protection circuit kicking in, though this will usually latch and keep the set shut off if excessive HV were detected.

Dead TV with periodic tweet-tweet, flub-flub, or low-low voltage

A TV which appears to be dead except for a once a second or so tweet or flub usually indicates an overload fault in the power supply or a short in one of its load circuits. In some cases, the low voltage (including B+) will just be reduced to a fraction of their normal value as a result of an overload on one of the outputs - usually the main B+.

This may be caused by a shorted rectifier in the power supply, flyback, or even the yoke, but check the the loads first. Wait a few minutes for the filter caps to discharge (but stay away from the CRT HV connector as it may retain a dangerous and painful charge for a long time), use an ohmmeter across the various diodes in the power supply. Using an ohmmeter on the rectifier diodes, the resistance in at least one direction should be greater than 100 ohms. If it is much less (like 0 or 5 ohms), then the diode is probably bad. Unsolder and check again - it should test infinite (greater than 1M ohms) in one direction.

Summary of possible causes:

- Bad solder connections.
- Other shorted components like capacitors.
- Other problems in the power supply or its controller.
- Bad flyback.

- Short or excessive load on secondary supplies fed from flyback.
- Short in horizontal yoke windings.
- Problem with startup drive (cycling on overvoltage).

Bypassing the Startup Circuit

Where the TV is dead and a startup problem is suspected, a TV service person would test for startup problems by injecting a signal into the base of the HOT of about 15.75 kHz. If the TV then starts and runs once this signal is removed, the diagnosis is confirmed. This is risky - you can blow things up if not careful (including yourself). A 555 timer based circuit will work fine as a signal source for this.

WARNING: be careful if you do this. The HOT circuit may be line-connected and it is possible to destroy the HOT and related components if this is not done properly. I once managed to kill not only the HOT but the chopper transistor as well while working in this area. An expensive lesson.

You can reduce the risk somewhat (to the TV at least) by using a series light bulb load and/or running on reduced line voltage. The most important thing to avoid is putting in an excessively long drive pulse which will result in the flyback transformer saturating, huge amounts of current, and likely a dead HOT and possibly other parts if there is nothing to limit the current. For NTSC/PAL, it is fairly safe to assume that a 50 percent duty cycle 15 to 16 kHz drive signal will not result in fireworks as long as there aren't other problems (like a shorted flyback/LOPT).

If after a second or so, the TV fires up (not literally!) and stays happy until it is turned off, a startup problem is almost certain. It could be the standby supply (if used) or a dedicated startup circuit that has failed.

But, don't push your luck - if the TV starts after a second or so of your drive signal but doesn't continue to run when it is removed, don't be tempted to leave your circuit connected - it could still be stressing other parts. Find out why the normal horizontal drive is not being generated - possibly a power supply or horizontal oscillator problem.

If nothing happens, either startup is not the problem or there are other components that have failed preventing the HOT drive signal from having any effect.

Shorted Components

A failure of the horizontal output transistor or power supply switchmode transistor will blow a fuse or fusable resistor.

Look for blown fuses and test for open fusable resistors in the power circuits. If you find one, then test the HOT and/or switchmode transistor for shorts.

Other possibilities: rectifier diodes or main filter capacitor.

While you are at it, check for bad connections - prod the circuit board with an insulated stick when the problem reoccurs - as these can cause parts to fail.

Startup problems - nothing happens, click, or tick-tick-tick sound

TVs and monitors usually incorporate some kind of startup circuit to provide drive to the horizontal output transistor (HOT) until the flyback power supply is running. Yes, TVs and monitors boot just like computers.

There are two typical kinds of symptoms: power on click but nothing else happens or a tick-tick-tick sound indicating cycling of the low voltage (line regulator) but lack of startup horizontal drive.

Check the voltage on the horizontal output transistor (HOT). If no voltage is present, there may be a blown fuse or open fusable resistor - and probably a shorted HOT.

However, if the voltage is normal (or high) - usually 100-150 V, then there is likely a problem with the startup circuit not providing initial base drive to the HOT.

The startup circuits may take several forms:

1. Discrete multivibrator or other simple transistor circuit to provide base drive to the HOT.

2. IC which is part of deflection chain powered off of a voltage divider or transformer.

3. Other type of circuit which operates off of the line which provides some kind of drive to the HOT.

The startup circuit may operate off of the standby power supply or voltage derived from non-isolated input. Be careful - of course, use an isolation transformer whenever working on TVs and especially for power supply problems.

Note that one common way of verifying that this is a startup problem is to inject a 15 kHz signal directly into the HOT base or driver circuit (just for a second or two). If the TV then starts up and continues to run, you know that it is a startup problem. However, this is a risky procedure for both you and the TV. See the section: Bypassing the Startup Circuit.

I have also seen startup circuits that were designed to fail. Turning the TV on and off multiple times would exceed the power ratings of the components in the startup circuit. Some Zenith models have this 'feature'.

When this situation exists, it could be that the circuit is not providing the proper drive or that due to some other circuit condition, the drive is not always sufficient to get the secondary supplies going to the point that the normal circuits take over.

I would still check for bad connections - prod the circuit board with an insulated stick when the problem reoccurs.

TV turns off after warming up

If you can turn it back on with the s momentary key or power button:

When it shuts off, do you need to push the power button once or twice to get it back on? Also, does anything else about the picture or sound change as it warms up?

1. If once, then the controller is shutting the TV down either as a result of a (thermally induced) fault in the controller or it sensing some other problem. Monitoring the voltage on the relay coil (assuming these is one) could help determine what is happening. The controller thinks it is in charge.

2. If twice, then the power supply is shutting down as the controller still thinks it is on and you are resetting it. A couple of possibilities here would be low voltage or high voltage regulation error (excessive high voltage is sensed and causes shutdown to prevent dangerous X-ray emission). A partially dried up main filter capacitor could also cause a shutdown but there might be other symptoms like hum bars in the picture just before this happened. Clipping a good capacitor across the suspect (with power off!) would confirm or eliminate this possibility.

If it uses a pull-knob (or other hard on/off switch), then this may be like pulling the plug and would reset any abnormal condition.

TV doesn't power up immediately

The TV may do nothing, cycle on and off for a while, power up and then shutdown in an endless cycle - or at least for a while. Then it comes on and operates normally until it is turned off.

A couple of possibilities:

1. The main filter capacitor or other filter capacitors in the low voltage power supply is dried up and this can cause all kinds of regulation problems.

2. The power supply regulator is defective (or marginal) allowing excessive voltage on its output and then the X-ray protection circuitry shuts you down.

If you can get access to a Variac, it would be worth bringing up the input voltage slowly and seeing if there is some point at which it would stay on.

If there is, then if the picture has serious hum bars in it the main filter cap could be bad. If more or less a decent picture with minor hum bars then it could be the regulator.

Old TV requires warmup period

So, what else is new? In the old days, a TV was expected to take a few minutes (at least) to warm up. We are all spoiled today. Of course, you usually maintained a full time technician or engineer to fiddle with the convergence adjustments!

A TV (from around 1983) needs at least 5 min. to warm up (lighting up the screen and making sound if I give it a cold start. Once warmed up, you can it off and on again from the front panel and it will work immediately. Another thing this TV has a sub-power switch in the rear.

1983 sounds a bit late, but sets in the late '70 during the transition from tubes to all solid state chassis often had the 'sub-power' switch providing some power to the filaments of the CRT and other tubes - usually in the deflection and high voltage circuits since these would take a while to heat up and stabilize. The idea was to leave this switch on all the time (except when going on vacation - it was sometimes labeled 'vacation') so that you would have nearly instant warm up. Supposedly, this led to an increased risk of fire as well (see the section: About instant-on TVs).

If it is a totally solid state chassis, then there is some component - probably a capacitor in the power supply since it affects both picture and sound - that is drifting with temperature and needs to be located with cold spray or a heat gun.

TV shuts down with bright picture or when brightness is turned up

This is probably a protection circuit kicking in especially if turning power off or pulling the plug is required to restore operation.

The detection circuit could be in the power supply or horizontal deflection output circuit. It may be defective or the current may be too high for some other reason. A couple of tests can be performed to confirm that it is due to beam current:

- Determine if behavior is similar when adjusting the user brightness control and the screen (G2) pot (on the flyback) or master brightness control. If the TV quits at about the same brightness level, overcurrent protection is likely.

- Disconnect the filaments to the CRT (unsolder a pin on the CRT socket) and see if it still shuts down under the same conditions. If it is overcurrent protection, shut down should now *not* take place since there is no beam current.

Relays in the Power Circuitry of TVs

Where power on or power off is erratic or only seems to work part way (e.g., the picture goes off but not the sound), it may just be a sticking or dirty relay. Of course, general on/off problems could also be relay related but could also be a lot of other things.

For erratic on/off problems, gently tapping on the relay when the problem occurs will confirm that the relay is at fault - if the set then switches on or off properly, it's almost certainly the relay and replacing it will fix the problem. But double check its solder connections to make sure it isn't a simple bad connection to the relay or in its vicinity.

So what exactly is the purpose of such a power relay in a TV set? Why doesn't the power switch on the TV just apply power directly instead of through a relay?

The usual reason for a relay instead of a knob switch is to permit a remote control to turn power on and off. If your TV does not have a remote, then it is simply the same chassis minus 24 cents worth of circuitry to do the remote function. Isn't marketing wonderful?

The only unknown is the coil voltage. It is probably somewhere in the 6 to 12 volt range. You should be able to measure this on the coil terminals in operation. It will be a DC coil.

However, the relay controls the 125 VAC (or 220 VAC) which you should treat with respect - it is a lot more dangerous than the 25kV+ on the CRT!

Almost certainly, the relay will have 4 connections - 2 for power and 2 for the coil. If it is not marked then, it should be pretty easy to locate the power connection. One end will go to stuff near the AC line and the other end will go to the rectifier or maybe a fusable resistor or something like that. These will likely be beefier than the coil connections which will go between a transistor and GND or some low voltage, or maybe directly into a big microcontroller chip.

However, a few sets use a latching relay - separate coils (sharing a common connection) to 'set' and 'reset' the relay - like a flip flop. In such a case, the controller knows which state the TV is in (on or off) and sens the appropriate pulse to the relay to change state. And, there will be NO voltage on the coils of a latching relay except when turning the set on or off.

Of course, the best thing would be to get the schematic. Some big public libraries carry the Sams' photofact series for TVs and VCRs. If not, take 10 minutes and trace it. You should be able to get far enough to determine the relay connections.

Once you are sure of the AC connections - measure across them while it is off and also while it is on. While off, you should get 110 to 125 VAC. While on and working - 0. While on and not working either 110 to 125 VAC if the relay is not pulling in or 0 if it is and the problem is elsewhere. We can deal with the latter case if needed later on. Note the even if the relay contacts are not working, the problem could still be in the control circuitry not providing the correct coil voltage/current, though not likely.

It may be expensive and/or difficult to obtain an exact replacement, but these are pretty vanilla flavored as relays go. Any good electronics distributor should be able to supply a suitable electrical replacement though you may need to be creative in mounting it.

What is a posistor?

A posistor is a combination of a PTC (positive temperature coefficient) resistor and another resistor-element to heat it up and keep it hot. Sometimes, these will go by the name posister or thermistor. The heater is a disk shaped resistor across the power line and the themister is a disk shaped device in series with the degauss coil. They are in clamped together to be in close contact thermally. You can pry off the lid and see for yourself.

The most common failure mode is for the part to short across the line.

Its function is to control degauss, so the only thing you lose when you remove one of these is the degauss function on power-on. When you turn the TV or monitor on, the PTC resistor is cold and low resistance. When heated, it becomes very high resistance and turns off the degauss coil but gradually - the current ramps down to zero rather than being abruptly cut off..

Computer Component Source stocks a wide variety, I believe but it may be cheaper to go direct to the manufacturer if they will sell you one.

Flameproof Resistors

Flameproof Resistor or Fusable Resistor are often designated by the symbol 'FR'. They are basically the same. The designation "Flameproof" means that if they fail due to excessive current, there will be no chance of, well, them going up in flames. :) They will also have a power rating and thus can act as a protective device, though a specific circuit may not depend on a precise fuse rating, rather that the resistor will open with massively excessive current.

You may see these in the switchmode power supplies used in TVs and monitors. They will look like power resistors but will be colored blue or gray, or may be rectangular ceramic blocks. They should only be replaced with flameproof resistors with identical ratings. They serve a very important safety function.

These usually serve as fuses in addition to any other fuses that may be present (and in addition to their function as a resistor, though this isn't always needed). Since your FR has blown, you probably have shorted semiconductors that will need to be replaced as well. I would check all the transistors and diodes in the power supply with an ohmmeter. You may find that the main switch mode transistor has decided to turn into a blob of solder - dead short. Check everything out even if you find one bad part - many components can fail or cause other components to fail if you don't locate them all. Check resistors as well, even if they look ok.

Since they function as fuses, flameproof resistors should not be replaced with higher wattage types unless specifically allowed by the manufacturer. These would not blow at the same level of overload possibly resulting in damage to other parts of the circuitry and increasing the risk of fire.

Then, with a load on the output of the power supply use a Variac to bring up the voltage slowly and observe what happens. At 50 VAC or less, the switcher should kick in and produce some output though correct regulation may not occur until 80 VAC or more. The outputs voltages may even be greater than spec'd with a small load before regulation is correct.

Width and height change with warmup

Since both width and height are affected, this points to something common like the low voltage power supply. If there are any indications of hum bars, first check the main filter capacitor(s) or substitute a known good one. There might even be other symptoms like faint retrace lines on at least part of the screen.

Start by monitoring the B+ to the flyback (feeding the HOT) to see if this drifts at all. If it does, then there is probably a low voltage regulator problem - bad capacitor, resistor, or chip. Use freeze spray to narrow it down. If this is solid, then there could be a high voltage drift but this would be somewhat unusual without other symptoms (like arcing) since the HV is nearly always tracks the low voltage supply.

Problems with SCR based regulators

Here are typical symptoms:

> "Sharp TV has a short blast of high voltage and sound then shuts down. All components in regulator area test good. I have two of these sets." Is there a good sharp tech out there thats seen this problem?"

(From: Mr. Caldwell (jcaldwel@iquest.net).)

There is a bulletin from Sharp on troubleshooting *any* SCR regulated TV, this can easily be adapted to RCA, GE, Emerson and Panasonic sets that have similar circuits given a little thought but the technician.

You are going to need to figure part of this out as I no longer have the schematics available. All this will do is allow you to rule out either the regulator or the horizontal section.

Don't plug this in until you've read the whole list.

Figure out how to bypass the turn on circuit from the microprocessor (unless it's a manual one). This is usually just jumpering the relay but sometimes Sharp puts a horizontal Vcc turn on transistor that also must be jumpered.

Next jumper across the SCR anode to cathode.

Now using an *variable isolation transformer* turn the voltage on it down and plug the set in. Bring the voltage up slowly, if you can bring the AC up so that the DC on the jumper across the SCR is within the regulated voltage you should have a picture and this rules out the horizontal section as the culprit.

If the set shuts down prior to getting the DC up enough then you've got problems in the horizontal section. Either you have something wrong with the high voltage transformer or the tuning caps or there is a problem with the x-ray protect pick off voltage to the deflection IC.

If it's the horizontal section you can set the AC at approx. 25v and look at the waveforms in the horizontal output section for defects like ringing.

I've never gotten a good troubleshooting technique down for the regulator since it's an active circuit the waveforms and voltages are not stable when it's failed. A good diode, transistor and capacitor checker will help.

It would help to get the service manual for that set, the training manual for that chassis and the bulletin dealing with troubleshooting SCR regulators.

Also the training manual should have a good explanation of how this regulator works. In a nutshell the regulator is a switched mode circuit that uses a winding from the high voltage transformer to turn off the SCR. The regulator is always turned off at the same time by a pulse from the high voltage transformer. Regulation is achieved by controlling when the SCR is allowed to turn on.

TV shuts down with dark picture or when changing channels

This may happen at any time or possibly after being on for awhile in which something heats up and drifts out of spec.

The low voltage regulator may be letting the voltage rise excessively. Then, a dark picture or video muting during a channel change triggers the X-ray or power supply overvoltage protection.

Monitor the output of the low voltage power supply B+ to see if it is stable as the brightness/scene changes.

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Deflection Problems

Deflection fundamentals

Note: the following is just a brief introduction. For more detailed deflection system theory of operation and sample circuits, see the document: TV and Monitor Deflection Systems.

The electron beams in the CRT need to be scanned horizontally and vertically in a very precise manner to produce a raster - and a picture.

For NTSC and PAL, the horizontal scan rates are 15,734 and 15,625 Hz respectively.

For NTSC and PAL, the vertical scan rates are 60 and 50 Hz (approximately) respectively.

The deflection yoke includes sets of coils for horizontal and vertical scanning oriented at 90 degrees with respect to each other. Additional coils are needed to correct for pincushion and other geometric defects.

The deflection circuits must be synchronized and phase locked to the incoming video signal.

Therefore, we have the following functions:

1. Sync separator to obtain horizontal and vertical synchronization pulses.

2. Horizontal oscillator which locks to horizontal sync pulses.

3. Horizontal drive followed by horizontal output which feeds deflection yoke (and flyback for HV and other voltages), Yoke requires a sawtooth current waveform for linear horizontal deflection. Horizontal output in all but the smaller TVs is a large discrete power transistor, most often an NPN bipolar type.

4. Vertical oscillator which locks to vertical sync pulses. Yoke requires sawtooth waveform for linear vertical deflection.

5. Vertical drive/output which feeds vertical deflection yoke. Newer TVs use ICs for vertical drive and output.

6. Various additional deflection signals to correct for the imperfections in the geometry of large angle deflection CRTs. These may be fed into the normal deflection coils and/or there may be separate coils mounted on the neck of the CRT.

About the vertical scan rate

Some people believe that the TV scan rate is locked to the local power line. TVs never ever used the line frequency for vertical rate. The vertical rate is not even equal to line frequency, actually 59.94 Hz (NTSC). It was set originally to 60 Hz to minimize the visibility of interference between the deflection and power transformer. When NTSC added color, it changed to 59.94 Hz for highly technical reasons. And, TVs no longer have power transformers.

See Symptoms of Some Common Deflection Problems when referring to the specific descriptions below.

Picture squeezed in then died

You were watching 'Knight Rider' reruns and all of a sudden, the picture "squeezed in" slowly from the right hand side. It "squeezed in" about 2 inches or so when the entire picture went dead - has remained like this since. Sound is fine, but no activity at all from the tube. Has it died? How much time, effort, and expense to fix?

No, it's not dead, at least it certainly is not the picture tube.

Your set probably didn't like Knight Rider - at least that episode!

Seriously, how old is the set? Is it a totally solid state chassis or are there tubes in the deflection circuits?

Is there any indication of light on the screen? Any indication of the 15735 Hz horizontal running at all? (You would normally hear the high pitch sound).

Newer TVs almost always derive voltages for the sound circuits from the horizontal deflection but older hybrids may run the sound off of its own power.

In any case, there is a problem in the horizontal deflection and you probably have no high voltage as well assuming no light on the screen.

The fact that it squeezed in first indicates that a partial short or other fault may have developed in the horizontal deflection circuits - possibly the deflection yoke or flyback transformer. It could also have been a bad connection letting loose. Once it failed completely, the horizontal output transistor may have bought the farm or blown a fuse.

TV non-linearity

Most modern TVs are nearly perfect with respect to linearity. There are never any user adjustments and there may not even be any internal adjustments. See the sections: Horizontal position, size, and linearity adjustment and/or Vertical position, size, and linearity adjustment.

A sudden change in linearity or a TV that requires a warmup period before linearity becomes acceptable may have a bad component - probably a capacitor in the horizontal deflection circuits. For the latter, try some cold spray or a heatgun to see if you can locate the bad part.

Horizontal deflection shutting down

Confirm that the horizontal deflection is shutting down (along with the high voltage since it is derived from horizontal deflection: listen for the high pitched deflection whine, test for static on the screen, see if the CRT filaments are lit, turn up the brightness and/or screen control to see if you can get a raster) and then why:

1. Power is failing to the horizontal output transistor - this could be due to a low voltage power supply problem, bad connection, etc.
2. Base drive to the horizontal output transistor is failing - could be a fault in the horizontal oscillator or bad connection.
3. Problem with the flyback transformer or its secondary loads (flyback may provide other power voltages).
4. X-ray protection is activating - either due to excess HV or due to a fault in the X-ray protection circuitry.

If the problem comes and goes erratically it sounds like a bad connection, especially if whacking has an effect. If it comes and goes periodically, then a component could be heating up and failing, then cooling, etc.

TV will not sync

There are a wide variety of causes for a TV that will not display a stable or properly configured picture. Among the symptoms are:

- Lack of sync horizontal - drifts smoothly horizontally. Depending on the difference between the video horizontal rate and the free-run frequency of the horizontal oscillator, the picture may be torn left or right (as shown in Symptoms of Some Common Deflection Problems or have multiple images superimposed horizontally. The situation where the picture is neatly split horizontally (which is what you might expect) is a special case where the frequencies are virtually the same. The key symptom common to all these is that there IS vertical lock (no blanking bar visible) AND there is no evidence that the deflection is even attempting to lock horizontally.

  This may mean that the horizontal sync signal is missing due to a sync separator problem or that there is some other fault in the sync processing circuitry.

- Incorrect lock horizontal - a more-or-less stable torn picture. This means that the sync signal is reaching the deflection system but that it is having problem locking to it. The horizontal oscillator free-run frequency may be too far from what it is supposed to be (15,734 or 15,625 for NTSC and PAL, respectively).

- Lack of sync vertical - rolls smoothly vertically. This may mean that the vertical sync signal is missing or the deflection system is ignoring it.

- Lock not stable vertical - jumps or vibrates vertically. This may be a fault in the vertical sync circuitry.

- Multiple or repeated images horizontally or vertically. Problems in sync processing circuitry.

  Additional comments on some of these problems follow in the next few sections.

Horizontal lock lost

A TV which loses horizontal lock when changing channels, momentarily losing the signal, or switching inputs may have a horizontal oscillator that is way out of adjustment or has drifted in frequency due to aging components.

Note that the characteristics of this are distinctly different than for total loss of sync. In the latter case, the picture will drift sideways and/or up and down while with an off frequency oscillator, the torn up picture will try at least to remain stationary.

This could be a capacitor or other similar part. Or, the oscillator frequency may just need to be tweaked (particularly with older sets). There may be an internal horizontal frequency adjustment - either a pot or a coil - which may need a slight tweak. If a coil, use a plastic alignment tool, not metal to avoid cracking the fragile core.

A schematic will be useful to locate the adjustment if any or to identify possible defective parts. Try a large public library for the Sams' Photofact for this set.

Insufficient width (without hum bars)

If there are hum bars or wiggles in the picture and/or hum in the sound, see the section: Reduced width picture and/or hum

bars in picture and/or hum in sound.

If both width and height are affected, the cause is likely something common: low, low voltage power supply voltages or excessive high voltage (resulting in a 'stiffer' beam).

(From: Jerry G. (jerryg@total.net).)

Lack of width is usually caused by defective power supply, low horizontal drive to the yoke and flyback, defective circuits in the pincushioning amplifier section, excessive high-voltage caused by defective voltage regulation, and or excessive loading on the secondary side of the flyback.

Vertical lock lost

This indicates a picture that is correct but rolling vertically.

If the picture is rolling down the screen the frequency of the vertical oscillator is incorrect - too high - and this may be the problem. Generally, the free run frequency of the vertical oscillator should be a little below the video rate (of around 50 or 60 Hz depending on where you live).

If it is rolling continuously without jumping, then there is a loss of sync from the sync separator or faulty components in the vertical oscillator causing it to totally ignore the sync pulses.

If it is rolling up rapidly and not quite able to remain locked, the free run frequency may be too low or there could be a fault in the sync circuits resulting in an inadequate vertical pull-in range.

On older sets, there was actually a vertical hold (and possibly even a separate vertical frequency) control. On anything made in the last decade, this is unlikely. There may be Vertical Frequency and Vertical Pull-in Range adjustments (and others) accessible via the service menu. However, if any of these ever change, it indicates a possible problem with the EEPROM losing its memory as component drift is unlikely.

As with everything else, bad connections are possible as well. You will need a schematic and possibly setup info to go beyond this.

Vertical squashed

This is a vertical deflection problem - possibly a bad capacitor, bad connection, flyback/pumpup diode, or other component. None of these should be very expensive (in a relative sort of way).

If the symptoms change - particularly if they become less severe - as the set warms up, a dried up electrolytic capacitor is most likely. If they get worse, it could be a bad semiconductor. Freeze spray or a heat gun may be useful in identifying the defective component.

It is often easiest to substitute a good capacitor for each electrolytic in the vertical output circuit. Look for bad connections (particularly to the deflection yoke), then consider replacing the vertical output IC or transistor(s).

A defective deflection yoke is also possible or in rare cases, a bad yoke damping resistor (e.g., 500 ohms, may be mounted on the yoke assembly itself).

Where the entire top half or botton half of the picture is squashed into into the center (i.e., only half the picture shows), a missing power supply voltage, defective vertical output IC, or a component associated with it is likely bad. A bad connection or blown fusable resistor may be the cause of a missing power supply voltage.

The following are NOT possible: CRT, flyback (except possibly where it's the source for a missing voltage but this is more likely just a bad solder connection at a flyback pin), tuner (except for the famous RCA/GE/Proscan or Sony models where the controller is at fault - see the sections on these specific brands). I am just trying to think of really expensive parts that cannot possibly be at fault :-).

Note that some movies or laser karaoke discs are recorded in 'letterbox' format which at first glance looks like a squashed vertical problem. However, the picture aspect ratio will be correct and turning up the brightness will reveal a perfectly normal raster above and below the picture.

Part of picture cut off

The following applies if the part of the picture is missing but not otherwise squashed or distorted. For example, 85% is missing but the portion still visible is normal size.

Wow! That's an interesting one, more so than the typical run-of-the-mill "my TV just up and died on me". Or, "my pet orangutan just put a hole in the CRT, what should I do"?

Since the size of the picture fragment is correct but 85% is missing, my first thought would be to check waveforms going into the vertical output stage. The supply voltage is probably correct since that often determines the size. It almost sounds like the waveform rather than being mostly on (active video) and off for the short blanking period is somehow only on during the last part of the active video thus giving you just the bottom of the picture. If there is a vertical output IC, it may be defective or the blanking input to it may be corrupted. The problem may be as far back as the sync separator. Then again who knows, maybe wait for the schematics.

CAUTION: To prevent damage to the CRT phosphors, immediately turn down the brightness so the line is just barely visible. If the user controls do not have enough range, you will have to locate and adjust the master brightness or screen/G2 pots.

Since you have high voltage, the horizontal deflection circuits are almost certainly working (unless there is a separate high voltage power supply - almost unheard of in modern TVs and very uncommon in all but the most expensive monitors).

Check for bad solder connections between the main board and the deflection yoke. Could also be a bad horizontal coil in the yoke, linearity coil, etc. There is not that much to go bad based on these symptoms assuming the high voltage and the horizontal deflection use the same flyback. It is almost certainly not an IC or transistor that is bad.

Single Horizontal Line

CAUTION: To prevent damage to the CRT phosphors, immediately turn down the brightness so the line is just barely visible. If the user controls do not have enough range, you will have to locate and adjust the master brightness or screen/G2 pots.

A single horizontal line means that you have lost vertical deflection. High voltage is most likely fine since there is something on the screen.

This could be due to:

1. Dirty service switch contacts. There is often a small switch located inside on the main board or perhaps accessible from the back. This is used during setup to set the color background levels. (On some sets, this is located on the CRT neck board and may be a jumper plug or other means of selecting service mode - not an actual switch.)

When moved to the 'service' position, it kills vertical deflection and video to the CRT. If the switch somehow changed position or got dirty or corroded contacts, you will have this symptom. Flip the switch back and forth a couple of times. If there is some change, then replace, clean, resolder, or even bypass it as appropriate.

2. Bad connection to deflection yoke or other parts in vertical output circuit. Bad connections are common in TVs and monitors. Check around the pins of large components like transformers, power transistors and resistors, or connectors for hairline cracks in the solder. Reseat internal connectors. Check particularly around the connector to the deflection yoke on the CRT.

3. Bad vertical deflection IC or transistor. You will probably need the service manual for this and the following. However, if the vertical deflection is done with an IC, the ECG Semiconductor Master Substitution guide may have its pinout which may be enough to test it with a scope.

4. Other bad parts in vertical deflection circuit though there are not that many parts that would kill the deflection entirely.

5. Loss of power to vertical deflection circuits. Check for blown fusable resistors/fuses and bad connections.

6. Loss of vertical oscillator or vertical drive signals.

The most likely possibilities are in the deflection output stage or bad connections to the yoke.

Keystone shaped picture

This means that the size of the picture is not constant from top to bottom (width changes) or left to right (height changes). Note that some slight amount of keystoning is probably just within the manufacturing tolerance of the deflection yoke and factory setup (geometry magnet placement, if any). On a TV, this is only noticeable with scenes having straight edges (e.g., video games) in relationship to the CRT bezel.

However, a sudden increase (and it will usually be rather substantial in a TV) may indicate a problem with the deflection yoke.

An open or short in a winding (or any associated components mounted on the yoke assembly) will result in the beam being deflected less strongly on the side where that winding is located. Typical TV yokes have fewer individual windings in parallel than high scan rate monitors so the effects of one such fault are more dramatic. See the section: Deflection yoke testing.

If the set has been dropped off a 20 story building, the yoke may have shifted its position on the neck, of the CRT resulting in all sorts of geometry and convergence problems (at the very least).

Loss of Horizontal Sync (also applies to vertical) after Warmup

The problem lies either in the horizontal oscillator or in the sync system. If it really is a problem with sync pulses not reaching the oscillator, the picture will move around horizontally and can be brought to hold momentarily with the hold control. If the picture breaks up into strips, there is a problem in the horizontal oscillator. Rotate the hold control: if the frequency is too far off, the picture will not settle into place at any adjustment of the hold control. Look around the horizontal oscillator circuit: all of the oscillator parts will be right there, or check on the horizontal oscillator module. Another horizontal problem can occur if the set is an RCA made from around 1972-1980: these sets are designed to slip very far off sync if the high voltage is too high, to protect against radiation. Turning up the brightness will decrease the number of bars if this system is in question, as the high voltage is decreasing. In this case, check around the high-voltage regulation system on the deflection systems board. I've had 2 1970's RCA's with this problem.

Intermittent jumping or jittering of picture or other random behavior

This has all the classic symptoms of a loose connection internal to the TV or monitor - probably where the deflection yoke plugs into the main PCB or at the base of the flyback transformer. TVs and monitors are notorious for both poor quality soldering and bad connections near high wattage components which just develop over time from temperature cycling. The problem may happen any time or more when cold or hot.

The following is not very scientific, but it works: Have you tried whacking the TV when this happened and did it have any effect? If yes, this would be further confirmation of loose connections.

What you need to do is examine the solder connections on the PCBs in the monitor, particularly in the area of the deflection circuits and power supply. Look for hairline cracks between the solder and the component pins - mostly the fat pins of transformers, connectors, and high wattage resistors. Any that are found will need to be reflowed with a medium wattage (like 40W) or temperature controlled soldering iron.

It could also be a component momentarily breaking down in the power supply or deflection circuits.

One other possibility is that there is arcing or corona as a result of humid weather. This could trigger the power supply to shut down perhaps with a squeak, but there would probably be additional symptoms including possibly partial loss of brightness or focus before it shut down. You may also hear a sizzling sound accompanied by noise or snow in the picture, static in the sounds, and/or a smell of ozone.

Horizontal output transistors keep blowing (or excessively hot)

Unfortunately, these sorts of problems are often difficult to definitively diagnose and repair and will often involve expensive component swapping.

You have just replaced an obviously blown (shorted) horizontal output transistor (HOT) and an hour (or a minute) later the same symptoms appear. Or, you notice that the new HOT is hotter than expected:

Would the next logical step be a new flyback (LOPT)? Not necessarily.

If the set performed normally until it died, there are other possible causes. However, it could be the flyback failing under load or when it warms up. I would expect some warning though - like the picture shrinks for a few seconds before the poof.

Other possible causes:

1. Improper drive to horizontal output transistor (HOT). A weak drive might cause the HOT to turn on or (more likely) shut off too slowly (greatly increasing heat dissipation. Check driver and HOT base circuit components. Dried up capacitors, open resistors or chokes, bad connections, or a driver transformer with shorted windings or broken or loose core can all affect drive waveforms.

2. Excessive voltage on HOT collector - check LV regulator (and line voltage if this is a field repair), if any.

3. Defective safety capacitors or damper diode around HOT. (Though this usually results in instant destruction with little heating).

4. New transistor not mounted properly to heat sink - probably needs mica washer and heat sink compound.

5. Replacement transistor not correct or inferior cross reference. Sometimes, the horizontal deflection is designed

based on the quirks of a particular transistor. Substitutes may not work reliably.

6. CRT shorting internally. If this happens only once in two weeks, it may be diffuclt to track down :-(.

The HOT should not run hot if properly mounted to the heat sink (using heatsink compound). It should not be too hot to touch (CAREFUL - don't touch with power on - it is at over a hundred volts with nasty multihundred volt spikes and line connected - discharge power supply filter caps first after unplugging). If it is scorching hot after a few minutes, then you need to check the other possibilities.

It is also possible that a defective flyback - perhaps one shorted turn - would not cause an immediate failure and only affect the picture slightly. This would be unusual, however. See the section: Testing of flyback (LOPT) transformers.

Note that running the set with a series light bulb may allow the HOT to survive long enough for you to gather some of the information needed to identify the bad component.

Horizontal output transistors blowing at random intervals

The HOT may last a few months or years but then blow again.

These are among the hardest problems to locate. It could even be some peculiar combination of user cockpit error - customer abuse - that you will never identify. Yes, this should not happen with a properly designed TV though newer horizontal processor chips are quite smart about preventing HOT killing signals from reaching the horizontal driver.

However, a combination of channel changing, loss of sync when switching video sources, and frequent power cycles, could test the TV in ways never dreamed of by the designers. It may take only one scan line that is too long to blow the HOT.

On the other hand, the cause may be along the lines of those listed in the section: Horizontal output transistors keep blowing (or excessively hot) and just not as obvious - blowing in a few days or weeks instead of a few seconds but in this case, the HOT will likely be running very hot even after only a few minutes.

Another possible cause for random failures of the HOT are bad solder connections in the vicinity of the flyback and HOT (very common due to the large hot high power components) as well as the horizontal driver and even possibly the sync and horizontal oscillator circuits, power supply, or elsewhere.

Vertical foldover

The picture is squashed vertically and a part of it may be flipped over and distorted.

This usually indicates a fault in the vertical output circuit. If it uses an IC for this, then the chip could be bad. It could also be a bad capacitor or other component in this circuit. It is probably caused by a fault in the flyback portion of the vertical deflection circuit - a charge pump that generates a high voltage spike to return the beam to the top of the screen.

Test components in the vertical output stage or substitute for good ones.

Comments on vertical problems

(From: Bert Christensen (bert.christensen@rose.com).)

As a general rule, vertical faults can be divided into two types: ones that cause geometric distortion (a circle will not be round) and those that simply black out a portion of the screen. The former are faults in the vertical oscillator, drive, or output stages. The latter are blanking faults. Blanking faults are almost always caused by electrolytic capacitors changing value and thereby changing the timing of the pulses which blank the screen during vertical retrace. In other words, the pulses are turning off the video signals at the wrong time.

The most common true vertical fault is geometric distortion and a foldover of white lines at the top of the screen. This is almost always caused by the electrolytic capacitor on or near the collector of the vertical output transistor or part of the IC which has the supply voltage (B+) on it. In the old tube days, the general rule was that bottom distortion was in the cathode of the output tube and distortion at the top was caused by a fault in the drive circuit.

Jagged or uneven vertical sweep

(From: Matthias Meerwein (Matthias.Meerwein@rt.bosch.de).)

I recently fixed two CRT display devices that both developed a very similar problem: The vertical deflection was severely "jagged" with uneven line spacing and partial vertical foldover. One patient was a nameless el-cheapo 28-inch TV (1988 made), the other one a 14 inch ADI SVGA monitor (1991 vintage).

My first suspicions were bad contacts on the PCB or yoke connectors or isolation / connectivity problems inside the yoke. However, as the picture didn't change with warmup or tapping, those causes could be ruled out. Examining the vertical deflection waveform with the scope showed the problem being a parasitic high frequency oscillation around the vertical output IC. On the TV, the oscillation extended over the entire scan period, while the monitor exhibited the problem only near the vertical current zero cross.

In both cases I found the capacitor of the RC damping network on the amp output to be at fault. Replacing it fixed the problem in both sets. This is not the well-known dried-up-electrolytic problem described in the FAQ. The culprits were mylar caps (.1 and .47 uF) looking completely unsuspicious. They were probably a bit underrated voltage-wise (40 volts) so I replaced them with 100 volts rated ones. The 2.2 ohms resistor in series with the cap was fine in both cases.

Excessive width/pincushioning problems

This would mean that the left and right sides of the picture are 'bowed' and the screen looks something like the diagram below (or the opposite - barrel distortion).

However, the obvious symptoms may just be excess width as the curved sides may be cut off by the CRT bezel.

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In particular, this sounds like a pincushion problem - to correct for pincushion, a signal from the vertical deflection that looks something like a rectified sinewave is used to modify width based on vertical position. There is usually a control to adjust the magnitude of this signal and also often, its phase. It would seem that this circuit has ceased to function.

If you have the schematics, check them for 'pincushion' adjustments and check signals and voltages. If not, try to find the 'pincushion' magnitude and phase adjustments and look for bad parts or bad connections in in the general area. Even if there are no adjustment pots, there may still be pincushion correction circuitry.

If the internal controls have absolutely no effect, then the circuit is faulty. With modern digital setup adjustments, then it is even tougher to diagnose since these control a D/A somewhere linked via a microprocessor.

Pincushion adjustment adds a signal to the horizontal deflection to compensate for the geometry of the CRT/deflection yoke. If you have knobs, then tracing the circuitry may be possible. With luck, you have a bad part that can be identified with an ohmmeter - shorted or open. For example, if the pincushion correction driver transistor is shorted, it will have no effect and the picture will be too wide and distorted as shown above.

However, without a schematic even this will be difficult. If the adjustments are digital this is especially difficult to diagnose since you don't even have any idea of where the circuitry would be located.

Faulty capacitors in the horizontal deflection power supplies often cause a similar set of symptoms.

Deflection yoke testing

A faulty deflection yoke can affect the geometry (size and shape) of the raster, result in insufficient high voltage and/or other auxiliary power problems, and blow various components in the low voltage power supply or elsewhere.

- A simple test to determine if the yoke is at fault for a major geometry problem (e.g., a keystone shaped picture) is to interchange the connections to the yoke for the axis that is not affected (i.e., the vertical coils if the width is varying from top to bottom). If the raster/picture flips (indicating that you swapped the proper connections) but the shape of the raster remains the same - the geometry is unchanged, the problem is almost certainly in the deflection yoke.

- Where high voltage (and other flyback derived voltages) are reduced and other problems have been ruled out, unplugging the deflection yoke (assuming no interlock) may reveal whether it is likely at fault. If this results in high voltage and a relatively clean deflection waveform or returns the power supply or deflection chip load to something reasonable, a defective yoke is quite possible.

  CAUTION: powering a TV or monitor with a disconnected yoke must be done with care for several reasons:

  - The CRT electron beam(s) will not be deflected. If it turns out that the yoke is the problem, this may result in a very bright spot in the center of the screen (which will turn into a very dark permanent spot quite quickly) :-(. Disconnecting only the winding that is suspect is better. Then, the other direction will still scan resulting in a very bright line instead of a super bright spot. In any case, make sure the brightness is turned all the way down (using the screen/G2 control on the flyback if necessary). Keep an eye on the front of the screen ready to kill power at the first sign of a spot or line. Disconnecting the CRT heater as an added precaution would be even better unless you need to determine if there is a beam.

  - Removing the yoke (which is effectively in parallel with the flyback) increases the inductance and the peak flyback voltage on the HOT. In the extreme, this may blow the HOT if run at full line voltage/normal B+. It is better to perform these tests using a Variac at reduced line voltage if possible.

- The deflection system will be detuned since the yoke inductance plays a very significant role in setting the resonance point in most designs. Don't expect to see totally normal behavior with respect to high voltage. However, it should be much better than with the faulty yoke.

- If possible, compare all measurements with a known good identical deflection yoke. Of course, if you have one, swapping is the fastest surest test of all! In many cases, even a not quite identical yoke will be close enough to provide useful information for testing. However, it must be from a similar piece of equipment with similar specifications - size and scan range. Don't expect a color TV yoke to work in a high performance SVGA monitor!

  Note: the substitute yoke doesn't have to be mounted on the CRT which would disturb purity and convergence adjustments but see the caution above about drilling holes in the CRT face plate!

The deflection yoke consists of the horizontal coils and vertical coils (wound on a ferrite core), and mounting structure. Little magnets or rubber/ferrite strips may be glued in strategic locations. DO NOT disturb them! In rare instances, there may be additional coils or other components mounted on the same assembly. The following deals only with the actual deflection coils themselves - the other components (if any) can be tested in a similar manner.

Where the test procedure below requires removal of the yoke, see the section: Removing and replacing the deflection yoke first.

- Horizontal - the horizontal section consists of an even number of windings hooked up in parallel/interleaved with half of the windings on each of the two ferrite core pieces.

  The horizontal windings will be oriented with the coil's axis vertical and mounted on the inside of the yoke (against the CRT neck/funnel). It may be wound with thicker wire than that used for the vertical windings.

  - Resistance check - This may be possible without removing the yoke from the CRT if the terminal block is accessible. Disconnect the individual windings from each other and determine if the resistances are nearly equal. Check for shorts between windings and between the horizontal and vertical windings as well.

    Typical resistance of the intact windings (at the yoke connector assuming no other components): TV or NTSC/PAL monitor - a few ohms (3 ohms typical), SVGA monitor - less than an ohm (.5 ohms typical).

  - Inspection - Look for charring or other evidence of insulation breakdown due to arcing or overheating. For the horizontal windings, this will require removing the yoke from the CRT since little if any of the windings are visible from the outside. However, even then, most of the windings are hidden under layers of wire or behind the ferrite core.

  - Ring test. See the document "Testing of Flyback (LOPT) Transformers". This deals with flyback transformers but the principles are the same. Disconnecting the windings may help isolate the location of a fault. However, for windings wound on the same core, the inductive coupling will result in a short anywhere on that core reducing the Q.

- Vertical - The vertical section is usually manufactured as a pair of windings wired in parallel (or maybe in series) though for high vertical scan rate monitors, multiple parallel/interleaved windings are also possible.

  The vertical windings will be oriented with the coil's axis horizontal and wound on the outside of the yoke. The wire used for the vertical winding may be thinner than that used for the horizontal windings.

  - Resistance check - This may be possible without removing the yoke from the CRT if the terminal block is accessible. Disconnect the individual windings from each other and determine if the resistances are nearly equal. Check for shorts between windings and between the horizontal and vertical windings as well.

Typical resistance of the intact windings (at the yoke connector assuming no other components): TV or NTSC/PAL monitor - more than 10 ohms (15 ohms typical), SVGA monitor - at least a few ohms (5 ohms typical).

- Inspection - Look for charring or other evidence of insulation breakdown due to arcing or overheating. The accessible portions of the vertical windings are mostly visible without removing the yoke from the CRT. However, most of the windings are hidden under layers of wire or behind the ferrite core.

- Ring test - Since the vertical windings have significant resistance and very low Q, a ring test may be of limited value.

Deflection yoke repair

So you found a big black charred area in/on one of the yoke windings. What can be done? Is it possible to repair it? What about using it for testing to confirm that there are no other problems before ordering a new yoke?

If the damage is minor - only a few wires are involved, it may be possible to separate them from each other and the rest of the winding, thoroughly clean the area, and then insulate the wires with high temperature varnish. Then, check the resistances of each of the parallel/interleaved windings to make sure that you caught all the damage.

Simple plastic electrical tape can probably be used for as insulation for testing purposes - it has worked for me - but would not likely survive very long as a permanent repair due to the possible high temperatures involved. A new yoke will almost certainly be needed.

Testing of flyback (LOPT) transformers

How and why do flyback transformers fail?

Flybacks fail in several ways:

1. Overheating leading to cracks in the plastic and external arcing. These can often be fixed by cleaning and coating with multiple layers of high voltage sealer, corona dope, or even plastic electrical tape (as a temporary repair in a pinch).

2. Cracked or otherwise damaged core will effect the flyback characteristics to the point where it may not work correctly or even blow the horizontal output transistor.

3. Internal shorts in the FOCUS/SCREEN divider network, if present. One sign of this may be arcover of the FOCUS or SCREEN sparkgaps on the PCB on the neck of the CRT.

4. Internal short circuits in the windings.

5. Open windings.

More than one of these may apply in any given case.

First, perform a careful visual inspection with power off. Look for cracks, bulging or melted plastic, and discoloration, Look for bad solder connections at the pins of the flyback as well. If the TV or monitor can be powered safely, check for arcing or corona around the flyback and in its vicinity, Next, perform ohmmeter tests for obvious short circuits between windings, much reduced winding resistances, and open windings.

For the low voltage windings, service manuals may provide the expected DC resistance (Sams' PhotoFact, for example). Sometimes, this will change enough to be detected - if you have an ohmmeter with a low enough scale. These are usually a fraction of an ohm. It is difficult or impossible to measure the DC resistance of the HV winding since the rectifiers are usually built in. The value is not published either.

Caution: make sure you have the TV or monitor unplugged and confirm that the main filter capacitor is discharged before touching anything! If you are going to remove or touch the CRT HV, focus, or screen wires, discharge the HV first using a well insulated high value resistor (e.g., several M ohms, 5 W) to the CRT ground strap (NOT signal ground. See the section: Safe discharging of capacitors in TVs and video monitors.

Partially short circuited windings (perhaps, just a couple of turns) and sometimes shorts in the focus/screen divider will drastically lower the Q and increase the load the flyback puts on its driving source with no outputs connected. Commercial flyback testers measure the Q by monitoring the decay time of a resonant circuit formed by a capacitor and a winding on the flyback under test after it is excited by a pulse waveform. It is possible to easily construct testers that perform a well. See the companion document Testing of Flyback (LOPT) Transformers for further information.

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High Voltage Power Supply Problems

HV power supply fundamentals

Most, if not all, TVs derive the high voltage for the CRT second anode, focus, and (sometimes) screen (G2) from the horizontal deflection system. This technique was developed quite early in the history of commercial TV and has stuck for a very simple reason - it is very cost effective. A side effect is that if the horizontal deflection fails and threatens to burn a (vertical) line into the CRT phosphors, the high voltage dies as well.

Most TV high voltage supplies operate as follows:

1. Horizontal output transistor (HOT) turns on during scan. Current increases linearly in primary of flyback transformer since it appears as an inductor. Magnetic field also increases linearly. Note: flyback is constructed with air gap in core. This makes it behave more like an inductor as far as the primary drive is concerned.

2. HOT shuts off at end of scan. Current decreases rapidly. Magnetic field collapses inductively coupling to secondary and generates HV pulse. Inductance and capacitance of flyback, snubber capacitors, and parasitic capacitance of circuitry and yoke form a resonant circuit. Ideally, voltage waveform across HOT during flyback (retrace) period will be a single half cycle and is clamped by damper diode across HOT to prevent undershoot.

3. Secondary of flyback is either a single large HV winding with HV rectifiers built in (most often) or an intermediate voltage winding and a voltage multiplier built in or a separate unit (see the section: What is a tripler?. The output will be DC HV pulses.

4. The capacitance of the CRT envelope provides the needed filtering to adequately smooth the HV pulses into a DC voltage.

5. A high resistance voltage divider provides the several kV focus voltage and sometimes the several hundred volt

screen (G2) voltage as well. Often, the adjustments for these voltages are built into the flyback. Sometimes they are mounted separately. The focus and screen are generally the top and bottom knobs, respectively.

What is a tripler?

In some TVs, the flyback transformer only generates about 6-10 kV AC which is then boosted by a diode-capacitor ladder to the 18-30 kV needed for modern color CRTs. The unit that does this is commonly called a tripler since it multiplies the flyback output by about 3 times. Some TVs use a quadrupler instead. However, many TVs generate the required HV directly with a winding with the required number of turns inside the flyback transformer.

Triplers use a diode-capacitor ladder to multiply the 6-10 kV AC to 18-30 kV DC. Many triplers are separate units, roughly cubical, and are not repairable. Some triplers are built in to the flyback - it is probably cheaper to manufacture the HV diodes and capacitors than to wind a direct high voltage secondary on the flyback core. In either case, failure requires replacement of the entire unit.

For external multipliers, the terminals are typically marked:

- IN - from flyback (6-10 kV AC).
- OUT - HV to CRT (20-30 kV DC).
- F - focus to CRT (2-8 kV).
- CTL - focus pot (many megohm to ground).
- G, GND, or COM - ground.

Symptoms of tripler failure are: lack of high voltage or insufficient high voltage, arcing at focus protection spark gap, incorrect focus voltage, other arcing, overload of HOT and/or flyback, or focus adjustment affecting brightness (screen) setting or vice-versa. Where there is overloading, if you disconnect the tripler and everything else comes back to life (obviously, there will be no HV or picture), then it is very likely bad.

High voltage shutdown due to X-ray protection circuits

A TV that runs for a while or starts to come on but then shuts down may have a problem with the X-ray protection circuitry correctly or incorrectly determining that the high voltage (HV) is too great (risking excessive X-ray emission) and shutting everything down.

A side effect of activation of this circuitry is that resetting may require pulling the plug or turning off the real (hard) power switch.

Was there anything else unusual about the picture lately that would indicate an actual problem with the HV? If this is the case, then there may be some problem with the HV regulation. If not, the shutdown circuit may be overly sensitive or one of its components may be defective - a bad connection of leaky cap (or zener).

If the horizontal frequency is not correct (probably low) due to a faulty horizontal oscillator or sync circuit or bad horizontal hold control (should one exist!), HV may increase and trigger shutdown. Of course, the picture won't be worth much either!

One symptom of excessive HV (but not required) is an overly bright picture of reduced size.

The HV shutdown circuit usually monitors a winding off of the flyback for voltage exceeding some reference and then sets a flip flop shutting the horizontal drive off.

On some Sony models, a HV resistive divider performs this function and these do fail - quite often. The big red Hstat block is a common cause of immediate or delayed shutdown on certain Sony monitors and TVs. See the section: Sony TVs/monitors and Hstat.

Low or no high voltage

Most of these problems are due to faults in the horizontal deflection system - shorted HOT, shorted windings or HV rectifiers in the flyback, defective tripler, or other bad parts on the primary side of the flyback.

However, if you discover an inch layer of filth inside the TV, the HV could simply be shorting out - clean it first.

In most cases, these sorts of faults will put an excessive load on the horizontal output circuits so there may be excessive heating of the HOT or other components. You may hear an audible arcing or sizzling sound from internal shorts in the flyback or tripler. Either of these may bet hot, crack, bulge, or exhibit visible damage if left on with the fault present.

Most modern TVs do not regulate HV directly but rather set it via control of the low voltage power supply to the HOT (B+), by snubber capacitors across the HOT, and the turns ratio of the flyback. The HV is directly related to the B+ so if this is low, the HV will be low as well. Faulty snubber capacitors will generally do the opposite - increase the HV and the X-ray protection circuits may kick in. However, low HV is also a possibility. The only way the turns ratio of the flyback can change is from a short which will manifest its presence in other ways as well - excessive heating and load on the horizontal output circuits.

While a shorted second anode connection to the CRT is theoretically possible, this is quite unlikely (except, as noted, due to dirt).

Excessive high voltage

Any significant increase in HV should cause the X-ray protection circuits to kick in and either shut down the set or modify the deflection in such a way as to render it harmless.

Symptoms include arcing/sparking of HV, smaller than normal picture, and under certain scenarios, possible excessive brightness.

Causes of the HV being too high are:

1. Excess B+ voltage to the HOT. The likely cause is to a low voltage regulator failure.

2. Open snubber capacitors across the HOT. These are under a lot of stress and are located near hot components so failure is possible.

3. Incorrect excessively long scan drive to HOT caused by failure of horizontal oscillator/sync circuits. However, other things like the HOT will probably blow up first. The picture will definitely be messed up.

4. Failure of HV regulator (tube sets and a few solid state sets - actual HV regulators are relatively uncommon today.) This may result in an underscanned (smaller than normal) picture.

Snaps, crackles, and other HV breakdown

Various problems can result in occasional or sustained sparking or arcing sounds from inside the monitor. Note that a static electricity buildup is common on the front of the screen. It is harmless and there iss nothing you can do about it anyhow.

The following may result in occasional or sustained sounds not commonly associated with a properly working TV or monitor. There may or may not be flashes or blanking of the screen at the same time as the audible noise. See the same-named sections that follow for details.

- Arcing, sparking, or corona from CRT HV anode (red wire/suction cup).
- Arcing at CRT sparkgaps.
- Arcing from flyback or vicinity.
- Arcing due to bad connections to or disconnected CRT return.
- Flashovers inside the CRT.

Arcing, sparking, or corona from CRT HV anode (red wire/suction cup)

Symptoms could include a sizzling corona or more likely, an occasional or rapid series of sharp snaps - possibly quite loud and quite visible - from the anode connection (at the suction cup) on the CRT to the grounded coating on the outside of the CRT or a chassis ground point (or any other conductor nearby). Corona is a high resistance leakage through the air without total breakdown. The snapping is caused by the sudden and nearly complete discharge of the CRT anode capacitance through a low resistance ionized path similar to lightning.

There are two likely causes:

1. Dirt, dust, grime, around and under the suction cup on the CRT are providing a discharge path. This may be more severe in humid weather. Safely discharge the HV and then remove and thoroughly clean the HV suction cup and the area under it and on the CRT for several inches around the HV connection. Make sure there are no loose wires or other possible places for the HV to discharge to in the vicinity.

2. The high voltage has gone through the roof. Usually, the X-ray protection circuitry should kick in but it can fail. If cleaning does not help, this is a likely possibility. See the sections: "High voltage shutdown due to X-ray protection circuits" and "Excessive high voltage".

Arcing from flyback or vicinity

Arcing may be visible or audible and result in readily detectable levels of ozone. Note that very slight traces of ozone may not indicate anything significant but if the TV smells like an office copier, there is probably some discharge taking place.

WARNING: It is possible for arcing to develop as a result of excessive high voltage. Symptoms might be a smaller than normal excessively bright picture but this may not be able to be confirmed until the flyback is repaired or replaced. See the section: Excessive high voltage.

- On the HV output, it will probably be a loud snapping sound (due to the capacitance of the CRT) with associated blue/white sparks up to an inch or more in length. If the arc length is short enough, this may turn into a nearly continuous sizzling sound with yellow/orange arc and melting/burning plastic.

- Prior to the HV rectifier, it will likely be a continuous sizzle with orange/yellow/white arc and melting/burning plastic or circuit board material.

- Internal arcing in the flyback may be audible and eventually result in a bulging and/or cracked case (if some other component doesn't fail first as this would take some time to develop).

- A corona discharge without actual sparks or a visible well defined arc is also possible. This may be visible in a totally dark room, possibly more likely when the humidity is high. A thorough cleaning to remove all dust and grime may be all that is needed in this case.

- If the arc is coming from a specific point on the flyback - a crack or pinhole - this may be patched well enough to confirm that the rest of the TV is operational and a new flyback is worth the money. Otherwise, there is no way of knowing if the arcing may have damaged other circuitry until a replacement flyback - possibly money wasted - arrives.

  To attempt a repair, scrape off any dirt or carbon that is present along the path of the arcing and its vicinity. Then, clean the area thoroughly with alcohol and dry completely. Otherwise, the dirt and carbon will just act as a good conductor and the arcing will continue under your repair! Several layers of plastic electrical tape may be adequate for testing. Multiple coats of high voltage sealer or non-corroding RTV silicone (if it smells like vinegar - acetic acid - as it cures, this may get in and affect the windings) would be better if the objective is an actual repair. A thick layer of Epoxy may be even better and affected less by possible HV corona. Either of these may prove to be a permanent fix although starting the search for a source for a new flyback would not hurt just in case. The arc most likely did damage the insulation internally which may or may not be a problem in the future.

  Also see the section: Dave's complete procedure for repair of an arcing flyback.

- In some cases, the pinhole or crack is an indication of a more serious problem - overheating due to shorted windings in the flyback or excessive secondary load.

- If the arc is from one of the sparkgaps around the CRT, the CRT socket, or the plastic 'alignment base' on the CRT itself, this could also be a flyback problem indicating internal shorts in the focus/screen network.

- If the arcing is inside the CRT, this could indicate a bad CRT or a problem with the flyback focus/screen network and no or inadequate sparkgap protection.

Where repair seems possible, first, clean the areas around the arc thoroughly and then try several layers of plastic electrical tape. If the TV works normally for say, an hour, then there is probably nothing else wrong and you can try for a proper sealing job or hope that tape holds out (put a few more layers on - each is good for about 8-10 kV theoretically).

However, replacement of the flyback really is the best alternative to minimize risk of future problems. This is the only option where there could be a potential issue of liability should subsequent failure result in a fire.

Once I had a TV where the main problem was a cracked flyback arcing but this took out one of the fusable resistors for the power supply to the *vertical* output so the symptoms included a single horizontal line. Don't ask me to explain - replacing that resistor and the flyback (the flyback tested good, but this was for someone else) fixed the TV.

In another case, a pinhole developed in the flyback casing probably due to poor plastic molding at the time of manufacture. This resulted in a most spectacular case of sparking to a nearby bracket. A few layers of electrical tape was all that was needed to affect a permanent repair.

Dave's complete procedure for repair of an arcing flyback

(From: Dave Moore (penguin@datastar.net).

First I clean the afflicted area with Electromotive spray from Autozone. It's for cleaning alternators. On Z-line I remove the focus control and wash with the alternator cleaner and a tooth brush until all dirt and carbon deposits are removed. Then I take an xacto knife and carve out the carbonized hole where the arcing broke through. Then take your soldering iron and close the hole by melting adjacent plastic into it. (clean any solder off your iron with solder-wick first). Then cut some plastic off of some other part off the flyback where it wont be needed and use this to plastic weld (with your iron) a hump of a patch into and over the arc hole. Smooth and seal with iron. Next apply as thick a layer of silicone rubber as you can and let dry overnight.

Arcing at spark gaps and gas discharge tubes on CRT neck board or elsewhere

These are protective devices intended to breakdown and divert excessive voltage away from the CRT (usually).

This is rarely due to a defective sparkgap or gas discharge tube but rather is a safety mechanism like a fuse designed to protect the internal electrodes of the CRT if the focus or screen voltage should become excessive. The sparkgap breaks down first and prevents internal arcing in the CRT. These sparkgaps may be built into the CRT socket as well.

Arcing at a sparkgap or a glowing or flashing discharge tube may be accompanied by total loss of picture or bad focus, brightness or focus fluctuations, or any of a number of similar symptoms. A common cause is a breakdown inside the focus divider (usually part of the flyback or tripler) but could also be due to excessive uncontrolled high voltage due to a failure of the B+ regulator or HOT snubber capacitor, or (ironically) even a short inside the CRT.

- Spark gaps may be actual two or three pin devices with seemingly no insides, part of the CRT socket, or printed on the circuit board itself.

- Gas discharge tubes look like small neon lamps (e.g., NE2) but could be filled with some other gas mixture to provide a controlled higher breakdown voltage.

Therefore, like a fuse, don't just replace or disable these devices, locate and correct underlying problem. The CRT makes an expensive fuse!

Arcing due to bad connections to or disconnected CRT return

The Aquadag coating on the outside of the CRT is the negative plate of the HV filter capacitor. If this is not solidly connected to the HV return, you will have your 25 kV+ trying to go where it should not be. There should be a wire solidly attached to the CRT neck board or chassis. Without this, voltage will build up until it is able to take some other path - possibly resulting in damage to sensitive solid state components in the process. Therefore, is is important to rectify the situation.

Warning: If you find this disconnected, don't just attach it anywhere. You may instantly kill ICs or other solid state components. It must be connected to the proper return point on the CRT neck board or chassis.

Flashovers inside the CRT

Due to sharp edges on the electron gun electrodes, impurities, and other manufacturing defects, there can be occasional arcing internal to the CRT. Properly designed HV, deflection, and power supply circuits can deal with these without failing but not all monitors are designed well.

There is nothing you can do about flashovers assuming your HV is not excessive (see the section: Excessive high voltage. If these persist and/or become more frequent, a new CRT or new TV will be needed.

Ozone smell and/or smoke from TV

Smoking is just as bad for TVs as for people and usually more quickly terminal.

White acrid smoke may indicate a failed electrolytic capacitor in the power supply probably in conjunction with a shorted rectifier. Needless to say, pull the plug at once.

A visual inspection should be able to easily confirm the bad capacitor as it will probably be bulging and have condensed residue nearby. Check the rectifier diodes or bridge rectifier with an ohmmeter. Resistance across any pair of leads should be more than a few ohms in at least one direction. Remove from the circuit to confirm. Both the faulty diode(s) and capacitor should be replaced (though the capacitor may work well enough to test with new diode(s).

If a visual inspection fails to identify the smoking part, you can probably plug the set in for a few seconds until the source of the smoke is obvious but be prepared to pull the plug in a real hurry.

If the smell/smoke is coming from the flyback, then it has probably gone belly up. You may be able to see a crack or bulge in the case. While the flyback will definitely need to be replaced, it is likely that nothing else is wrong. However, it might be prudent to use a Variac when performing initial testing with the replacement just in case there is a secondary short circuit or excess HV problem.

X-ray and other EM emission from my TV or monitor?

X-ray radiation is produced when a high velocity electron beam strikes a target containing heavy metals. In a modern TVs and monitors, this can only take place at the shadow mask/aperture grille and phosphor screen of the CRT.

For X-rays, the amount of radiation (if any) will be proportional to brightness. The energy (determined by the CRT high voltage, called kVP in the medical imaging field) is not affected. This is one reason many monitors and TVs are designed with brightness limiting circuits.

In any case, there will be virtually no X-ray emissions from the front of the CRT as the glass is greater than an inch thick and probably contains some lead for added shielding. Also see the section: Should I be worried about X-ray exposure while servicing a TV or monitor?.

Electromagnetic radiation (EM) is produced mostly from the deflection yoke and to a lesser extent from some of the other magnetic components like transformers and inductors. Depending on monitor design (some are specifically designed to reduce this), EM emissions can vary quite a bit. Frequencies range from the 50/60 Hz of the power line or vertical scan rate to several hundred kHz in the AM broadcast band. The intensity and spectral distribution will vary depending on horizontal and vertical scan rate.

A totally black screen will reduce X-ray emission to zero. It will not affect EM emissions significantly as most of this comes from the magnetic parts, particularly the deflection yoke.

There is no measurable microwave, IR, or UV radiation.

I refuse to get into the discussion of what, if any, health problems result from low level EM emissions. There is simply not enough data.

Should I be worried about X-ray exposure while servicing a TV or monitor?

The only source of X-rays in a modern TV or monitor is from the CRT. X-rays are generated when a high velocity electron beam strikes a heavy metal target. For anything you are likely to encounter, this can only happen in a vacuum - thus inside the CRT. The higher the voltage, the greater the velocity and potential danger. Really old TVs (prior to around 1975) may still have HV rectifier and regulator tubes - other sources of X-rays. However, modern TVs and monitors implement these functions with solid state components.

The thick front CRT faceplate protects users adequately but there may be some emission from the thinner sides. At 25-30 kV (quite low as X-ray energies go) X-rays will be stopped by almost any metal so what you have to worry about is where there are no shields.

Other than lowering the brightness (or high voltage!), there isn't anything you can do to reduce X-ray emission from the front of the monitor. Any sort of add-on screen (grounded or otherwise) unless it is made of thick leaded glass, will have no significant effect on X-rays. If you are still concerned, sit farther away.

However, realistically, there is very little danger. I would not worry about exposure unless you plan to be sitting for hours on the sides, behind, or under the TV or monitor - with a picture (there will be none if the screen is black).

It is interesting that even those 1.5" Watchman and .5" camcorder viewfinder CRTs have X-ray warning labels even though the high voltage used with these isn't anywhere near high enough to be of any concern!

More on radiation from TVs and monitors

(From: Jerry Greenberg (jerryg50@hotmail.com).)

Your standard TV set or monitor should not exceed about 0.2 mR/Hr of radiation from a distance of 5 cm from any part of the cabinet. Most TV monitor equipment is less than half of this amount.

The CRT has a coating on the inner wall of its glass envelope, and also there is a metal shadow mask or aperture grill in the front. There is also a metal shroud around its parameter.

The type of emission from the CRT is known as soft X-Ray emission. This is because it is low power, and is in the lower X-Ray region.

The X-Ray emission is strongest at the rear of the TV set because there is some opened area where the electron gun is located. But, this is very weak as well. The radiation from a TV or monitor is not being focused to one point, and is also below the threshold level of being dangerous.

The long term effect of the total radiation from normal operating TV equipment is not fully known. However, the effect of X-Ray radiation is accumulative over time if there are no breaks in between the exposures. As for standard focused X-Rays like the ones used in a medical or security facility, these and most of their effects are well known.

As for normal working TV equipment, when used normally, the total radiation is less that what you would get when walking on the street. There are many satellites beaming down signals, radio and TV broadcast stations, communications systems, and then cell phones.

The X-Ray radiation in a TV set is emitted from the effect of the High Voltage drive generating the electron beam. If the High Voltage exceeds the designed safety limit for the CRT, then there is concern that the X-Ray radiation may have some effect on anyone that is in close proximity to the CRT. The amount of by which the high voltage exceeds the design specfifications will determine the total X-Ray emission. Since this emission is not focused into a fine area, its immediate danger is also greatly reduced.

All TV sets by law must have in their design some type of protection to shut the TV down if there is excessive High Voltage, excessive High Voltage current drive, and a number of other safety criterias.

There is also the concern about electromagnetic radiation. In fact all radio frequencies are based on electromagnetic radiation (EMR).

There was a great concern about the low frequency EMR. This would come from the power supply, deflection amplifier stages, and then from the deflection yoke and flyback transformer. There different types of EMR from TV sets.

Concerning TV's and monitors, this radiation worry comes up from time to time. If a woman is pregnant it would be wiser for her to not expose the unborn baby by working close to a terminal or monitor. This nonexposure is a good policy to make sure that everyone is safe rather than suffer any type of damage or health risks.

As for a safety concern for a mother to be, or a small baby, they can be in front of a TV set but at least 5 to 7 feet away. From this distance there should not be any danger at all.

The above is from my personal observations and is very general. I have also read various publications over the years that pertain to this subject.

I have a personal concern about the radiation from TV sets and monitors because I do an extensive amount of service on these. I am also doing a lot of picture tube changes in monitor equipment. I am then exposed for a few hours because I must do the purity and convergence setups of these sets. I have some days where I work 10 to 12 hours doing TV and monitor service work.

If you want a TV monitor that will put out near zero X-Ray radiation, and very low electromagnetic radiation, then go for one of the new LCD flatscreen monitors.

Flyback shot by 4 year old with water pistol

Your 4 year old son shot the Sony in the flyback transformer. Smoke and sparks everywhere. Great aim!

Who says these FAQs cannot be funny?

Needless to say, unplug the set immediately. Inspect around the target area for obviously blown or damaged components. Test fuses and fusable resistors. Repair burnt solder connections and circuit board traces. Once the set is entirely dried out, power it up - preferably through a series light bulb and/or Variac until you are sure nothing else will let loose. Look, listen, and smell for any unusual behavior. If it now works, then consider yourself lucky. If not, there may be damage to transistors, ICs, or other components.

(From: Richard Symonds (edison@nelson.planet.org.nz).)

We're seeing another 'hazard' these days, people cleaning their television screens with window cleaner - no problem in the days of separate chassis but with the entire circuit board jammed under the tube on most TVs these days just a few drips and its all over. Some have just corroded the switch banks (had one recently just got into the A/V switch - when you walked around the room the set changed to A/V and back by itself!) but a few have got around the microprocessors and surface mount components and resulted in complete write-offs. I suppose the damage is the opposite of electroplating as the microprocessors have constant voltage to them. Never mind, they'll be a good source of parts for future use.

Blooming or breathing problems

There are several symptoms that are basically similar:

- Blooming is defined as an expansion of the raster or horizontal sections of the raster with bright material. For example, switching between dark and light picture causes the size of the picture to expand by 10%. A slight change in size is unavoidable but if it is greater than 1 or 2 percent from a totally black image to a full white one, this is either an indication of a defective TV or one that is badly designed. The cause is poor low or high voltage regulation.

  Check the B+ to the horizontal deflection. This is usually well regulated. If it is varying in sympathy to the size changes, trace back to determine why the low voltage regulator is not doing its job. The reason for the size change is that the high voltage is dropping and reducing the stiffness of the electron beam.

- Expansion of the raster width in areas of bright imagery is an indication of short term regulation problems. The video drive may be interacting with the other power supplies. Check for ripple - this would be at the vertical scan rate - in the various regulated power supplies. The cause may be a dried up electrolytic capacitor - once you locate the offending voltage, test or substitute capacitors in that supply.

In both these cases, if this just started after some work was done to the TV, the brightness limiter and/or video drive may simply be set so high that the TV cannot supply enough current to the high voltage. If the brightness is acceptable with these turned down slightly and still have acceptable brightness, then there may be nothing wrong.

- Breathing is defined as a periodic change in the size of the raster which may be independent of what is displayed or its severity or frequency may be related to the brightness or darkness of the image. This is another type of regulation problem and may be caused by bad electrolytic capacitors or other components in the low voltage power supplies.

  If the TV uses a switchmode power supply or low voltage regulator separate from the horizontal deflection, first check its output(s) for a variation in voltage at the breathing rate. Test with a light bulb or resistor load to confirm that the problem is here and not the deflection or other subsystem of the TV.

- A condition with somewhat similar symptoms is bad focus - fuzzy picture - but only with bright (high beam current) scenes. This could be just a matter of adjusting the focus control but may also indicate sub-optimal filament voltage due to bad connections or components in the filament circuit, or a tired worn CRT. You won't get high beam current without some serious spot blooming (a fat beam because too much cathode area is used) and you will get cathode 'poisoning' after prolonged use.

  Visually inspect the neck of the CRT for the normal orange glow of the filaments and check for bad connections and bad parts.

Erratic focus or screen (G2) voltage and/or controls on flyback

Symptoms may include fluctuating focus or brightness. In extreme cases, the result may be a too bright or dark picture or other behavior caused by breakdown in the Focus/Screen(G2) divider network.

Usually, this will require flyback replacement to repair reliably. Sometimes, the section with the controls can be snapped apart and cleaned but this is not common.

First, just try rotating the screen (G2) control back and forth a few times. This may clean up the contacts and eliminate the erratic behavior. Possibly, positioning it a bit to one side of the original location will help. Then, use the individual or other master background/bias adjustments to compensate for the improper brightness.

If pressing in on the erratic control helps to stabilize the setting, you might try adjusting it to the optimal position and then put a dab of hot-melt glue (or Superglue if you can manage not to stick your fingers together) on the shaft to hold it with a little more contact force.

If none of this helps, here is a 'well it's going in the dumpster anyhow' procedure to try:

After discharging the CRT (so you don't get zapped) drill a tiny hole in the plastic cover near the bad control. Be careful you don't damage anything inside - you just want access to the contacts of the controls. Use a hand drill with, say, a 1/16" bit. Don't drill more than about 1/8" deep which should enter the airspace. Then spray some contact cleaner through the hole and work the controls. Wait sufficient time (say, 24 hours) for everything to dry COMPLETELY and see if behavior changes (or it works at all).

This is a 'you have got to be kidding' type of repair so no guarantees :-).

If by some miracle it does work, fill the hole with a drop of RTV or just put a couple of layers of electrical tape over it.

Focus/Screen divider bypass surgery

This is kludge number 41256 but may be the difference between a bit more life and the dumpster.

If the previous extreme measures don't help, then it may be possible to simply substitute a good divider network externally.

Note that if there is evidence of internal breakdown in the divider of the original flyback (hissing, cracks, overheating, bulging case, etc.), this will not work unless you can disconnect it from its HV connection.

There are two issues:

1. Is this a stable situation? Even if you provide an external substitute, the parts inside the flyback may continue to deteriorate eventually resulting in other more total failure of the flyback or worse.

2. If you provide an external focus/screen divider, it must be done is such a manner (including proper mounting and super insulation) such that it cannot be called into question should there be a fire where the monitor is even the slightest bit suspect.

Various size external focus/screen divider networks can be purchased but whether this is truly a cost effective solution is not obvious.

(From: Larry Sabo (sabo@storm.ca).)

I just ordered a 'bleeder resistor' from Data Display Ltd (Canadian sub of CCS) to use as a cure for flybacks with flaky focus/screen pots. It contains focus and screen pots, and costs Cdn$ 16.99, which is a lot less than a complete flyback, that's for sure. I expect it will be compatible with quite a wide range of flybacks.

I have used bleeder resistor assemblies from duff flybacks a couple of times with good success. You connect the HV lead into the HV cap of the original flyback, ground all pins of the sub flyback, and use the focus and screen leads from the sub bleeder assembly in place of the originals.

Looks like hell but works fine. Mounting (and securing) the substitute is a challenge given the limited space available. I only use this approach on what would otherwise be uneconomical to repair, and always advise the owner or customer of the cobbling job. It also enables you to verify whether it is the flyback that needs replacement, versus the CRT.

Decaying or erratic focus or screen (G2) voltages

The following applies to both CRT focus voltage (which should be a few kV) and screen or G2 voltage (which should be several hundred V).

> "The screen voltage will come up to normal after sitting over night, 400 V or so. After approximately 5 minutes or slightly longer, I hear a slight arcing. From that point on, the screen voltage will wander anywhere from 75 V up to maybe 150 V. Adjustment of the screen control on the flyback has only a small effect and is not permanent. Removing the CRT pcb results in the screen voltage returning to normal."

This is very likely a short between electrodes inside the CRT unless there is something on the neck board that is breaking down as a result of some connection to the CRT. The flyback should largely not know the difference with the socket plugged into the CRT. However, on rare occasions, there is contamination within the 'plastic alignment base' on the end of the CRT neck. (It is possible to *carefully* remove the plastic piece and clean the CRT glass/pins. Reinstall the plastic piece if it is still intact or leave it off - just take care in replacing the CRT neck board.)

One possibility is that glue used to hold components down on some circuit boards has deteriorated and turned conductive. Check for tan to brown stuff shorting traces on the CRT neck board. If this is present on the focus or screen traces or wires, it may just be your problem. Scrape off all of the old glue and then clean thoroughly. Repair any damaged traces.

What happens to the HV? A HV breakdown possibly inside the CRT would result in all the voltages being dragged down.

What happens to the picture?

If you connect a charged HV capacitor (guessing a couple hundred volts, a couple microfarads) between G2 and G1 or focus, you **will** know if tapping the neck results in a momentary short! I cannot predict whether this will be a temporary cure or permanent killer. See the section: Rescuing a shorted CRT.

Here is another thing to try: put a 100 M ohm or so resistor between SCREEN and the CRT socket. This should not affect the behavior much until the failure occurs. Then, check the voltage on both sides with a high impedance voltmeter (1000 M). If the CRT is arcing, it will be much lower on the CRT side and will probably fluctuate. You can play similar games with focus voltage.

Disconnecting flyback wire(s) from CRT driver board

In some cases, there may be one or more separate wires running to directly to the CRT socket. These are typically for focus which has a relatively high voltage so better insulation is needed but there may be no obvious means of removal should flyback replacement be needed.

One alternative is simply to cut the wire(s) in a location that is well away from any place to short out, solder, and then do a most excellent job of insulating the splice. If there is more than one wire, make sure to label them first if they aren't color coded.

However, you may find that the cap on the CRT socket snaps off using a thin knife blade or screwdriver. The wire may be soldered or just pressed in place in such a way that pulling it out is difficult or impossible without removing the cover. If there is more than one wire, label them before removal unless the locations are clearly marked. Sometimes the color is stamped on the plastic but there may just be a designation like "A" and "B".

(From: Raymond Carlsen (rrcc@u.washington.edu).)

The last one I worked on puzzled me for a few moments. See if you can see a space between the little cup (where the wire enters the socket) and the socket itself. Pry up on the cap with a knife and it should pop right off. The wire is soldered to a pin under it. Don't apply heat for very long... you may melt the socket.

Focus or screen voltage drifts after warmup only when CRT is connected

> "I have a 3-5 yr old TV that loses screen voltage. I believe that the problem is specific to the CRT or the flyback, either one is a guess I'd rather be sure of prior to ordering a part.
>
> The screen voltage will come up to normal after sitting over night, 400 V or so. After approximately 5 minutes or slightly longer, I hear a slight arcing. From that point on, the screen voltage will wander anywhere from 75 V up to maybe 150 V. Adjustment of the screen control on the flyback has only a small effect and is not permanent. Removing the CRT pcb results in the screen voltage returning to normal.

> I cannot find the source of the arcing, as it happens quickly and I have always been on the other side of the set when it happens. I have replaced the CRT socket, thinking the spark gap was arcing. I have checked the CRT for G1 and HK shorts on a sencore CRT checker, it checks good, but I am aware that since it is an intermittent problem, that the checker probably will not catch it."

This is very likely a short between electrodes inside the CRT unless there is something on the neck board that is breaking down as a result of some connection to the CRT. The flyback should largely not know the difference with the socket plugged into the CRT. However, on rare occasions, there is contamination within the 'plastic alignment base' on the end of the CRT neck. (It is possible to *carefully* remove the plastic piece and clean the CRT glass/pins. Resinstall the plastic piece if it is still intact or leave it off - just take care in replacing the CRT neck board.)

One possibility is that glue used to hold components down on some circuit boards has deteriorated and turned conductive. Check for tan to brown stuff shorting traces on the CRT neck board. If this is present on the focus or screen traces or wires, it may just be your problem. Scrape off all of the old glue and then clean thoroughly. Repair any damaged traces.

What happens to the HV? A HV breakdown possibly inside the CRT would result in all the voltages being dragged down.

What happens to the picture?

If you connect a charged HV capacitor (guessing a couple hundred volts, a couple microfarads) between G2 and G1 or focus, you **will** know if tapping the neck results in a momentary short! I cannot predict whether this will be a temporary cure or permanent killer.

Here is another thing to try: put a 100 M ohm or so resistor between SCREEN (or FOCUS) and the CRT socket. This should not affect the behavior much until the failure occurs. Then, check the voltage on both sides with a high impedance voltmeter (>1000 M). If the CRT is arcing, it will be much lower on the CRT side.

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Raster, Color, and Video Problems

No color - black and white picture

This means absolutely no color - equivalent to a black and white picture. Not even a hint of color.

First, confirm that the source is actually in color - try another channel or input device.

Next, check the settings of the color control - it may have accidentally been turned down. If your TV has some kind of automatic picture mode, try turning if off and adjusting the color control. Try adjusting fine tuning if you have such a control and the problem is with a broadcast or cable transmission.

At this point with a confirmed color signal source, there is a problem with the chroma circuitry.

Note that to the average person, the obvious question becomes: is my color picture tube bad? The answer is a definitive NO. It is virtually impossible for a defective CRT to cause a total loss of color. A defective CRT can cause a lack of a primary color - R, G, or, B or a short between two colors which will mess up the color but is not likely to result in a black and white picture.

Some possibilities in no particular order:

1. Weak signal or defect in tuner/IF causing loss of signal strength.

2. Coler killer set too high (internal control) if it has one.

3. Defective part around the chroma chip/circuit. Faulty color oscillator.

4. Bad connections in area of chroma chip/circuit.

5. Defective chroma chip (don't suspect this first just because it is probably very expensive).

A service manual or Sams', DMM, and scope will help greatly in attempting to troubleshoot this unless it is an obvious bad connection. Try prodding the main board around the chroma chip with an insulated tool to see if you can make the color come and go.

I had one set where a $.02 resistor decided to open up causing just this problem - perfect BW picture, no color. Another had a coil with a broken wire.

Saturated color but almost no brightness

This means you have lost the luminance input to the chroma decoder or final video chip. A failure of the brightness limiter may result in similar symptoms.

A few common causes are:

- Check the service switch (if any). Its contacts may be dirty and moving it back and forth a few times or using contact cleaner may be all that is needed.

- Check for open high value resistors around the chroma decoder IC.

- Check for open high value resistors in the brightness limiter circuit.

With a scope and schematic (or even just a pinout for the chip), you should be able to trace the luminance signal to see where it is getting lost.

This is also *not* a picture tube problem. :-)

(From: John Mehrtens (sarge@drag-net.com).)

I have had several TVs and monitors where the delay line in the luminance circuitry has failed. Usually it's made out of glass, and inherently is fragile. Sometimes whacking the monitor would make it come back, leading to the thought of connectoritis or a cold solder joint -- where in fact it was the delay line (long rectangular unit with two to four leads). Replacing the delay line was the solution, but to check it first it'd be a good idea to look for 'in' and 'out' on the line and short the pins. The picture may be shifted, colours may not line up, but it'll tell you that it's the delay line if the picture comes back at all. It's better than looking at a saturated picture with no luminance! :)

Brightness control has no effect

The following assumes that the picture is fine but the brightness is fixed - probably at too high a level. However, there could be several interrelated problems if a common supply voltage were missing, for example.

If it is a knob, then it should be varying the control grid (G1) voltages relative to the cathodes (K) of the CRT. This is not likely to be a very complex circuit. If you do not have a schematic, I would start by tracing from the control, check continuity and solder connections. Check the control itself for proper operation with an ohmmeter. A power supply going to one side of the control (negative probably) may be missing. Tbe control grid voltage will end up on the little board on the neck of the CRT - check there as well for bad solder connections or open resistors.

If brightness is a digital control, then you will need a schematic unless there is an obvious bad connection.

One color is too weak or too strong

If the problem is slight and/or has gradually gotten worse, this may just require an adjustment of the color brightness/background/bias and/or color gain/drive controls inside the TV. See the section: Color balance adjustment.

Note that if it is possible to obtain a good black and white picture with the user color control set to its minimum, then this is not likely a problem with one of the primary color channels (red, green, or blue) but with the chroma decoding circuitry. Or, perhaps, you are just watching MTV!

Even if it appears as though there is an excess, this may actually be a reduction in one of the primary colors. For example, a magenta tinge is represents a reduction in the strength of the green signal.

- Too high an intensity for one of the color channels will result in a tint of one of the primaries: red, green or blue.
- Too low an intensity for one of the color channels will result in a tint of the complement of one of the primaries: yellow, cyan, or magenta.
- Problems mainly in the shadows or dark areas of the picture usually represent a fault with brightness/bias/background.
- Problems mainly in the highlights or bright areas of the picture usually represent a fault with the gain/drive.

A color that that is now suddenly brighter or darker than normal resulting in incorrect color balance or a tint in the background could be due to a number of causes:

- Bad connections or bad component in video amplifier or on CRT neck board for that color.
- Fault in chroma decoder.
- Weak gun in CRT (reduced color).

Psychodelic color

The means colors that are not normal and that adjustment of the user controls is not able to correct it so that all colors of the picture are properly displayed at the same time. For example, you are unable to get any yellows or blues in scenes that should have these colors..

Make sure the user color and tint controls have not been accidentally turned while cleaning or purposedly misadjusted by small (or large) kids.

Perform the user setup described in the section: User picture adjustment.

Confirm that the source is not a weird color video - try another channel or a tape.

Verify that this is not a missing color problem - one of the primary R, G, or B, has disappeared. If so, refer to the section: Intermittent or missing colors.

Once these have been eliminated, you are left with the following possibilities:

1. Defective part around the chroma chip/circuit. Misadjusted color oscillator.

2. Bad connections or short circuit in area of chroma chip/circuit.

3. Defective chroma chip (don't suspect this first just because it is probably very expensive).

4. Bad degauss circuit resulting in lack of degauss or abrupt termination of degauss current rather than smooth tail off. The CRT is not being properly demagnetized and color purity is totally messed up.

5. Bad CRT - the shadow mask has been damaged and it is impossible to properly adjust purity across the screen.

A service manual or Sams', DMM, and scope will help greatly in attempting to troubleshoot this unless it is an obvious bad connection. For (1)-(3), try prodding the main board around the chroma chip with an insulated tool to see if you can restore normal color. For (4) try manually degaussing (see the section: Degaussing (demagnetizing) a CRT. If this clears up the colors until at least when it is power cycled, then a degauss problem is likely.

Something as simple as a bad resistor or inductor can be the cause - don't immediately suspect the most expensive and difficult to replace part.

No picture/dark picture/erratic picture

With power off, remove the picture tube socket (carefully!) and clean the pins with fine sandpaper and use contact cleaner on the socket. This source of bad connections can result in a variety of erratic symptoms.

TV and monitor manufacturing quality and cold solder joints

Any intermittent problems with monitors that cause random sudden changes in the picture brightness, color, size, or position are often a result of bad connections. Strategically placed bad connections can also cause parts to blow. For example, a bad connection to the SCR anode in a phase controlled power supply can result in all the current passing through the startup resistor, blowing it as well as other components. I had a TV like this - the real problem was a bad solder joint at a pin on the flyback. Thus, erratic problems, especially where they are power or deflection related, should not be ignored!

Bad solder joints are very common in TVs and monitors due both to poor quality manufacturing as well as to deterioration of the solder bond after numerous thermal cycles and components running at high temperature. Without knowing anything about the circuitry, it is usually possible to cure these problems by locating all bad solder connections and cleaning and reseating internal connectors. The term 'cold solder joint' strictly refers to a solder connection that was either not heated enough during manufacturing, was cooled too quickly, or where part pins were moved before the solder had a chance to solidify. A similar situation can develop over time with thermal cycling where parts are not properly fastened and are essentially being held in by the solder alone. Both situations are most common with the pins of large components like transformers, power transistors and power resistors, and large connectors. The pins of the components have a large thermal mass and may not get hot enough during manufacturing. Also, they are relatively massive and may flex the connection due to vibration or thermal expansion and contraction.

To locate cold solder joints, use a strong light and magnifier and examine the pins of large components for hairline cracks in the solder around the pin. Gently wiggle the component if possible (with the power off). Any detectable movement at the joint indicates a problem. With the power on, gently prod the circuit board and suspect components with an insulated tool to see if the problem can be effected.

When in doubt, resolder any suspicious connections. Some monitors may use double sided circuit boards which do not have plated through holes. In these cases, solder both top and bottom to be sure that the connections are solid. Use a large enough soldering iron to assure that your solder connection is solid. Put a bit of new solder with flux on every connection you touch up even if there was plenty of solder there before.

Why can't TV manufacturers learn to solder properly?

I can think of several potential reasons - all solvable but at higher manufacturing cost.

1. Mass of large component leads (like shields) does not get adequately heated during manufacture leading to latent cold solder joints. While they may look ok, the solder never actually 'wetted' the heavy pins and therefore did not form a good mechanical or electrical bond.

2. Thermal cycles and differential thermal coefficients of circuit boards, traces, and solder. While it is not easy to do anything about the material properties, using plated through-holes or a similar mechanical via would greatly increase the surface area of the joint and prevent the formation of cracks.

3. Vibration. This is also directly related to the single sided circuit boards without plated through-holes to strengthen the joints.

4. Lack of adquate mechanical support (single sided circuit boards without plated through-holes (vias).

I believe that the single most significantimprovement would come about by using plated trhough-holes but this would add to the cost and apparently the consumer is not willing to pay more for better quality and reliability! Some designs have used rivlets - mechanical vias instead of plated ones. While this is good in principle, the execution has often been flawed where cold solder joints resulted between the rivlets and the circuit board traces due to lack of adequate process control.

The Sony and RCA/GE tuner shield problem is interesting because this could have been solved years ago at essentially no additional cost as other manufacturers - and their own repair procedures - have proven.

Intermittent or missing colors

This is a catch-all for some of the most common TV and monitor problems.

Note that due to the additive color scheme used in all emissive color displays like CRT or flat panel TV sets and video monitors, a single missing primary color (red, green, or blue) will result in the following appearance (for a white screen):

```
   Missing Color       Appearance
 ------------------------------------------------
      Red              Cyan (blue-green)
      Green            Magenta (reddish-purple)
      Blue             Yellow
```

Which color is affected may be even more obvious if the set has a color on-screen display for which you recall the proper colors.

- If gently whacking the set can make the color(s) come and go suddenly, then bad connections are probable. The most likely place for these are solder pads on the little circuit board on the neck of the CRT or even dirty CRT socket pins that are not making solid contact. Try prodding the CRT neck board with an insulated stick to see if you can affect the colors.

  Although not impossible, this is not likely to be a CRT problem.

- If the color fades in and out with a delay of about 10-15 seconds, it is probably intermittent power to the CRT filament for that color and probably means a bad CRT since the three filaments are wired in parallel inside the CRT. One of the internal connections has come loose.

  Look in the neck of the CRT to make sure all three filaments are glowing orange. If one is out or goes on and off, toss the set. Replacing the CRT is probably not worth it. However, if they all go on and off together (all colors would be fading in and out though perhaps not quite in unison), then bad connections for the CRT filaments on the CRT neck board are indicated.

To narrow down the problem:

- Locate the output for the bad color on the video driver board on the neck of the CRT. This will probably read a significantly higher voltage than the corresponding pins for the good colors. A circuit problem is likely - probably on this board.

- Test components on this board for the good and bad color channels. A shorted transistor or open resistor can kill one channel. Swap parts between good and bad colors to confirm.

- Gently pull the CRT neck board off of the CRT and replace it. This will tend to clean the contacts.

- Connect an output of the video/chroma circuit/chip that is working (i.e., a color that appears on the screen) to *all* three color drivers on the CRT neck board.

  - If you now get a more-or-less black and white picture (there may be a moderate color tint as the relative intensities of R,G,B may not be balanced), the problem is likely with the chroma decoder or its support circuitry.

    Note: the picture will be the intensity of only one color channel so it will not be quite *normal* in any case.

  - If you still have missing or messed up colors, the problem is on the CRT neck board or with the CRT.

Most of the causes of intermittent colors boil down to bad connections of one form or another. For totally dead colors - not intermittent - bad components are also a possibility.

- Printed circuit board on the CRT neck. This is a common location for cold solder joints. Check with a bright light and magnifying glass for hairline cracks around the pins of larger parts. Prod and tap with an insulated tool to see if the problem is effected. Resolder if necessary.

- Cold solder joints elsewhere in TV or monitor usually around the pins of large parts such as transformers, power transistors and resistors, and internal connectors.

- Internal connectors (including CRT socket) that need to be cleaned and reseated. Remove, clean with contact cleaner, burnish, and replace.

Some commentary on monitor and TV whacking

Anytime that intermittent symptoms are experienced, I recommend gently whacking the patient to determine if mechanical shock or vibration affects the behavior. Here are a couple of responses to this suggestion.

(The following is from Marc Gelfond (71363.1700@CompuServe.COM).)

I just love the bit about "whacking it". It brings to mind an episode from the old Andy Griffith show, where a new fangled piece of electronics gear, was broght into Emmets repair shop. After many long hours of fruitless troubleshooting, out of frustration Emmet gave the thing a whack, and sure enough it fixed the problem.

As we say in the Telephony business, it "CCWT" or Came Clear While Testing. Another saying is that it "CCBFM" Came Clear By F------ Magic!!

(To which Gavin Adams (gaa@hopi.com) comments):

In the video industry we had a saying concerning malfunctioning gear:

"If it's broke, hit it with a hammer"
"If that doesn't fix it, paint it and sell it"

My DEC 16" monitor is case in point. Evey once in a while it would lose sync, and smacking it would bring it back (sometimes a few smacks). Recently it gave up the ghost completely, and after the local DEC office gave me a quote of $900 to fix it (Bermuda), I ordered a new Viewsonic 17" for the same price.

I ripped the guts out of the DEC beast, painted it with a marble finish, put plants in it, and sold it! :>

Retrace lines in picture

During the time the electron beam is returning from right to left at the end of a line and bottom to top (over the course of multiple lines), it is supposed to be result in no visible light on the screen. However, a number of faults can result in visible retrace lines.

The appearance will likely be a general reduction in contrast from the visible horizontal retrace on every scan line and two dozen or so diagonal lines lines (lower left to upper right) resulting from the vertical retrace.

The retrace lines may be either white or gray (possibly with a slight color tint due to unequal settings of the color adjustments) or a primary color - red, green, or blue. Anything in between is also possible but less likely.

White/gray retrace lines

Where all colors are involved - the lines are essentially white or gray (or with a slight tint due to slight unequal settings of the color adjustments), look for something common like an incorrectly adjusted screen (G2) or master brightness/background/bias control or a problem in one of these circuits, a defective power supply or a problem in the blanking circuitry:

- Screen (G2) or master brightness/background/bias control - mark setting and then see if a slight adjustment removes the retrace lines. See the chapter: "TV Adjustments". Of course, if this happened suddenly, the problem is not due to a misadjusted control though a dirty pot is possible - turn it back and forth - this might clean it and restore normal operation.

- Power supply or connection to CRT neck board - insufficient voltage will result in the CRT never totally blanking. Check (usually scan derived) power supply components (from flyback).
- General power supply - check B+ for correct value and ripple. A main power supply fault might result in these symptoms (and usually many others).
- Blanking circuit - this may be a part of the video/chroma chip or separate. Check waveforms to determine if the blanking pulses are making it to the video output.

Red, green, or blue retrace lines

Where only one color is showing, suspect an incorrectly adjusted individual background/bias control or bad part on the CRT neck board for that color.

- Individual brightness/background/bias control(s) - mark setting of pot for the problem color and then see if a slight adjustment removes the retrace lines. See the chapter: "TV Adjustments". Of course, if this happened suddenly, the problem is not due to a misadjusted control though a dirty pot is possible - turn it back and forth - this might clean it and restore normal operation.
- Component or connection on CRT neck board - insufficient voltage to or incorrect biasing of the video driver for this color can result in the CRT never totally blanking. Compare voltages and signals, and swap components between good and bad channels to confirm.
- Blanking circuit - this may be a part of the video/chroma chip or separate. Check and compare waveforms of good and bad colors to determine if the blanking pulses are making it to the video output.

There is a slight possibility that a bad CRT may result in visible retrace lines. To eliminate this possibility:

- Disconnect the filament - all evidence of a picture, raster, and retrace lines should disappear once the filaments/cathodes have cooled (15 seconds or so. If there are still visible retrace lines, the CRT is suffering from cold or field emission from someplace (may not even be the cathode).
- Turn down the screen (G2) control on the flyback (usually). If one color remains no matter how you set the control, again there is some kind of weird emission from the CRT. However, if white/gray retrace lines remain, the problem may be in the screen supply.

See the section: Bad CRT causing retrace lines.

Bad CRT causing retrace lines

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The TV which I bought last started developing retrace lines after a month or so of use. I took it back to the lab for warranty (special deal) and had it examined by the real experts. They found that even with the filament supply disconnected and VG2 at 0V the screen would still light up. They could even see that the electrons weren't even coming from the cathode. That was with only the picture tube in a test rig. So in this case the obvious conclusion had to be that the tube was bad, and it was replaced (32" 16:9 SF, very $$). It had something to do with processing problems during manufacturing of the electron guns.

So even if this was a rare case, it *can* happen that retrace lines are due to a bad picture tube. It's more usual to suspect the VG2 (screen voltage) or a defect somewhere in the RGB video path.

Red, green, or blue full on - fog over picture

This could be a heater-cathode (H-K) short in the CRT, a failure of a component in the chroma circuits or video output (driver board), or bad connections there or elsewhere.

Don't panic - heater-cathode shorts in CRTs can often be worked around.

Note: before proceeding, it is a good idea to make sure that the screen is degaussed - else you could be attempting to track down problems with the wrong color!

Some simple tests can confirm or rule out other possibilities.

- Compare the voltages for the video drive signals to the CRT on the little board on the neck of the CRT with the CRT both connected and unplugged. A schematic will help greatly in locating these signals.
  - If there is a significant difference especially on the bad color, then the CRT is a likely candidate. Try tapping the neck of the CRT GENTLY (with it plugged in and while viewing a picture) to see if it is an intermittent problem.
  - If there is no significant difference, you may have a bad driver or a problem in the chroma circuits.
- Look for bad connection/cold solder joints, probably on the little board on the neck of the CRT. Use an insulated stick to gently prod the board and its components in an effort to induce/cure the problem. Look carefully for hairline cracks around the component leads.
- You can swap components between two colors and/or test with an ohmmeter on that driver board to determine what is bad. The nice thing about color monitors and TVs is that there three copies of each of these components. Swapping and/or comparisons between these is an excellent diagnostic technique.
- Another simple test: Disconnect the cathode for the full-on color from its drive. If it is still full-on, there is probably an H-K short in the CRT since the only way to get each color on the screen is via the cathode connection to the CRT neck board. If it is removed and there is still that color, the current must be taking another path inside the CRT.
- Alternatively, interchange the outputs of the bad color with a good one by jumpering on the video driver board (on the CRT neck). If the bad color changes, then the problem is in the circuitry and not the CRT.

Here is the procedure in more detail (example for red full on):

(From: J. K. Emerine (jkemerine@aol.com).)

To identify if the fault is in the CRT or a control problem try this (WITH SET OFF):

On the CRT board, lift the output end of the green cathode final resistor. Do the same with the offending red cathode's resistor. Use short insulated jumpers to 'swap' drive signals - drive the red cathode with the green drive and the green cathode with red drive. (Note that if this problem only occurs after a warmup period, color at turn on will be - well - wierd, but it is just a test.)

- If the symptom returns = 'goes red' the CRT is shorting. (See the section: Providing isolation for a CRT H-K short. --- sam)

- If instead the symptom becomes 'goes green' then the red drive leg has the fault and the CRT is probably good. (In this case, there may be bad connections or a bad component on the CRT drive board or further back in the chroma circuitry. --- sam)

Shorts in a CRT

Occasionally, small conductive flakes or whiskers present since the day of manufacture manage to make their way into a location where they short out adjacent elements in the CRT electron guns. Symptoms may be intermittent or only show up when the TV or monitor is cold or warm or in-between. Some possible locations are listed below:

- Heater to cathode (H-K). The cathode for the affected gun will be pulled to the heater (filament) bias voltage - most often 0 V (signal ground). In this case, one color will be full on with retrace lines. Where the heater is biased at some other voltage, other symptoms are possible like reduced brightness and/or contrast for that color. This is probably the most common location for a short to occur.

- Cathode to control grid (K-G1). Since the G1 electrodes for all the guns are connected together, this will affect not only the color of the guilty cathode but the others as well. The result may be a very bright overloaded *negative* picture with little, none, or messed up colors.

- Control grid to screen (G1-G2). Depending on circuitry can result in any degree of washed out or dark picture.

- Screen to focus (G2-F). Screen (G2) and focus voltage will be the same and the controls on the flyback will interact. Result will be a fuzzy white raster with retrace lines and little or very low contrast picture. Symptoms will be similar to those of a flyback with breakdown in the focus/screen divider network.

- Focus to high voltage (F-HV). High voltage will be pulled down - probably arcing at the focus spark gaps/other protective devices. Line fuse and/or HOT may blow. A high impedance short may only result in increased focus voltage but this is probably unusual.

- Other locations between electron gun elements as feed wires.

Except for the high voltage to other places, the short may actually be located in the CRT *socket* or even on the CRT neck board, probably in the spark gap(s) for the problem pins. Remove the socket and test between the suspect pins on the CRT itself. If the CRT itself is fine, the spark gaps should be inspected and cleaned/repaired and/or components replaced. At this point, the cause may still be present - a short inside the flyback for example resulting in excessive voltage on one or more pins.

Assuming this is not the case, replacing the CRT may be the best solution but there are a variety of 'techniques' that can often be used to salvage a TV that would otherwise end up in the dump since replacing a CRT is rarely cost effective:

1. Isolation - this will usually work for H-K shorts as long as only one gun is involved.

2. Blowing out the short with a capacitor - depending on what is causing the short, this may be successful but will require some experimentation.

3. Placing the CRT (TV or monitor) face down on a soft blanket and *gently* tapping the neck to dislodge the contamination. Depending on the location of the short, one side or the other might be better as well. Sometimes, this can be done in-place while watching the picture.

A combination of (2) and (3) may be required for intermittent shorts which don't appear until under power. See the sections below for additional details. However, for shorts involving the focus and high voltage elements, even a sharp edge can result in arcing even if there is no actual short. There is no remedy for these types of faults.

Providing isolation for a CRT H-K short

This procedure will substitute a winding of your own for the one that is built in to the flyback to isolate the shorted filament from the ground or voltage reference. Note that if you have a schematic and can determine where to disconnect the ground or voltage reference connection to the filament winding, try this instead.

The flyback is the thing with the fat red wire coming out of it (and perhaps a couple of others going to the CRT board or it is near this component if your set has a separate tripler) and may have a couple of controls for focus and screen. It should have some exposed parts with a ferrite core about 1/2-3/4" diameter.

The filament of the CRT is the internal heater for each gun - it is what glows orange when the set is on. What has happened is that a part of the fine wire of the bad color's filament (assuming this is indeed your problem) has shorted to the cathode - the part that actually emits the electrons. Normally, the heater circuit is grounded or tied to a reference voltage so when it shorts to the cathode, the cathode voltage level is pulled to ground or this reference.

You will need some well insulated wire, fairly thick (say #18-22). Find a spot on the flyback where you can stick this around the core. Wrap two turns around the core and solder to the CRT filament pins after cutting the connections to the original filament source (scribe the traces on the board to break them). Make sure you do not accidentally disconnect anything else.

This winding should cause the filaments to glow about the same brightness as before but now isolated from ground. If they are too dim, put another turn on the flyback to boost the voltage as this will result in low emission, blooming, and possible damage to the cathodes after awhile. (Don't go overboard as you may blow the filament totally if you put too many turns on the core - you then toss the TV.)

Route the wires so that there is no chance of them getting near the high voltage or any sharp metal edges etc. Your picture quality may be a tad lower than it was before because of the added stray capacitance of the filament wiring being attached to the the (formerly bad) video signal, but hey, something is better than nothing.

If you are not inclined to build your own isolation transformers, kits are available.

Rescuing a shorted CRT

If the short is filament-cathode (H-K), you don't want to use the following approach since you may blow out the filament in the process. If this is the case, you may be able to float the filament and live with the short (see the section on: "Red, green, or blue full on - fog over picture".

Shorts in the CRT that are between directly accessible electrodes can be dealt with in a more direct way than for H-K shorts. At this point you have nothing to loose. A shorted CRT is not real useful.

If the short is between two directly accessible electrodes like cathode-grid, then as a last resort, you might try zapping it with a charged capacitor. Start with a relatively small capacitor - say a few uF at a couple hundred volts. Check to see if the short is blown after each zap - few may be needed. Increase the capacitance if you fell lucky but have had little success with the small capacitor.

If the fault is intermittent, you will, of course, need to catch the CRT with the socket disconnected and the short still present. Try some gentle tapping if necessary. If you do this with the charged capacitor across the suspect electrode, you **will** know when the short occurs!

Also see the section: High voltage to focus short.

Picture tube replacement

It is possible to replace the picture tube. However, this is likely to be both expensive and possibly time consuming with respect to adjustments like purity and convergence. When replacing:

- Discharge both the old and new tubes before you start to be sure you won't have any unpleasant surprises.
- Take extreme care when handling - at the very least, a slip can result in a broken neck and a bad and expensive day.

  "The 25VCXP22 picture tube of my RCA Accutouch XL-100 CCU-942 TV start fading. Its 100% transistorized, everything still works perfectly after about 20 years service. But:

  - Can I still buy new RCA 25VCXP22 picture tube? What is the approximate cost?
  - Any equivalent tube for direct replacement? Cost?
  - If no replacement picture tube is available, what is other option?"

(From: Chris Jardine (cjardine@wctc.net).)

What you have here is genericly referred to as the 25V as opposed to the 25A picture tube. While there are minor differences with respect to the letters after the V for the most part they are interchangeable. When I worked my way through engineering college I worked at a TV repair shop and my job was mostly changing picture tubes. Yeah, we did enough of them to keep a tech busy 4 to 5 hours a day changing them and I got pretty good and could change, color balance, convergence, etc. the tube in about 45 minutes. We for the most part used 3 major tubes, 1) 25A, 2) 25V, and 3) 21FJ (a little nostalgic for those who remember this one). This was back when your TV would have been fairly new (1981 to 82). These are available from many different sources - RCA, Channel Master, Wisconsin Tube, etc. The price would vary depending on the quality of the tube. I remember that we could get a 25A for about $35 at the time due to our volume - one truck per month. The most expensive I've seen them has been just over $200. This is quite a range and there are now many other types of tubes including in-line, trinitron, etc.

I hope this helps and thanks for the trip down memory lane!

(From: Chris Jardine (cjardine@wctc.net).)

The important thing here is that the tube begins with 25V. If it does it should work in your set. The only thing you have to know is whether the tube has 'ears' attached permanently. The 25V comes both with and without these mounting ears permanently attached. I know that you can still get one of these from any of a number of suppliers. I know that Channel Master and RCA (Thomson, whatever!) still make them available as well as any of a number of local CRT rebuilders.

High voltage to focus short

Symptoms would be (with the unit powered and high voltage present):

- With the CRT neck board plugged into the CRT, the focus spark gap is likely arcing.
- With the socket unplugged, putting anything connected to ground (or any other circuitry) near the focus pin would result in a juicy spark or arc. WARNING: Removing the CRT socket and powering the set may destroy the CRT on some models. See the section: Warning about disconnecting CRT neck board.

If the CRT is gassy or up to air, forget it - it might make a decent fish tank :-). In this case, there would be visible arcing INSIDE the CRT probably not confined to a single location.

However, if there is just a metal whisker between the F and HV, that might be able to be cleared by careful tapping or a charged capacitor. You may even be able to see it if you were to remove the yoke - the gap is pretty large, about 1-2 mm - the last gap between electrodes before the start of the internal (Dag) coating.

See the section: Rescuing a shorted CRT.

Note that other damage may have been done as

Other components including the flyback, HOT, and parts on the CRT neck board and beyond, may have been damaged as a result of the short. Zapping the CRT may be just the beginning of what is required to repair it all.

Dark picture

A TV or monitor with a picture that is too dark may have a fault or the CRT may just be near the end of its useful life.

First, confirm that your video source - computer, camera, etc. - is producing a proper signal.

Is the brightness at all erratic? Does whacking the monitor have any effect? If so, then you may have bad connections on the CRT driver card or elsewhere. If the brightness tends to fade in and out over a 10 to 20 second period, a bad filament connection is likely. Check for the normal orange glow of the filaments in the neck of the CRT. There should be 3 orange glows. If they are excessively reddish, very dim, or fade in and out, you have located a problem. See the section: Picture fades in and out.

Common causes of brightness problems:

0. Dirty CRT faceplate or safety glass. Don't laugh. It sounds obvious, but have you tried cleaning the screen with suitable screen cleaner? It is amazing how dirty screens can get after a few years - especially around smokers!

   Wipe gently with a slightly dampened cloth - not soaking or you may end up with real problems when the water drips down inside and hits the electronics! On TVs with a separate protective faceplate, clean both the front and rear surfaces of this plate as well as the CRT itself.

1. Old CRT. The brightness of the CRT deteriorates with on-time. It does not matter much how bright your run your TV. An indication of a weak CRT would be that turning up the SCREEN (G2) or master brightness control only results in a not terribly bright gray raster before the retrace lines show up. There may be indications of poor focus and silvery highlights as well. A CRT brightener may help. See the section: Brightening an old CRT.

2. Bad component in filament circuit or bad connection reducing filament voltage. This should be easy to check - there are only a few parts involved. If it is erratic, bad connections are likely.

3. Brightness control faulty - bad pot, bad connections, or problem with its power supply. Depending on specific problem, control may or may not have any effect. If digitally adjusted, there could be a problem with the logic or control chip. If the button or menu item has no effect at all, then a logic or control problem is likely.

4. Improperly set SCREEN (G2) voltage (usually on flyback) or faulty divider network. See the section: Adjustment of the internal SCREEN and color controls.

5. Improperly set video bias (background) levels or fault in video drive circuitry. See the sections starting with: "Optimal procedure for setting brightness/background and screen adjustments".

6. Fault in video amplifiers. With all three color affected equally, this would most likely be a power supply problem. A video amplifier problem is likely if turning up the SCREEN (G2) or master brightenss control results in a very bright raster before the retrace lines appear. Cheack signals out of the video/chroma(IC.

7. Fault in beam or brightness limiter. Many TVs and monitors measure the beam current (possibly indirectly) and limit the maximum to a safe value. The purpose of this may be to protect the CRT phosphors, and/or to assure that the power supply does not go out of regulation, and/or to limit X-ray emission. If this circuit screws up, a dark picture may result. Checking the signals and voltages at the CRT socket should determine if this is the problem.

8. High voltage is low. However, this would likely result in other symptoms as well with focus, size, and geometry.

Brightening an old CRT

If performing adjustments of the internal background and/or screen controls still results in a dark picture even after a long warmup period, the CRT may simply be near the end of its useful life. In the old days of TVs with short lived CRTs, the CRT brightener was a common item (sold in every corner drugstore, it seemed!).

You can try a similar approach. Caution: this may shorten the life of the CRT - possibly quite dramatically (like it will blow in a couple of seconds or minutes). However, if the monitor or TV is otherwise destined for the scrap heap, it is worth a try.

The approach is simple: you are going to increase the voltage to the filaments of the electron guns making them run hotter. Hopefully, just hotter enough to increase the brightness without blowing them out.

Voltage for the CRT filament is usually obtained from a couple of turns on the flyback transformer. It is usually easy to add an extra turn or two which will increase the voltage and thus the current making the filaments run hotter. This will also shorten the CRT life - perhaps rather drastically. However, if the TV or monitor was headed for the dumpster anyhow, you have nothing to lose.

Picture tube brightener

(From: Kevin Carney (carneyke@mhv.net).)

Try a CRT brightener from MCM Electronics about $20. It boosts the filament voltage a volt or two. I have used them before and they help. You can also try running a power supply on the filament with the monitor OFF. Set the supply at the filament voltage and slowly bring the voltage up. If the filament is 6.3 volt bring it up gradually to 10 -12 volts for about a half hour. This will brighten it up some. Be careful because too much voltage can open the filament !

Before doing this did you check the screen voltage setting and the RGB settings for drive and background ?

There are also commercial CRT rejuvenators that supposedly zap the cathodes of the electron guns. A TV repair shop may be able to provide this service, though it is, at best, a short term fix.

More drastic measures to brighten CRT

(From: LEE (leep@mailhub.scf.lmsc.lockheed.com).)

As a start, I crank the brightness control all of the way up. I then turn the color control all of the way up. I let the set run with a bright screen for around 15 min. This procedure cleans up the cathode surfaces so that they can emit more electrons. Now turn the controls back to normal and see if any improvement took place. If not, Wrap 2 or 3 turns of around 18 gauge insulated wire around the flyback and add this extra power in series with existing filament leads from flyback. You can experiment with the number of turns etc. to get brighter filaments. do not run the filaments white - just a brightened yellow. This will probably turn out to be around 8-9v in most cases. I had to do this on two different Sanyo replacement flybacks as they had low filament voltage from the factory. (flakey replacement parts). I`ve been running one of these Sanyos for around 4 years now with a nice bright picture (13")

Left portion of screen is dark or faded

> "I've got an old TV where the left 1/3 of the screen is 'faded'. It is especially noticable when a dark picture is showing (like a night time scene)."

This is normally caused by a bad filter capacitor on the power supply line (typically 200 V) that feeds the RGB output transistors. It is usually a scan derived voltage off of the flyback. Look for an electrolytic capacitor of around 4.7 to 10 uF, 160 to 250 V fed from a rectifier diode on this supply.

Color balance changes across screen from left to right

The characteristics are that a solid white screen will tend to be blue tinted on one side and red tinted on the other. This is usually a subtle effect and may be unavoidable with some designs.

There are several possibilities:

1. Purity - this means the beams are landing on the wrong phosphor dots. This is what would be affected by moving from one location to another or even rotating the TV on its base without degaussing. If the problem just appeared, degaussing may be needed.

   What do you have near the TV or monitor? Loudspeakers or other devices which generate magnetic fields can easily cause all sorts of color purity problems. Relocate the offending device(s) or the TV or monitor and then degauss it.

   See the section: Degaussing (demagnetizing) a CRT.

   If the problem still persists, purity adjustment may be needed. However, this isn't likely to have changed so look for other causes before tackling these adjustments.

2. Unequal electron gun to shadowmask/screen distance - the electron beams for the red and blue video travel slightly different distances on the left and right sides of the screen so their intensity (due to focus not being optimal and other factors) in each case may differ slightly affecting color balance.

3. Doming - This would only happen in very bright areas and causes the shadow mask to expand and distort. (Doming should not be a problem with Trinitron CRTs which use tensioned wires in their aperture grill.) This would also not really affect left-right color balance in particular.

I don't really know how much of a problem (2) is in practice or whether some manufacturers compensate for it.

Bleeding highlights

On very bright areas of the picture, one or more colors may bleed to the right resulting in a trail of those colors. The difference between this problem and the section: Trailing lines in one or more colors is that in this case, only highlights are affected.

One cause of this is that the color gain, contrast, or intensity controls (whatever they are called on your set) are set too high. See the section on: "Color balance adjustment". Check the settings of any brightness limiter controls as well.

Trailing lines in one or more colors

Assuming this is not a form of ghosting resulting from poor reception conditions, then it could be any of the following:

- Poor decoupling in the power supplies for the video drive circuits - probably on the CRT neck board. Check for bad (low uF or high ESR) filter capacitors (electrolytic mostly) on this board or the power supplies feeding it.

- Insufficient CRT filament voltage. This could be a result of bad connections or a bad component in the filament power supply (probably from the flyback). Check to see if the filaments are glowing bright orange and check the voltage if possible (though this can be tricky since it is often fed from a winding on the flyback and is a pulse waveform, not DC or a sinusoid. The service manual (or Sams' Photofact) will probably have info and waveforms.

- Bad CRT (more likely if only one color is affected). A weak electron gun can result in this behavior. Swap it with one that work properly. If the same color is still bad, that CRT gun is weak. The CRT will need rejuvenation or need to be replaced (more likely, the entire TV will be tossed into the dumpster).

One simple test would be to swap two of the color outputs to the CRT pins. If the behavior moves with the swap (i.e., from red to blue), then it is likely an electronic problem. If it is still the same colors, it is probably the CRT.

Brightness changes from left-to-right across screen

Slight variations in brightness across the face of the CRT are not unusual. In fact, if you used a photometer to actually measure the brightness, you might be amazed at the actual variance even with the best monitor or TV - you just don't notice it. However, a major variation - usually a decay from left to right but could be the other way indicate a component failure. Of course, make sure the face of the screen is clean!

- A fault in the power supplies to the video amplifier and/or video output circuits. Most likely, an electrolytic capacitor has dried up and is not adequately filtering the power derived from the flyback which then has ripple at the horizontal scan rate and thus locked to the screen. The voltage decays from left-to-right between horizontal flyback pulses.

  The most likely location for these capacitors is in the vicinity of the flyback transformer on the mainboard or on the CRT neck board. Check the capacitors with capacitor tester or ESR meter and/or take a look at the power right at the video amplifier and video output drivers.

- Horizontal linearity is bad - this may actually be a horizontal geometry problem and not a brightness problem.

  See if objects on left side of the screen are stretched compared to those on the right (or vice-versa). If they are, the problem is in the horizontal deflection circuits - possibly a bad S correction capacitor or linearity coil.

- Inoperative degauss circuit, TV moved or rotated without degaussing, or magnetic field from some other device (like a permanent magnet) is affecting CRT - slight amounts of magnetization may reduce brightness (by moving the beams into the black space between phosphor dots) before affecting color purity (where the beams land on the wrong phosphor dots).

  Try deguassing manually. See the section: Degaussing (demagnetizing) a CRT.

Picture fades in and out

If the picture faded away on the order of 10-20 seconds (and if it comes back, also comes up to full brightness in same time frame - possibly with the persuasion of some careful whacking) AND with NO other significant changes such as size, focus, etc., then take a look in the back of the tube for the filament to be lit - the orange glow near the CRT socket. If there is none, then you probably have a bad solder connection on the circuit board on the neck of the CRT. Look for fine cracks around pins on that board. Try prodding it with an insulating stick to see if the picture comes back. Resolder if necessary. Dirty or corroded CRT pins/socket contacts can also do this - remove, inspect, clean, and replace the neck board. It is probably not a bad CRT as the filaments are usually wired in parallel and all would not likely go bad at the same time.

However, if only a single color fades in and out, then a bad connection inside the CRT is a distinct possibility - look for only one of the filament's glow to be coming and going. This is probably not worth fixing.

If the picture faded away with other symptoms, then there is probably a fault in the video amplifier/output one of its power supplies - still probably a loose connection if you are able to get it back by whacking.

Occasional brightness flashes

These may last only a fraction of a scan line or much much longer.

This could mean an intermittent fault in a variety of places including the video circuitry and SCREEN power supply:

- Brightness circuitry - SCREEN, master background or its power supply. Could be in or around flyback or focus/screen divider. Could perhaps be in the CRT, but probably less likely.

- Video amp before or at chroma demodulator - since after this point, you would most likely get colored flashes since only one of the RGB signals would likely be effected.

If you get it from all sources, then tuner/IF is ruled out.

Suppose you just have no signal to a direct video input. What do you get? If you still get flashes, it should be real easy to monitor either the video outputs or SCREEN supply (with a HV divider on your scope) for noise. Then trace back to power or noise source.

Excessive brightness and/or washed out picture

There are a number of possibilities including incorrect screen (G2) or bias (G1) voltages, or a problem in the video or blanking circuitry. Any of these could be the result of bad connections as well. A short in the CRT can also result in these symptoms.

- Excessive brightness/washed out picture is often an indication of a problem with the screen (G2) supply to the CRT. May be a bad capacitor or resistor divider often in the flyback transformer assembly or on the board on the neck of the CRT.

- If the excessive brightness just developed over time, then a simple adjustment of the screen or background brightness controls may keep it (and you) happy for a long time.

  When good, a typical value would be in the 200 to 600 VDC at the CRT. The screen (it may also be called master brightness, bias, or background) control should vary this voltage. However, it may be difficult to measure as the resistors in the voltage divider network may be quite large - hundreds of M ohms. If your unit has an external screen control (less likely these days) and it has no effect, trace out the circuitry in the immediate vicinity and check the resistors and potentiometer for opens, look for bad connections, etc. If it is built into the flyback transformer and is sealed, the entire flyback will need to be replaced unless the actual problem turns out to be a bad connection or bad component external to the flyback.

- Where the brightness control has no effect, suspect a missing bias supply to the G1 (control grid) electrodes of the CRT. This is usually derived from the flyback with a simple rectifier/filter capacitor power supply. Parts may have failed (though not likely the flyback itself). Adjusting the user brightness control should vary this voltage over a typical range of 0 to -50 V with respect to signal ground.

- It could also be a problem with biasing of the video output transistors. There may individual controls for background brightness on the little board on the neck of the CRT. However, we are looking for a common problem since all colors are wrong in the same way. This is likely to be a missing voltage from a secondary supply from the flyback.

- A short between electrodes inside the CRT can result in brightness problems. It may be possible to check this with an ohmmeter with the power off and the CRT socket removed. Test between G1, G2, and F where all colors are affected though a short between F and G2 will result in the focus control changing brightness and vice-versa - a classic symptom.

  However, in some cases, it only shows up when operating and one must deduce the presense and location of the short from its affect on voltages and bias levels.

  See the section: Rescuing a shorted CRT and other related topics.

First, check for bad connections/cold solder joints by gently prodding with an insulating stick. Check voltages and bias levels.

Bad focus (fuzzy picture)

Focus voltage on the CRT is usually in the range of 2-8 kV DC and should be controllable over a fairly wide range by the focus pot - usually located on the flyback or a little panel in its vicinity:

- If adjusting the pot results in a position of acceptable focus, you may be done. It is not unusual for the focus setting to drift a over time.

- If the setting is already as good as possible but not really good enough, the CRT may be tired. Alternatively, the filament voltage may be too low. Check for bad connections in the filament circuit.

- If the optimal setting is out of range of the focus pot, the problem is likely leakage in the focus divider in the flyback or one of the components on the CRT neck board.

Also see the sections: "Focus adjustment" and "Focus drifts with warmup".

The focus wire usually comes from the flyback or if the general area or from a terminal on a voltage multiplier module in some cases. It is usually a wire by itself going to the little board on the neck of the CRT.

If a sparkgap (a little 2 terminal device with a 1/8" gap in the middle) is arcing with power on, then the resistive divider has shorted inside the flyback, focus board, or HV multiplier - whatever you TV has - and the this unit will need to be replaced. Ditto if the SCREEN control affects focus and/or vice-versa.

Using a suitable high voltage meter (range at least 10 kVDC, 1000 M ohm or greater input impedance), you should be able to measure it connected and disconnected. The ground return will be the outside coating of the CRT which may or may not be the same as the metal chassis parts. If the voltage is very low (less than 2 kV) or too high and the pot has little effect:

- When measured right off of the source disconnected from the CRT neck board, then the problem is probably in the focus network in the flyback (or wherever it originates). Sometimes these can be disassembled and cleaned or repaired but usually requires replacement of the entire flyback or voltage multiplier. Note: you may need to add a HV (10 kV) capacitor between the focus wire and DAG ground to provide filtering so you get a DC level for your meter.

- When measured with the focus wire attached to the CRT neck board with the CRT connected but reasonable with the CRT unplugged, there is probably a short between the focus and another electrode inside the CRT. See the section: Rescuing a shorted CRT.

- When measured with the focus wire attached to the CRT neck board with the CRT unplugged, there is likely a component on the CRT neck board that is leaky or breaking down. Also, check for decayed (tan or brown) glue which may turn leaky with age.

Focus drift with warmup

This could be due to a problem with the focus voltage power supply, components on the CRT neck board, or a tired worn CRT.

Focus is controlled by a voltage of 2-8 kV DC usually derived from the flyback transformer and includes some resistors and capacitors. One of these could be changing value as it warms up. (assuming nothing else changes significantly as the unit warms up - e.g., the brightness does not decrease.)

Focus voltage is derived from a subset of the high voltage winding on the flyback using a resistive voltage divider which includes the focus pot. These are extremely high value resistors - 200 M ohm is common - and so leakage of any kind can reduce or increase the focus voltage. All other things being ok - i.e., the picture is otherwise fine - I would suspect this type of failure rather than the CRT.

The connection to the CRT is usually a separate wire running from the flyback or its neighborhood to the CRT neck board. Look for components in this general area. Use cold spray or a heat gun to isolate the one that is drifting. If you have access to a high voltage meter, you should be able to see the voltage change as the TV or monitor warms up - and when you cool the faulty part. If it is in the flyback, then sometimes the part with the adjustments clips off and can be repaired or cleaned. Most often, you will need to replace the flyback as a unit.

- If the optimal adjustment point of the focus control doesn't change that much but the best focus is simply not as good as it should be, the CRT is probably the problem. However, if the optimal point produces acceptable focus but it changes (and possibly moves off of one end of the adjustment knob range) as the unit warms up, the flyback or one of the components on the CRT neck board are likely drifting.

- If you have a high voltage meter, you can measure the focus voltage to determine if it is being changed by the focus pot and if it is in the ball park (2-8 kV typical). Sometimes, the part of the flyback with the focus pot can be snapped off and cleaned or parts replaced but usually you need to replace the whole unit. There may a capacitor or two on the PCB on the neck of the CRT that could have increased leakage as well thus reducing the focus voltage.

- To determine if the CRT is the problem, for sharp focus after the unit has warmed up. Power-off for an hour or so and carefully pull the CRT neck board off of the CRT. Then, power up the unit. Let it run long enough such that there would have been a detectable focus drift. Now, power-down, plug the CRT neck board back in, and power-up. Watch the image as it appears on the screen:

    - If the focus starts out fuzzy and sharpens up as the image appears and gradually becomes sharper as the CRT warms up the CRT is likely tired.

The only catch here is that plugging the CRT neck board into the CRT results in an additional load on the flyback due to the picture beam current which heats it more as well. Thus, if the problem takes a few minutes to appear, keep the brightness turned down except to check the appearance of the picture from time to time.

You can set the focus control for optimum when warmed up and just turn the TV on in well in advance of your favorite shows or add a user focus adjustment by drilling a hole in the plastic case for an *insulated* screwdriver or flyback focus knob extender :-). The CRT may continue to function for quite a while so this is not impending doom.

- If the focus is relatively stable as the image appears and increases in brightness *and* is about as sharp as it would be with the TV warmed up, the problem is most likely in the flyback. However, also check for bad components or decayed (tan or brown) glue on the CRT neck board. A drifting flyback will need to be replaced as it will probably get worse and fail completely. Clean the surface of the circuit board and CRT socket in the vicinity of the focus and screen terminals and traces. Contamination or just dirt and grime can easily cause problems especially on humid days since the resistance of these circuits is extremely high (100s of M ohms).

- If the focus is relatively stable as the image appears and increases in brightness *and* is similar to what it would be with the monitor cold, you have a very strange situation where some load on the high voltage power supply, perhaps, is causing a thermal problem. This would be rare.

Bad focus and adjustment changes brightness

This is the classic symptom of a short between the focus and screen supplies - probably in focus/screen divider which is part of the flyback or tripler. If you have a high voltage meter, measuring the focus voltage will show that (1) it is low and (2) it is affected by the SCREEN control Similarly, the SCREEN voltage will be affected by the FOCUS control (which is what is changing the brightness.

There is a slight possibility that this may be in the CRT as well. Measure the FOCUS and SCREEN voltage with a high voltage meter. If they are identical pull the plug on the CRT. If they are now their normal values, then a shorted CRT is a distinct possibility - see the section: Rescuing a shorted CRT.

Charlie's comments on focus problems

(From: Charles Godard (cgodard@iamerica.net).)

Most true focus problems that I have encountered (when the IHVT is ok) are related to leaks or resistance on the focus output. The diming of the screen when the focus pot is adjusted leads me to think in terms of a leaky socket. I'd remove the ground from the CRT socket to the tube dag and see if it sparks. If so there may be a leak in the socket to ground. It could also be leaking to another pin, such as the screen grid. A rhetorical question: What happens to the screen voltage when the focus pot is adjusted?

I have seen sockets that had no arching or other telltale signs, leak through the plastic housing to ground out the focus voltage.

Look closely at the screen. If the blurring is in the form of small circles, then you have an open or hi-resistance focus electrode inside the tube. The circles may vary in visibility with brightness.

If you still haven't found the problem, try to confirm that this is truly a focus problem. Remove the CRT socket and observe the hi-voltage. If it climbs more than about 1k, say all the way up to 25 kV, then you may have a beam current problem rather than a focus problem. In that case re-check all CRT board voltages. WARNING: Removing the CRT socket and powering the set may destroy the CRT on some models. See the section: Warning about disconnecting CRT neck board.

If you have done all of the above and removing the socket makes no change in the high voltage, then try to determine why the high voltage is low.

Watch the screen as the brightness, contrast, or screen control are adjusted. See if you can observe any signs of blooming. When the IHVT doesn't provide enough current to satisfy the demands of the tube for current, the the picture tends to appear to expand like a balloon. i.e., bloom. This can be caused by not enough drive to the IHVT. Carefully monitor the b+ to the horizontal drive stages to see that is is stable and correct.

Blank picture, good channel tuning and sound

Since the tuner and sound are ok, horizontal deflection which usually generates power for most of the set is also working.

Does 'blank picture' means a totally black screen with the brightness and contrast controls having no effect whatsoever? Or, is there is no picture but there is a raster - scan lines on the screen? The direction in which troubleshooting should proceed differ significantly depending the answer.

Here are some questions:

1. As above, is there any light on the screen at any settings of the brightness and contrast controls, and/or when switching channels? Can you see any raster scanning lines?

2. Can you hear the high pitched (15735 Hz) of the horizontal deflection?

3. Looking in the back of the set, can you see the glow of the CRT filament?

4. Do you get that static on the front of the tube that would indicate that there is high voltage? Any cracking or other normal or abnormal sounds or smells?

Possible causes of no raster:

- No or low high voltage (low voltage, deflection, or high voltage power supply failure).

- Fault with other voltages like G1 or screen (G2) to CRT.

- Filament to CRT not getting powered.

- Drive to CRT bad/shut off as a result of fault elsewhere. For example, failure of the vertical deflection may disable HV or blank the screem to protect the CRT from burn-in due to the very bright horizontal line that would result. With some sets, it is possible that the X-ray protection circuitry will blank the screen without affecting tuning or audio.

Possible causes of no video (but a good raster): Problem in video IF, video amplifiers, video output, cutoff due to other fault.

It could be as simple as a bad connection - try gently prodding the boards with an insulated stick while watching the screen. Check for loose connectors and reseat all internal connectors.

Purple blob - or worse

Have you tried demagnetizing it? Try powering it off for a half hour, then on. Repeat a couple of times. This should activate the internal degausser. See the section: Degaussing (demagnetizing) a CRT.

Is there any chance that someone waved a magnet hear the tube? Remove it and/or move any items like monster speakers away from the set.

Was your kid experimenting with nuclear explosives - an EMP would magnetize the CRT. Nearby lightning strikes may have a similar effect.

If demagnetizing does not help, then it is possible that something shifted on the CRT - there are a variety of little magnets that are stuck on at the time of manufacture to adjust purity. There are also service adjustments but it is unlikely (though not impossible) that these would have shifted suddenly. This may be a task for a service shop but you can try your hand at it if you get the Sams' Photofact or service manual - don't attempt purity adjustments without one.

If the set was dropped, then the internal shadow mask of the CRT may have become distorted or popped loose and you now have a hundred pound paper weight. See the "Sony1" and "Sony2" photos in James Sweet's Sony/Trinitron Directory for some screen shots showing the symptoms resulting from a monitor falling on its face. :(If the discoloration is slight, some carefully placed 'refrigerator' magnets around the periphery of the tube might help. See the section: Magnet fix for purity problems - if duct tape works, use it!.

It is even possible that this is a 'feature' complements of the manufacturer. If certain components like transformers and loudspeakers are of inferior design and/or are located too close to the CRT, they could have an effect on purity. Even if you did not notice the problem when the set was new, it might always have been marginal and now a discoloration is visible due to slight changes or movement of components over time.

Color rings - bullseye pattern

This probably means the degaussing circuitry is terminating suddenly instead of gradually as it should. The most likely cause is a bad solder connection to the degauss thermistor or posistor or something feeding it.

You can confirm this by manually degaussing the screen with the TV or monitor turned on. If the problem disappears, the above diagnosis is probably valid. Check for bad solder connections in the vicinity of the degauss components and AC line input.

Magnet fix for purity problems - if duct tape works, use it!

The approach below will work for slight discoloration that cannot be eliminated through degaussing. However, following the procedures in the section: CRT purity adjustment would be the preferred solution. On the other hand, the magnets may be quick and easy. And, where CRT has suffered internal distortion or dislocation of the shadowmask, adjustments may not be enough.

In any case, first, relocate those megablaster loudspeakers and that MRI scanner with the superconducting magnets.

The addition of some moderate strength magnets carefully placed to reduce or eliminate purity problems due to a distorted or dislocated shadowmask may be enough to make the TV usable - if not perfect. The type of magnets you want are sold as 'refrigerator magnets' and the like for sticking up notes on steel surfaces. These will be made of ferrite material (without any steel) and will be disks, rectangles, flexible strips. Experiment with placement using masking tape to hold them in place temporarily. Degauss periodically to evaluate the status of your efforts. Then, make the 'repair' permanent using duct tape or silicone sealer or other household adhesive.

Depending on the severity of the purity problem, you may need quite a few magnets! However, don't get carried away and use BIG speaker or magnetron magnets - you will make the problems worse.

Also note that unless the magnets are placed near the front of the CRT, very significant geometric distortion of the picture will occur - which may be a cure worse than the disease.

WARNING: Don't get carried away while positioning the magnets - you will be near some pretty nasty voltages!

(From: Mr. Caldwell (jcaldwel@iquest.net).)

I ended up with the old 'stuck on a desert island trick':

I duck taped 2 Radio Shack magnets on the case, in such a way as to pull the beam back.!!!!

A $2 solution to a $200 problem. My friend is happy as heck.

RCA sells magnets to correct corner convergence, they are shaped like chevrons and you stick them in the 'right' spot on the rear of the CRT.

(From: Tom Sedlemyer (wesvid@gte.net).)

First set purity as best you can.

Obtain some pieces of refrigerator door magnet strips from an appliance repair shop (they usually have some lying around).

Cut the strips into 1 inch pieces. Place a strip as on the bell of the picture tube as close to the yoke as possible and in line with the corner that has the purity error. Rotate the magnet until you correct the purity error and tape it in place. Multiple magnet strips can be used and you may experiment with the size of the strips for best effect. It is very important that the strips are positioned close to the yoke or the effect will not hold. The only drawback to this method is some very slight distortion of the geometry of the raster, but it beats hell out of paying for a new CRT.

Color TV only displays one color

I assume that now you have no other colors at all - no picture and no raster. Let us say it is red - R.

It is probably not the CRT. Do you have a scope? Check for the R, G, and B video signals at the CRT. You will probably find no signals for the defective colors.

This is almost certainly a chroma circuit problem as any failure of the CRT or a video driver would cause it to lose a single color - the other two would be ok. Therefore, it is probably NOT the CRT or a driver on the little board on the neck of the CRT.

Try turning up the SCREEN control to see if you can get a G and B raster just to confirm that the CRT is ok.

Locate the video drive from the mainboard for the good and a bad color. Interchange them and see if the problem moves. If so, then there is a video signal problem. If not, it is on the little CRT board.

It could be a defective chroma IC or something else in the chroma decoder.

Disappearing Red (or other color)

Problem: I have been given an old colour TV. The reception is good, but very often, when the contrast and brightness of the TV image is low (e.g. when a night scene is shown), the red colour slowly disappears, leaving behind the green and blue image and many red lines.

The remaining red retrace are the giveaway that this is most likely not a CRT problem.

(If there were no red lines, it could be the filament for the red gun of the CRT going on and off due to a bad connection inside the CRT - bad news.)

How is a black and white picture? (Turn down the color control).

If B/W picture is good, then the problem is somewhere back in the chroma decoder circuitry.

Check the video input to the CRT video driver board and signals on that board. If B/W picture is also bad, then you can compare red and green signals to determine where they are becoming different. The red lines in your description sounds like the red video output circuit is drifting and messing up the background level, blanking, screen, or other setting. Could be a capacitor or other component.

The wandering black blob on old Sony

> "I had a Sony KV-1920 TV (very old) that suddenly started to displayed a black blob on the screen. The blob was anywhere from 1" around to almost the size of the entire screen. It had a sharp, not fuzzy, outline, and it would shrink in size as the TV warmed up, usually disappearing completely in 30 minutes. It shrank in sudden jumps, not gradually. Sometimes the blob would be stationary, other times it would tumble around rapidly all over the screen."

(From: Raymond Carlsen (rrcc@u.washington.edu).)

Measure the regulated +130 volt line... I think you'll find it has drifted upwards just enough to trigger the "protective" blanking circuit. In those sets, if the B+ (and consequently the HV) went up, the screen was automatically blanked so you couldn't use the set. It was before HV shutdown. Older RCA TV sets used to throw the horizontal out of sync. The low voltage regulator is an analog type with a pass transistor that is probably leaky, causing the high B+. Changes in line voltage and loading (with brightness changes) cause the partially blanked picture to change (the black blob moves around, sometimes blanking the entire screen). When you replace the defective component, reset the 130 volts with the pot, and you're back in business. The pot itself may have a bad spot... just move it one way or the other to get off that spot.

Vertical brightness or color bars

These are typically more or less equally spaced possibly more evident at the left side of the screen. They result only in brightness or color variations, not deflection speed. Diagonal lines are straight and not squiggly.

Note that the appearance of these bars differs from those caused by ringing in the deflection circuits where diagonal lines will show a squiggling stair-step appearance.

The most likely cause is a dried up electrolytic capacitor in the scan derived power supply for the video or chroma circuits or video output. Check for this ripple with a scope or test/replace any suspect capacitors.

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Tuner, AGC, and Sync Problems

No reception from antenna or cable

Make sure your source is providing a signal and that the cable connectors are good (center pin not broken or bent). Try another TV if possible.

Make sure you source select switch or mode is set correctly. Someone may have accidentally set it to direct video or AUX input.

Are all bands affected? If so, the tuner or IF is faulty. If there is a lot of snow, then it is probably toward the front (circuitry wise) of the tuner. If it is just a black screen, then it could be in the IF or video amplifier.

If only certain bands are bad - channels 2-6 for example, then certain parts of the tuner circuitry are faulty. However, make sure the CATV mode is set correctly as this affects reception on a band-by-band basis.

The problems may be due to bad solder connections of the tuner shields, connectors, coils, and other components. Try prodding the tuner to see if you can make the problem come and go or at least change.

Picture is overloaded, washed out, or noisy

This indicates an Automatic Gain Control (AGC) problem often caused by a dried up capacitor. You will probably need a schematic to go much further. This could be a problem in the tuner, IF, or video amplifiers.

The following assumes you are sure the signal source is strong - try a VCR or other local one (channel 3/4, not the RCA jacks).

(From: Glenn Watkins (blueribb@mail.comcat.com).) Substitute a variable voltage source for the tuner's AGC voltage. Most of the time the range of AGC is from 1 to 7 volts. If you can get a decent snow free picture with an external AGC source, then the tuner is probably OK.

Jumping picture on white scenes

This could be an AGC problem if the picture appears overloaded. However, if the picture is normal except unstable, the sync separate is the place to look:

(From: Jack Schidt (jack@wintel.net).)

White screens are a worst case video pattern for sync separators, and will cause an erratic shift in the vertical multivibrator trigger level unless the horizontal and video information is filtered out [integrated] prior to driving the vertical sync input of the processor IC.

This will show up with a scope as high frequency noise going into the vertical sync input.

Look for a small electrolytic [in fact, all of them], around 1-10 uF or so near the deflection/sync processor IC. Often simply increasing the value of this cap will help.

Interference when using VCR RF connection

(Some of these comments also apply to use of LaserDisc players, satellite receivers, video games, or other sources with RF modulator (Channel 3/4) outputs).

This may consist of patterns or lines in the picture.

If this only happens on the antenna or cable, it may be a problem with these sources or the tuner in the VCR rather than the TV. As a test, try the connecting the TV directly to the antenna or cable.

If it only happens on cable, there may be a (temporary) problem with cable transmission - contact your cable company.

If it happens on playback of good quality (commercial) recordings, then it could be a compatibility problem between the VCR and TV.

Make sure your patch cable connections are secure and that the cables are not damaged - in particular that the center pin is intact.

Try fine tuning if your TV has this capability. If this does not help, try switching the channel 3/4 selector on the VCR to the opposite position and try that channel, sometimes one will be better than the other particularly if one of these or an adjacent channel is active in your area.

If you have RCA baseband video inputs on your TV, try this connection to the VCR. These should work better in any case.

Confirm that it is not actually a problem with the VCR - try another TV if possible.

If you just changed your component placement, the VCR or TV may be picking up interference from another component. Turn off everything but the VCR and TV and see if that identifies the culprit. Move the TV away from the VCR so see if they are interfering with each other - the TV may be introducing interference into the VCR.

Occasionally, the particular patch cable or its length may affect reception quality - try another one.

If none of this helps, you VCR's RF modulator may be bad or slightly weak. Alternatively, the tuner in the TV may be faulty. If reception is generally noisy on all sources, AGC or RF/IF alignment may need adjusting. However, not all tuners are created equal. Your TV may simply be making the best of a marginal situation.

A light dimmer on the same circuit as the TV may result in similar symptoms. If you are tuning up your motorcycle (or automobile) in the same room, this may be spark ignition interference.

RF Interference on TV

> "I have interference lines on my TV - they are particularly heavy on 2, not so prominent on 9 - one TV is on Radio Shack Color Supreme 100 (souped up rabbit ears), other is on a roof top antenna, both have coax from antenna to TV. I have HAM operator two doors away. Is there an FAQ on interference - if so where. How do I need to describe the interference pattern in order to seek help. Thanks."

The FCC had an online interference handbook, with color photos showing how different types of interference affect a TV's picture. This has vanished from the FCC Web site but is now on the Kyes TV Web site:

- FCC TV Interference Handbook

Another Web page on interference which includes portions that have obviously been copied from the FCC document is at:

- Colin's Interference Handbook

(From: Andrew Mitchell (amitchell@sympatico.ca).)

Probably the easiest solution is to visit your ham neighbor and describe your difficulty. Amateur radio operators are licensed by federal governments (FCC) and are required as part of their examination to demonstrate a knowledge of this type of interference. It may well be that the ham is not the source of the problem and even if this is the case I'm sure he or she will be of assistance.

(From: Alan N. Alan, WDBJ-TV, KM4IG (alann@intrlink.com).)

OK, as a HAM myself, I can understand this. Channel 2 is the lowest TV channel, right above the six meter band, 50-54 Mhz. Channel 9 is well into VHF above 175 Mhz. It is possible that your neighbor operates 6 meters.

I would talk to him. First, the chances are it is YOUR equipment, and his is legal and meets FCC specs. But I would be willing to bet he will be very cooperative to help you solve your interference.

The thing to do is talk to him, calmly, and tell him about your problem. Then, schedule a time where he can transmit his gear and see if your problem exists along with his transmissions.. If it does, you can go from there. Many ham clubs have many engineers and radio and TV people in their memberships that will jump in and help you solve your problem. Again, he is probably legal, and consumer equipment is not known for it's RF resistance. Consumer manufacturers cut corners wherever they can. This includes filtering and design.

Problems with ground loops and video hum bars

> "I am having a problem isolating where my ground loop problem is coming from. The symptoms I see are Bars on my TV which scroll up the screen. The problem is these bars come and go, and when they are present they vary in intensity. I have verified that the cable ground is connected to the earth ground on the outside of the house, but the problem still remains. This problem is also screwing up any attempts to do video electronics experimentation. I am really tired of seeing these bars and any help you could give would be appreciated."

(From: Paul Grohe (grohe@galaxy.nsc.com).)

1. Do these bars show up on other TV's connected to the same cable?

2. Is your TV connected to anything else? A/V receiver? VCR?

   If so, unplug *all* the equipment and plug it in one-at-a-time until the hum appears. If you have an AV receiver in the system, try running a jumper wire from the incoming CATV ground at the TV to the receivers chassis ground (usually the "phono ground screw").

   If you have any devices with un-polarized plugs, unplug them and rotate them 180 degrees, and plug them back in.

3. If you connect a temporary antenna and view "off-the-air" signals, are the bars still there?

If you still cannot eliminate the hum, try building a simple "ground isolator" out of two 75-300 ohm baluns, as described in the link below:

- ePanorama's Groundloop Information Pages

Place it as close to the TV as possible.

(From: Charles Godard (cgodard@iamerica.net).)

This seems like a cable company problem, but you need to prove it to the cable guy before he will start climbing pole's and changing amps and couplers looking for an intermittent amp. (And I don't blame him.)

At the main cable line to the house and remove all couplers and put a single line from the cable direct to the rf input on a single TV, then watch it for a few of days. If the problem re-occurs call the cable guy and show him what you have done and explain the problem again.

Put yourself in the shoes of the cable guy. He comes into a house with VCR's and all the gadgets we all have hooked up to our TV's with lines running all over the house, and can't get to the back of the TV to see what's there, and he's not a TV repair guy anyway and nobody else in the neighborhood is complaining and this problem may happen when it rains but it may not. mmmhhh

If it does not show up on the single TV, then the problem is probably yours. Add one device at a time until you find the trouble maker. Start with the your Cable AMPLIFIER.

(From: 4real (alan69@iname.com).)

You eliminate all of the other junk attached between your main cable input to your house and your TV to be sure it isn't the cause.

You will definitely want to suspect a problem with the amplifier you have installed. Especially if it is one of those cheap ones. Usually when the filter capacitor in an amplifier goes bad it will cause the hum bars you are describing, and they can be intermittent. Another problem may be that you have too much signal going into the amplifier. Amps are rated to handle a certain amount of input signal (measured in db) depending on the number of channels you wish to amplify, and the gain provided by the amp. If you try to feed an amplifier with too much signal it will overdrive it and cause a venetian blind, or herringbone effect. It could also be possible that the cable company is supplying a signal with reverse tilt. That means more signal on the lower channels and less on the higher ones. The lower channels might be the ones overdriving the amplifier. The only way to tell for sure is to measure it with a signal level meter. (very expensive unless you happen to be in the business and have one handy) If this is the case (too much signal going in) you probably don't need the amplifier to feed only 2 TVs.

The last thing I can think of and the cable guy should have checked this: They use 60 VAC on their main trunk lines to power their line amplifiers. The taps which feed the individual houses are supposed to prevent this ac from going to the individual lines. Occasionally one of these devices fails or a line guy forgets to pull a fuse and hence the ac gets sent to your TV. It won't necessarily fry your TV but can cause problems. It may even damage the TV tuners that are connected to that feed. In most cases if you touch the center conductor of the cable and a good ground you can feel the ac. It isn't enough to hurt you but you will definitely know it's there. To be on the safe side you should test it with a volt meter.

(From: Cliff R. (craeihl1@nycap.rr.com).)

My guess would be your cable amplifier. The fact that you see TWO bars on your screen tells me that it's 120 Hz interference - the frequency caused by ailing full wave power supplies used in these amps. Take the amp out of the line for a few days. If you don't have "snow" in the picture with it out, s...can it! If you find it was bad and can't live without it, you might try making sure all your internal cable, splitters, and connections are good quality & in good shape. Radio Shack stuff......well, it stinks! You can purchase primo splitters & cable from your cable company and its not that expensive. Certainly cheaper than an amp (which you might not need if the cabling were up to snuff).

You could also cry to the cable company for more signal into your house. This may or may not work but it's worth a shot.

I would put an amp in line only as a LAST resort. Most of the inexpensive amps sold are......cheap. They can easily cause more trouble than they cure. If you must, go with a primo unit from Blonder-Tongue or Jerrold.

(From: Charles Hope (charles.hope@argonet.co.uk).)

It sounds very like a problem that I had and solved.

Cause: Modern TV sets antenna connector does not have true earth on the screen but is at a potential of half mains supply. It is possible to draw about 30 micro-amps from this.

Hum bars are induced in the amplifier because there is a small resistance in the earth path between output and input giving about 1 volt drop of this stray mains signal. Worse when raining because the cable ground is better then.

Solution: Either ground the antenna screen or fit a "braid breaker" in the screen.

Missing or noisy channel or block of channels

If you are unable to receive certain channels or blocks of channels, this is a tuner problem - could be as simple as bad connections - or even simpler:.

First, check to see that the tuning mode is correct - TV, CATV, as this is the most common cause of channels 'disappearing'.

TV channels are assigned frequencies ranging from 72 to almost 800 MHz depending on broadcast or cable channel assignment. To tune over such a wide range requires splitting it up into various bands even if these are not actually defined. If you have a varactor tuned set, then you already know about the Vl, Vh, and U bands which may use separate front-end components. Even modern quartz PLL synthesized tuners need to allocate circuitry depending on frequency range. Therefore, if a block channels is not working, it could be due to a failure of some component related to that frequency range. Aside from looking for bad connections, resoldering the shields and connector pins, prodding, pressing, praying, etc. you will need a schematic to have any chance of finding such a fault.

There is another slight possibility. Some TVs have a parental lockout capability (pre V-chip) to prevent kids or other unauthorized access to selected channels. The channel selections may have been accidentally altered. Check your user manual for instructions on programming this feature. Even on models without this option, the same internal circuitry could be present but not normally accessible. A power surge or stray cosmic ray could have put the set in a screwy mode. Unplugging power for a minute or probably a much longer time might possibly reset such an anomaly.

Loss of Channel after Warmup

If there is a general loss of picture and sound but there is light on the screen, then most likely the tuner or IF stage is pooping out.

With both no sound and no picture but a raster and static, it is most likely a problem in the tuner, power to the tuner, or its controller (if non-knob type).

If it recovers after being off for a while, then you need to try a cold spray in the tuner/controller to identify the component that is failing. Take appropriate safety precautions while working in there!

If it stays broken, then most likely some component in the tuner, its controller, or its power supply as failed. There is a slight chance that it could be a bad solder connection - I have seen these in the tuner modules of RCAs on several occasions (and many other manufacturers - apparently not a solved manufacturing problem even after 40+ years!

Channel tuning drifts as set warms up

This may be a slight drift - like someone is messing with the fine tuning or such a substantial change in tuning frequency that the channels go by as though you are surfing.

Possible causes depend on tuner type:

1. Quartz tuner (10 button direct access digital synthesizer) - For a slight drift, a component is probably changing value, possibly the crystal in the reference oscillator. For gross changes - flipping through channels - it is more likely to be a digital control problem - the microcontroller is misdirecting the synthesizer to change frequency.

2. Varactor tuner (buttons but not direct channel access) - If only a single pushbutton selection is the problem, the the varactor tuning diode for that button is probably changing capacitance. If all channels in a band (Vl, Vh, U) are having a problem, it is more likely to be a drifting D/A or faulty AFT (Automatic Fine Tuning) circuit or power supply.

3. Turret or switch tuner (Knobs) - A component like a capacitor is changing value.

You will have to get in there with a heat gun or cold spray and track it down the old fashioned way. At least, the problem is almost certainly localized to the tuner box (and possibly the controller if applicable).

As noted, gradual slight changes in tuning are likely due to frequency determining components drifting.

Uncontrolled channel surfing is probably a logic problem. For the quartz tuner, this could still be marginal connections causing the microprocessor to misdirect the synthesizer to change channels.

For the latter case, particularly, the cause may still be bad connections resulting in loss of channel memory and/or erratic behavior.

Noise in picture and sound due to bright scene

When a bright scene comes, the screen flashes and there is a lot of noise in the sound. When a dark scene comes, there is no flash or noise. Changing channel does not help. The noise persists even when the sound is muted.

(The following is from: Lattuca@Midwest.net (Sam Lattuca))

When the video detector level is adjusted too high, you will get noise in the sound while screen contains a lot of white information (i.e. letters) but won't when only dark scenes are present. The video level adjust is usually a small coil normally located near the IF section. Since your set is several years old, this wouldn't be uncommon. It can be adjusted while watching the picture and listening to the sound.

Internal interference - switchmode power supplies and digital circuitry

(From: Mr. Caldwell (jcaldwel@iquest.net).)

On virtually all newer televisions and in particular Mitsubishi televisions there is a problem with interference being emitted by the switched mode power supply.

The common symptom of this 'fault' is snake like dotted 'S' lines on channels 2-6. It doesn't matter if it's cable, antenna or satellite(channel 3/4), this symptom can occur.

The common cause of this interference being allowed into the tuner is cabling. The super cheap 'suitable for garbage tie' cable that comes with even the most expensive VCR's is the culprit in most cases. The second is a set of rabbit ears the least common is an open or high resistance to ground connection (usually at a connector) on the incoming cable line.

To fix this there is only one reliable solution. All cabling must be hand made RG-6 cable. Make as follows:

1. Strip the outer sheath of the cable to expose the braid and *fold the braid* away from the end so that it covers the unstripped outer braid.

2. Strip the inner conductor to it's proper length.

3. Install a good quality RG-6 connector *over the folded* braid.

4. Crimp with the proper RG-6 attachment to the cable crimpers, don't use a set of pliers or other -crushing- device.

If the cable company doesn't waterproof the outside connectors, Radio Shack sells a 'sealing tape' just for this purpose. Most cable companies use self sealing 'o-ring' connectors.

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

There is also interference from internal microprocessors and digital text generators (on-screen display, close captioning, teletext). And with 100 Hz digital television there is a wealth of sources ...

Using only high quality shielded cable as described above seems like really good advise, FWIW I'd like to second that. I wish that everyone would take antenna cables as seriously as you.

Generally, double-braided cable (using copper foil for second shield) and coaxially constructed connectors are recommended. But I think that the hand-mountable F-type connectors (Radio Shack) would be equally good, though less robust, if mounted properly.

As far as antennas go, a decent rooftop antenna should always be better than whatever rabbit ear construction you might think of. In this case, distance counts too, the antenna WILL pick up interference.

Those darn rabbit ears

So you bought a high performance TV and a set of $20.00 rabbit ears and there are lines on channels 2 to 6. Go buy a set of rabbit ears that has *only* a coax connector on the back, throw the cable supplied with it in the bin for 'twist ties'. Also buy an inexpensive surge suppressor that has a cable protector, enough RG-6 cable and connectors for two cables.

- Make one cable long enough to get the antenna away from the set (12ft) and the other to connect the antenna to the surge suppressor.

- Connect the long cable to the set and the other end to the surge suppressor.

- Find an outlet away from the set and plug the surge suppressor in (pick the most sane order for all of this.)

- Connect the shorter cable to the surge suppressor and connect the other end to the antenna.

You're done and if you thought carefully you would have put the antenna near your easy chair so you can adjust the picture or put the antenna where you'll get the best reception and prevent interference. The surge suppressor was needed to ground the other end of the coax so as not to make the outer shield an antenna for the interference from the TV's power supply. This method can also help allevate 'dead spots' when using rabbit ears.

Herringbone lines in picture

(From: Isaac Bergen (isaac.bergen@sympatico.ca).)

Could be interference. If the pattern slowly moves up the screen, the problem is from the 60 Hz power. A line of dots or thin lines usually means corona discharge (arcing) from a nearby power line (especially on humid days). Could also be from a bad filter capacitor in the TV's power supply. A "checkered" pattern could be from a digital type noise source like a computer, etc. If you move the TV to another room and the interference changes, that's probably it.

EM or RFI hell?

> "About a mile from my home there are four TV (channels 2, 4, 9 and 14) and several broadcast FM transmitters, all working with powers in the 100+ Kw ERP class.
>
> Radio reception is a nightmare, mostly (I think) because of IM products in overloaded front end stages. In most bands there are several regions at a spacing of about 100 Khz, each 30 to 40 Khz wide with a harsh buzz stronger than anything else."

(From: Don Klipstein (don@Misty.com).)

If the buzz is of a frequency like the power line frequency or a harmonic thereof, then the nearby transmitters may not be the culprit. Instead, nearby corona on a high voltage power line, a nearby neon sign, or a nearby light dimmer may be the offender. Although the noise from these is usually broad-band, the noise could get concentrated into bands spaced 100 kHz apart if something resonant around 100 kHz is involved in the noise production.

I would try temporarily turning off all fluorescent lights, neon signs, lights with dimmers, etc. and asking your neighbors to do the same to see if any of these is the offender. I have often found light dimmers to be major RF noise sources.

Possibly, an RF noise filter for the AC power for your receiver may help things. If you isolate a single offending appliance, it may help to plug it into an RF noise filter. If you use any filters with either the offending appliance or the receiver, try all combinations of plug reversal to see what works best. Both leads of any offending appliance may not equally spew noise, and both lines in the filter may not equally block noise. Both lines of the receiver's power cord may not equally bring noise into the receiver, if this is the route the noise takes.

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Audio Problems

Picture fine, no audio

First check that any muting control is not activated. This might be a button on the remote or set itself. If you have a headphone jack, it may have dirty contacts as plugging in a headphone usually mutes the speaker.

If the set is mono or only one channel of a stereo set is out, then check for bad connections to the loudspeaker. Test the loudspeaker by disconnecting one of the wires (with the power off!) and measuring its resistance with an ohmmeter (it should be less than 100 ohms - probably less than 8 ohms). Or momentarily touch a 1.5 volt battery to the speaker terminals - you should get a click or pop from the speaker.

Next, trace back from the speaker output terminals to the circuit board and look for bad solder connections or a loose or dirty connector.

If these tests do not reveal anything, you probably need a scope (or audio signal tracer) and schematic. Or at least the part number off of the chip. Is the final amp a chip also or just a transistor? Have you tested the transistor? If there is little or no buzz from the speaker, that would indicate a problem fairly near the output. If the tuner/if were bad, I would expect some noise/humm pickup from the low level audio stages. Get the part number off of the chip. If it is in a socket, check the contacts for corrosion or looseness.

Weak or distorted audio

Assuming you are not attempting to play it at ear shattering levels, this may be due to an alignment problem in the IF/audio demodulator, a bad audio IC or other circuitry, bad connection, or a defective speaker.

If your TV has an earphone or audio line out jack, try this to see if it is clear. If so, then your problem is in the final audio amp or speaker(s).

If only one channel of a stereo TV is affected, it is almost certainly the audio amp or speaker for that channel. Interchange connection to the two speakers temporarily and see if the problem moves.

If the problem is at all intermittent - try gently whacking the TV - then it is likely a bad connection - either a cold solder joint or a dirty or tired IC socket.

The audio amplifiers in newer TVs are almost always ICs and replacements are usually readily available. If the IC is in a socket, remove the IC, clean the pins and socket contacts and reinstall it. Sometimes, the contacts on old socket lose their springiness and do not provide solid connections. Such a socket will need to be replaced.

If the set uses discrete transistors, it s also possible for one of these to become noisy.

If your TV is fairly old - 10 years or so - this may be an alignment problem requiring tweaking of a coil in the sound IF. See your service manual. It may be possible to have similar problems with newer TVs but this is relatively rare.

There could also be bad electrolytic capacitors, probably in the power supply area. Even though you might think this would result in hum and there is none (even when there is no audio in the program or the sound is turned down) dried up caps can result in distorted sound that may sound like a sort of clipping. An ESR meter is best for testing (with power off!) but carefully jumpering known good caps across suspect ones (again with power off, then turn on the set and check), will eventually find the bad one(s).

Buzzing TV

Do you actually mean buzz - low frequency as in 60 Hz? Or, do you really mean high pitched whine. If the latter, see the section: High pitched whine or squeal from TV with no other symptoms. Or, it may be a combination of both effects. Is the buzz through the speaker or from the inside of the set?

- If it is the speaker, then it is a problem with the audio circuitry. This could be a design issue - very common or an actual fault (if it wasn't there before). It could also be interference caused by fluorescent lights or appliances like vacuum cleaners with universal motors or body massagers with vibrator interrupters (which generate sparks).

  Where the source of the problem cannot be located or eliminated, consider using a (HiFi) VCR for the tuner with an external stereo amplifier and the disable the internal speaker.

- There is a slight possibility that the AC power in your house has some harmonic content - the waveform is not sinusoidal. This might be the case if you try to run on the same circuit as an active dimmer or something else with thyristor control. Proximity to heavy industry could also cause this.

  Relocating the offending device to another branch circuit may help. You could also try a line conditioner (not just surge suppressor) which includes filtering. Or, use a HiFi VCR as your audio source (see above). Else, petition to have that metal foundry move out of the neighborhood :-).

- However, a buzzing that only occurs when the picture has sharply defined text or graphics, may be an overload problem at the source - some TVs simply handle it better than others.

  If it is a fault in the TV, an adjustment to the tuner or IF may be needed.

  (From: Paul Weber (webpa@aol.com).)

  Not to disparage proponents of the evil demon theory, but the phenomenon is more commonly known as "sync buzz". It is caused by poor performance in the TV's audio circuitry. It can usually be fixed by (1) reducing the signal strength and/or (2) tweaking the sound IF coil. Unfortunately, some of the latest TV receivers have no sound IF coil to adjust. If your TV has a sound IF coil, it can be done by ear, if you don't care about sound quality. However,I'd recommend taking it so a competent shop and describing the symptoms. Use the term "sync buzz in the audio," and they'll know what you mean. Be advised that it can't be cured in some TVs due to poor design.

- If it is from inside the set (and not from the speaker), it is in the deflection (probably vertical) or power supply. Either of these can vary in severity with picture content due to the differing current requirements based on brightness. It could be a power supply transformer, deflection yoke, or other magnetic component. Even ferrite beads have been caught buzzing when no one was looking :-). Any of these parts could vibrate if not anchored securely or as they loosen up with age.

  Some hot-melt glue, RTV silicone, or even a strategically wedged toothpick may help. A new part may or may not quiet it down - the replacement could be worse!

  See the section: Reducing/eliminating yoke noise.

- Some TVs are simply poorly designed. You cannot infer the severity of this annoyance from any specifications available to the consumer. It is strictly a design (e.g. cost) issue. The size of the TV is not a strong indicator of the severity of the problem but there will be some relationship as the power levels are higher for larger sets. The best you can do is audition various TVs very carefully to find one that you are satisfied with.

BTW, when I got my new super-duper RCA Colortrak in 1980, it had a similar annoying buzz - even had a repair guy out who behaved as though this was to be expected. I did get used to it and am not even aware of it today - and still use that set.

Additional comments:

(From: Karen (kclark9835@aol.com).)

Also for some audio buzz problems especially in the older units don't overlook the possibility of a misaligned trap. or a touch-up of the sound discriminator may prove helpful.

(From: Alan (algba@ix.netcom.com).)

If the buzz is coming from the speaker suspect a bad saw filter in the if circuit (very common).

If it is coming from elsewhere in the set it could be the flyback transformer, line input choke, or most common on those sets - the deflection yoke. I have repaired many of these yoke by using a wooden shim and some silicone rubber. In the collar of the yoke just ahead of the lock down clamp, there are some metal strips under the plastic. These are magnet that are used for convergence correction at the top and bottom of the picture. If you disturb them too much it will throw off the convergence.

Chattering yoke

This is a special case of buzzing originating from the deflection yoke.

(From: John Del (ohger1@aol.com).)

I am assuming your talking about a NAP yoke made by Panasonic/Quasar also used by them as well. The vibration comess from the metal shunt inside the yoke which is used for "self convergence". The shunts were held by a mastic material that breaks down into a powdery substance.

Remove the yoke from the tube and bore a small hole in the plastic on both halves (top and bottom). These holes will be at the 12 and 6 positions, as the 3 and 9 will have windings visible. Fill the holes with white glue and let the glue settle in, rotating the yoke as it does. The glue will soak into the powdery material and harden it. You will have to do this several times until the glue oozes out near the clamp. Give it a full day to dry. This is better than paying $60 to $80 for the yoke.

High pitched whine or squeal from TV with no other symptoms

First, make sure it is not coming from the loudspeaker itself. If it is, then we are looking at an unusual electronic interference problem rather than simply mechanical vibration.

If it is a new set and think the sounds will drive you insane, returning it for a refund or replacement may be best alternative. However, you may get used to it in time. I don't know about returning a set to a store that doesn't take refunds (I won't even ask about that!).

In most cases, this sound, while annoying, does not indicate an impending failure (at least not to the set - perhaps to your mental health) or signify anything about the expected reliability of the set though this is not always the case. Intermittent or poor connections in the deflection or power supply subsystems can also result in similar sounds. However, it is more likely that some part is just vibrating in response to a high frequency electric current.

There are several parts inside the TV that can potentially make this noise. These include the horizontal flyback transformer, deflection yoke, other transformers, even ferrite beads in the horizontal deflection circuits. In addition, transformers or chokes in the switching power supply if this is distinct from the horizontal deflection circuitry. Or even a portion of the sheetmetal used for shielding if in close proximity to a magnetic component.

You have several options before resorting to a 12 pound hammer:

- As much as you would like to dunk the TV in sound deadening insulation, this should be avoided as it will interfere with with proper cooling. However, the interior of the entertainment center cabinet can be lined with a non-flammable sound absorbing material, perhaps acoustic ceiling tiles. Hopefully, not a lot of sound energy is coming from the front of the set.

- Move the TV out of a corner if that is where it is located - the corner will focus sound energy into the room.
- Anything soft like carpeting, drapes, etc. will do a good job of absorbing sound energy in this band. Here is your justification for purchasing those antique Persian rugs you always wanted :-).

If you are desperate and want to check the inside of the set:

- Using appropriate safety precautions, you can try prodding the various suspect parts (flyback, deflection yoke, other transformers), even lowly ferrite beads, with an insulated tool such as a dry wooden stick. Listen through a cardboard tube to try to localizing the source. If the sounds changes, you know what part to go after.
- Once you have located the guilty party, some careful repositioning, a strategically wedged wooden toothpick, or a dab of RTV silicone or hot-melt glue may keep it quiet. Where the yoke is the guilty party, see the section: Reducing/eliminating yoke noise.
- It is possible to coat the flyback transformer, but this is used mostly when there a loose core or windings and you are getting not only the 15,735 Hz horizontal (NTSC) but also various subharmonics of this. This is probably acceptable but may increase the temperature of the flyback.
- A replacement flyback (or whatever part) may cure the problem unless it is a design flaw or manufacturing quality problem. However, the replacement part could be noisier. You really do not want to replace the yoke (aside from the cost) as convergence and other service adjustments would need to be performed. Other transformers can be replaced.

Note that the deflection frequency - just over 15 kHz for NTSC and PAL - is on the border of audible for adults but will likely be loud to younger people possibly to the point of being terribly annoying - or worse. If you are over 40 (men more so than women), you may not be able to hear the fundamental at all (at least you can look forward to silence in the future!). So, even sending the TV back for repair may be hopeless if the technician cannot hear what you are complaining about!

BTW, if you have a really old tube type TV, the power tubes (damper and horizontal output) can also whine but these sets are few and far between these days :-).

Reducing/eliminating yoke noise

(From: Terry DeWick (dewickt@esper.com).)

Carefully look under vertical core next to plastic liner, on top and bottom is a plate called the astigmatism shunt, it has come loose. Work RTV, epoxy, or service cement onto it to glue it down and noise should quit.

(From: TVman (tvman@newwave.net).)

I have fixed a total of 27 of these sets with noisy yokes by removing the yokes and using motor armature spray sealant.

If you carefully mark the EXACT position of everything (yoke, purity magnets), and slide the yoke off the CRT, then once the yoke has been sealed with motor armature spray sealant and has dried thoroughly, put the yoke back EXACTLY where it was, there should be no problems.

The only thing I have had to do was set the purity on one set, but it was off a little to begin with.

Whining when off?

Many TVs actually run their switchmode power supplies even when off to power the standby stuff like the remote control receiver, real time clock or timer, and channel memory. Depending on the design of the regulator, the power supply may be running at a low chopper frequency due to the light load. Some people, dogs, and rodents are then annoyed. It could also be an indication of a fault like a bad capacitor or loosened transformer core if this symptom just developed - your hearing isn't likely improving :-(.

There is so much running nowadays in 'off' electronics!

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Miscellaneous Problems

General erratic behavior

You press VOLUME UP and the channel changes or a setup menu appears all by itself just at the climax of your mystery story.

Before you break out the screwdriver (or 12 pound hammer), cover up the IR remote sensor. Some types of electronic ballasted fluorescent lights may confuse the remote control receiver. Someone or something may be sitting on the remote hand unit or it may be defective and continuously issuing a bad command. Or, the kids across the street may have nothing better to do than to drive your TV (and you) nuts with their remote!

There is also a slight chance power line interference (from a light dimmer or external sources) may result in similar symptoms. See the section: Wiring transmitted interference.

Assuming this is not the source of the problem:

Check for bad connections - see if gently whacking the TV makes any difference or triggers the errant behavior. Bad connections in the power supply, system controller, or tuner, may result in this sort of behavior. See the section: TV and monitor manufacturing quality and cold solder joints. See the sections and separate documents on problems with RCA/GE/Proscan and Sony TVs if yours is made by one of these companies.

A microcontroller or other electronic problem is also possible. If the symptoms only develop after the set warms up, it may be heat related (though simple bad connections are more likely). Use 'circuit chiller' or a heat gun to identify the bad part.

Wiring transmitted interference

The power that comes from the wall outlet is supposed to be a nice sinusoid at 60 Hz (in the U.S.) and it probably is coming out of the power plant. However, equipment using electric motors (e.g., vacuum cleaners), fluorescent lamps, lamp dimmers or motor speed controls (shop tools), and other high power devices, may result in a variety of effects.

While TVs normally include some line filtering, the noise immunity varies. Therefore, if the waveform is distorted enough, some effects may show up even on a high quality TV.

Symptoms will usually be one or two areas of noise moving slowly up the screen.

The source is probably local - in your house and probably on the same branch circuit - but could also be several miles away.

- The rate will be the difference between the power line frequency (60 Hz in the U.S.) and the scan rate (59.94 Hz for NTSC). This results in a drift of about 16 seconds for a complete cycle (8 seconds if the inteference is at 120 Hz).

    - A single bar would indicate interference at the power line frequency.

    - A pair of bars would indicate interference at twice the power line frequency.

  Either of these are possible.

- Try to locate the problem device by turning off all suspect equipment to see if the problem disappears.

- The best solution is to replace or repair the offending device. In the case of a light dimmer, for example, models are available that do a better job of suppressing interference than the typical $3 home center special. Appliances are supposed to include adequate noise suppression but this is not always the case.

  If the source is in the next county, this option presents some significant difficulties :-).

- Plugging the TV into another outlet may isolate it from the offending device enough to eliminate or greatly reduce the interference.

- The use of a line filter may help. A surge suppressor is NOT a line filter.

- Similar symptoms could also be produced by a defective power supply in the TV or other fault. The surest way of eliminating this possibility is to try the TV at another location.

Jittering or flickering due to problems with AC power

If you have eliminated other possibilities such as electromagnetic interference from nearby equipment or a faulty video cable or problems with the video input (e.g., cable or VCR) - then noisy or fluctuating AC power may be a possibility. However, most modern TVs usually have well regulated power supplies so this is less common than it used to be. Then again, your TV may just be overly sensitive. It is also possible that some fault in its power supply regulator has resulted in it becoming more sensitive to small power fluctuations that are unavoidable.

One way to determine if the problem is likely to be related to AC power is to run the TV on clean power in the same location connected to the same video input. For example, running it on an Uninterruptible Power Source (UPS) with the line cord pulled from the wall socket would be an excellent test. The output of the UPS's inverter should be free of any power line noise. If the TV's image has now settled down:

1. Large appliances like air conditioners, refrigerator, or washing machines on the same circuit might cause significant power dips and spikes as they cycle.

   Plugging a table lamp into the same outlet may permit you to see any obvious fluctuations in power. What else is on the same circuit? Depending on how your house or apartment is wired, the same feed from the service panel may be supplying power to widely separated areas.

2. For some unfathomable reason, your TV may just be more sensitive to something about the power from the circuit in that room. There may be nothing actually wrong, just different. While unlikely, a light dimmer on the same circuit could be producing line-conducted interference.

If you have a multimeter, you could at least compare the voltages between the location where it has problems and the one where it is happy. Perhaps, the TV is sensitive to being on a slightly different voltage. This might only be a problem if some circuitry in the the TV is marginal in some respect to begin with, however.

3. There could be a bad connection somewhere on the circuit. If your house has aluminum wiring, this is a definite possibility.

   Try a table lamp since its brightness should fluctuate as well. This should be checked out by a competent electrician as it represents a real fire hazard.

An electrician may be able to pinpoint the cause but many do not have the training or experience to deal with problems of this sort. Certainly, if you find any power line fluctuations not accounted for by major appliances, on the same circuit this should be checked by an electrician.

TV blows fuses or trips breakers or worse when A/V connections are made

You have sent the TV for repair and now three times, it blows something the instant anything is connected to it in your house. Other A/V equipment operates fine.

Assuming all the other stuff is plugged into the same outlet asn is 115 VAC equipment and that thsi happens instantly when the TV is connected:

Next time they bring it back, measure the voltage between the A/V connector shields and the shields on your cables - I wouldn't be surprised to find some substantial fraction of 115 VAC between them. This would mean that there is an internal short in the TV (their problem - any competent service center will routinely check for signal-AC ground shorts) resulting in a connection between the non-isolated AC ground and the signal ground. When you connect your equipment, you complete a path which results in a short circuit. Depending on the design of the TV and where the fault lies, much more than a simple fuse may be destroyed. This is similar to connecting a scope probe ground to a live chassis TV - see the section: Safety guidelines.

My TV has the shakes

You turn on your TV and 5-10 seconds later, the display is shaking or vibrating for a second or so. It used to only occur when first turned on, but now, the problem occurs 3 times in 30 seconds. Of course, many variations on this general theme are possible.

Some possibilities:

1. External interference - did you change anything or move your A/V setup recently? Do you have a computer monitor nearby?

2. Defective circuitry in TV - power supply regulation, deflection, or bad internal connections are possible.

3. Defective video cable (unlikely) - wiggle the cables to be see if you can induce the problem.

4. Loose trim magnets of other magnetic components on or near deflection yoke. This is somewhat rare but if the adhesive comes apart, the magnetic fields from the deflection current can cause the parts to vibrate which will result in a jitter or movement of the picture. There may even be audible crackling or snapping sounds associated with this vibration.

Note that many of the sources of electromagnetic interference that are problems with computer monitors like transformers and power lines will not cause noticeable shaking, wiggling, or jiggling on a TV because the power line and vertical scan are at almost exactly the same frequency and any such movement would be very slow.

TV displays black box with normal picture border

When the set is first turned on, it works fine for about 20-30 seconds, then the picture goes away - all but about 1 inch of picture all around the outer edge of the screen. The square ring of picture that is left, is dim but otherwise normal.

(The following from: (jack haney) jhaney@pacifier.com))

If this is a newer set, this sounds very much like a "closed caption" box for a captioning system not being used in your area. Newer Mitsubishis do much the same thing. If the wrong caption type is selected inadvertantly, all you'll see is a large black box on screen taking up about all but an inch each way.Try turning off all closed caption. The first time I saw this I looked like a damn fool in front of a customer, took me 30 minutes to figure it out.

Advertising overload

> "I noted the advertsing programs put in bright several frames of overshooting white signals in purpose of attracting attention which I do not want also it gets on my nerves sometimes. *flash* *flash* Ughhh! Is there a way to cutoff the "overload" or tone down that?"

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

Technically, the TV takes care of its own overload protection. Or at least it *should*, on some TV's you will certainly observe the line transformer going into saturation for a while. Other than that there is not much you can do, each TV should represent its input signals with as much fidelity as possible. Change channels?

(I already suggested not watching. :-) --- Sam.)

Strange codes appearing on TV screen

> "I've seen this sort of thing on a TV I bought a couple of years ago. I only see it when Proctor & Gamble ads are on.
>
> The newer TVs are required to have Closed Caption decoding (CCD). My TV has an OFF-ON button for CCD. It also has a button labeled CH1-CH2. When pushed in I get the verbal text on the screen like I should. When the button is out, I get the funny codes from Proctor & Gamble."

(From: Tim (jollyrgr@mc.net).)

The code you are seeing is Closed Caption 2. My Zenith has CC 1, 2, 3, 4, as well as Text 1, 2, 3, and 4. I have seen CC 1 which is the normal closed captions. CC 2 is used for commercial logging/identification. There should be a way to completely turn off the captions. The TV, as you state, has a switch for turning off the captions and should solve your problem.

Releasing 'demo' mode

You really want to watch CNN but the TV insists on promoting itself:

- For Fisher TVs:

(From: Alan (algba@ix.netcom.com).)

Hold down the menu key on the remote for 8 seconds to switch it out of that mode or back in again.

- Here are several possibilities for LXI TVs:

  - Press VOLUME UP and VOLUME DOWN buttons together. Set will turn off. Then power back on normally.

  - Press VOLUME UP and CHANNEL DOWN buttons together.

  - Try holding the MENU button for 5 to 10 seconds. (Sanyo/Fisher sets manufactured for Sears.)

  - Try holding the SETUP button for 5 seconds.

- For Magnavox TVs:

  (From: L. Tankersley (boat39@mail.idt.net).)

  Try pressing both volume control buttons on the TV at the same time and releasing. The demo mode should go off and the set turn off by itself. Turn the set back on and it should be back to normal.

- For Sanyo TVs:

  (From: Bill A. (Lucy27@ix.netcom.com).)

  Try pressing the "menu" button on the unit and keep it depressed for about 15 to 20 seconds. This should release the demo mode.

TV was rained on

Was the set plugged in when the leak started? Any piece of equipment with remote power-on capability has some portions live at all times when plugged in and so there may have been damage due to short circuits etc. Substantial damage could be done due to short circuits.

Otherwise, you may just need to give it more time to dry out. I have had devices with keypads getting wet that required more than a week but then were fine. There are all kinds of places for water to be trapped and take a long time to evaporate.

If the set got wet while unplugged (in a leaky attic or wet basement), for example, or it has a pull or click knob on/off switch, then give it time to dry out - completely. Assuming all visible water is drained, a week represents a minimum safe time to wait. Don't rush it.

Generally, some moisture will not do any permanent damage unless the set was on in which case you will simply have to troubleshoot it the old-fashioned way - one problem at a time.

TV was dropped

You have probably seen the TV advertisements - I don't recall what they were for - where a late model TV is dropped out a many story window on a bunjie cord to rebound once undamaged and without hitting a baby in a stroller but then smash to smithereens on the sidewalk once the stroller had moved. Needless to say, this is generally not a recommended way to treat a TV set!

However, mishaps do happen.

Assuming it survived mostly intact - the CRT didn't implode, you could still have a variety of problems. Immediately unplug the set!

If you take it in for service, the estimate you get may make the national debt look like pocket change in comparison. Attempting to repair anything that has been dropped is a very uncertain challenge - and since time is money for a professional, spending an unknown amount of time on a single repair is very risky. There is no harm is getting an estimate (though many shops charge for just agreeing that what you are holding was once - say - a TV, or was it a fishtank?)

This doesn't mean you should not tackle it yourself. There may be nothing wrong or very minor problems that can easily be remedied. The following are likely possibilities:

1. Cracked circuit boards. These can be repaired since TVs usually have fairly wide open single or two sided boards.

2. Broken circuit components. These will need to be replaced.

3. Broken solder connections particularly to large heavy components on single sided boards. Reflow the solder. If the trace is cracked or lifted, repair as in (1).

4. Broken mounting brackets. These are usually made of cheap plastic and often don't survive very well. Be creative. Obtaining an exact replacement is probably not worth the trouble and expense.

5. Components knocked out of line on the CRT envelope or neck - deflection yoke, purity magnets, convergence magnets and coils, geometry correction magnets. These will need to be reattached and/or realigned. Some CRTs use little magnets glued to the funnel portion of the CRT envelope. If any of these have come loose, it could be quite a treat to figure out where they went and in what orientation.

6. Internal damage to the CRT - popped or distorted shadow mask, misaligned electron guns. Unfortunately, you will probably have no way of identifying these since you cannot see inside the CRT. They will not be apparent until all other faults have been remedied and the TV set is completely realigned. At that point, extremely severe purity or convergence problems that do not respond to the normal adjustment procedure would be one indication of internal damage. Give the TV a nice funeral. See the "Sony1" and "Sony2" photos in James Sweet's Sony/Trinitron Directory for some screen shots showing the symptoms resulting from a monitor falling on its face. :(For a large screen TV, the effects may be even more dramatic.

If you still want to tackle a restoration:

As noted, unplug the TV even if it looks fine. Until you do a thorough internal inspection, there is no telling what may have been knocked out of whack or broken. Electrical parts may be shorting due to a broken circuit board or one that has just popped free. Don't be tempted to apply power even if there are no obvious signs of damage - turning it on may blow something due to a shorting circuit board. If it is a portable, remove the batteries.

Then, inspect the exterior for cracking, chipping, or dents. In addition to identifying cosmetic problems, this will help to locate possible areas to check for internal damage once the covers are removed.

(At this point, most people will assume there is no interior damage and plug the set back in and turn it on. My recommendation is to resist this temptation since as noted, this could result in further damage making the repair more expensive if there are circuit problems. However, if the unit was on at the time of the "incident" or you are really determined to get to the conclusion and would just throw the thing in the trash if it doesn't work or blows up, go for it! But, if you're the more cautious type, continue with the systematic diagnosis and repair procedure that follows.)

Next, remove the cover. Confirm that the main filter capacitors are fully discharged before touching anything. Check for mechanical problems like a bent or deformed brackets, cracked plastic parts, and anything that may have shifted position or jumped from its mountings. Inspect for loose parts or pieces of parts - save them all as some critical magnets, for example, are just glued to the CRT and may have popped off.

Carefully straighten any bent metal parts. Replace parts that were knocked loose, glue and possibly reinforce cracked or broken plastic. Plastics, in particular, are troublesome because most glues - even plastic cement - do not work very well. Using a splint (medical term) or sistering (construction term) to reinforce a broken plastic part is often a good idea. Use multiple layers of Duco Cement or clear windshield sealer and screws (sheetmetal or machine screws may be best depending on the thickness and type of plastic). Wood glue and Epoxy do not work well on plastic. Some brands of superglue, PVC pipe cement, or plastic hobby cement may work depending on the type of plastic.

Inspect for any broken electronic components - these will need to be replaced. Check for blown fuses - the initial impact may have shorted something momentarily which then blew a fuse.

There is always a risk that the initial impact has already fried electronic parts as a result of a momentary short or from broken circuit traces and there will still be problems even after repairing the visible damage and/or replacing the broken components. This is most likely if the set was actually on but most modern TVs have some circuitry energized at all times.

Examine the circuit boards for any visible breaks or cracks. These will be especially likely at the corners where the stress may have been greatest. If you find **any** cracks, no matter how small in the circuit board, you will need to carefully inspect to determine if any circuit traces run across these cracks. If they do, then there are certainly breaks in the circuitry which will need to be repaired. Circuit boards in consumer equipment are almost never more than two layers so repair is possible but if any substantial number of traces are broken, it will take time and patience. Do not just run over them with solder as this will not last. Use a fine tipped low wattage soldering iron and run #22-26 gauge insulated wires between convenient endpoints - these don't need to be directly on either side of the break. Double check each connection after soldering for correct wiring and that there are no shorts before proceeding to the next.

If the circuit board is beyond hope or you do not feel you would be able to repair it in finite time, replacements may be available but their cost is likely to be more than the equipment is worth. Locating a junk unit of the same model to cannibalize for parts may be a more realistic option.

Degauss the set as any impact may magnetize the CRT. Power cycling may work but a manual degaussing is best.

Once all visible damage has been repaired and broken parts have been replaced, power it up and see what happens. Be prepared to pull the plug if there are serious problems (billowing smoke or fireworks would qualify).

If there are obvious problems with color, disconnect (or disable) two of the 3 primary colors with a B/W picture (color control turned all the way down) or solid raster displayed. If the raster is not now a pure color, you have a CRT or CRT purity adjustment problem.

Perform any purity, convergence, or other realignment as needed.

Then proceed to address any remaining problems one at a time.

Really cleaning a TV inside and out

(This was written for computer monitors but applies equally well to modern TV sets.)

(From: Dr. Ludwig Steininger (drsteininger@t-online.de).)

Often I get defective monitors, which are more than 5 years old, and have been run in offices for 8 to 10 hours/day. So, their case and pcbs usually are very dirty and dusty.

What do I do (it's no joke!): After removing the case I carefully put them in a bath (on a flexible layer) and let them have a intensive shower of pure cold water (for 1 to 2 minutes). Additionally, the case is cleaned with soap or a detergent containing liquid (being careful, not to spill to much of it onto the PCBs). After rinsing with fresh clear water, dust and other kinds of dirt are removed and the monitors look new again. Then I allow all drops of water to run off. This can effectively be supported by turning the monitor on another side from time to time (duration: approximately 1 hour). Before turning on AC again, I let the wet monitor dry in ambient air for about 2 days (in the sunshine this can be finished in 1 day only).

This procedure has been applied for many monitors. I've never had any bad experiences (it's very important to wait, until the pcbs are really dry!). Considering this experience, I just can't imagine, that it might not be possible, to "save" a TV set or computer monitor, which has been drowned or some liquid has been spilled, and AC has been plugged off ASAP (although I've never had such a case). I think, that in such a case, it's important to have a rapid shower in order to prevent corrosion and deposits.

By the way: I know a German company, which uses water from cleaning PCBs of computer hardware for cleaning them after being contaminated by smoke from a fire.

So, in case of spillage, one has nothing to loose. Just try to shower your monitor or TV set!

Setup menus will not go away or hieroglyphics on screen

Both these problems could be caused by a faulty microcontroller or its associated circuitry. However, bad connections in the vicinity of the controller logic could also be at fault.

Unless you see something obvious, you will need schematics.

Setup adjustments lost - TV service codes

Many modern TVs have RAM, somewhat like the CMOS SETUP memory in your PC, that store all factory adjustments. When power is lost, there is power surge, lightning strike nearby, nuclear detonation or EMP, it may have put bad information into the ram and thrown it out of adjustment. There is a way to get into the service mode (depress and hold a secret button down and turn set on, special combination of buttons on the remote, etc.) and then use the remote to reinitialize and adjust the problems out.

HOWEVER, IF YOU DON'T KNOW WHAT YOU DOING YOU COULD GIVE YOURSELF WORSE PROBLEMS. YOU COULD EVEN BLOW VERY EXPENSIVE PARTS WITH SOME SETS!

Try not to make any unnecessary changes and document every change you make!!! That way you can go back if you do anything wrong (hopefully). However, some changes - even if nothing fails - will result in an unviewable picture thus making it extremely difficult to see what you are doing.

The Sams' Photofact manual for your set should describe this process - you may be able to get Photofacts from a local library, or you can buy them from Radio Shack or a place like MCM Electronics or an electronics distributor. The June, 1998, issue of "Electronic Servicing and Technology" (ES&T) had an article on service mode if you have access to this publication (it won't be in your public library).

Some examples follow. You would need to check the service information for your specific model to be sure. However, trying the procedures described below probably will not hurt. The TV will just ignore you if it doesn't like your codes! However, if you do get in, make sure you know what you are doing or your original problem may be inconsequential compared to your new ones!

- Ferguson/Thomson Technology T49F television (TX91 chassis and probably others as well).

  (From: Peter Radlberger (peter.radlberger@blackbox.at).)

  1. Unplug SCART cable.

  2. Switch to Standby, then switch mains off.

  3. Hold blue button on remote, power up.

  4. Repress blue button, service screen appears.

  5. Select function with blue, adjust with Vol+/-, store new value with highlighted Memo and Vol+. Restore jumps to original value, ROM are production defaults.

  6. Leave with Standby.

- Some Hitachi models:

  (From: Kahlid Ataya (kahlidataya@yahoo.com).)

  1. Turn the TV off with the main switch.
  2. Press and hold the A/V button on the front panel and turn the TV on with the main switch.
  3. Wait about 10 seconds and the TV will go on and service mode will appear on the screen.

- Some JVC models (JA chassis):

  (From: Roger Dowling (rogerd@globalnet.co.uk).)

  Press the DISPLAY key (may look like a small TV screen with a cross in the bottom right corner) and the CINEMA/GAME key of the remote control simultaneously.

  (From: Andy Cuffe (baltimora@psu.edu).)

  I have used this on JVCs from 1995:

  1. Set the clock to 3:21 AM.

  2. Start the clock as you normally would but press MUTE while "Thank you" is flashing.

  3. Press menu up or down just after MUTE.

  4. Use up/down to select options and left/right to adjust. The settings are automatically saved when you exit.

  (From: P. White (pwhite4@aol.com) and David Rigolo (stormdav@ix.netcom.com).)

On the new line of JVC sets (some models include: AV-36850, AV-32850, AV-27850, and AV-32820), hold the "Display" and "Video Status" buttons on the remote simultaneously. The set will bring up a service menu. Good luck trying to navigate the service menus with out a manual.

(From: Yorkie (magicfriend@ntlworld.com).)

Press the MENU and INFORMATION buttons down together and then press 1 then 2 then 3 while still holding the first 2 buttons down.

- Some Magnavox models: Enter 062596 then MENU. The channels will change but when MENU is pressed, the TV will enter the service menu.

  (From: Gscivi (gscivi@aol.com).)

  Hit MENU on the remote, while the menu is still up press the numbers 061596 or 061597. One of these will bring up the service menu. Now, your right/left arrows on remote will switch between the numbers across the bottom of the screen, highlight the number set right after the 'setup or service' option. The arrow up/down will change to the next service position.

- Some Mitsubishi models: Use your remote and press MENU then 2357 use VIDEO to select service menu and ADJUST to set values.

  There is more info on Mitsubishi service modes at: Don Page's Mitsubishi Service Mode Page.

- Some Nokia (ITT) models:

  (From: Stefan Huebner (Stefan.Huebner@rookie.antar.com).)

  Press mono/stereo - Channel C - Hypersonic within 1 second, The display now shows SE. Leave the service mode with the standby button.

  (From: Janus Christian Krarup (jckrarup@image.dk).)

  Press: [OK],[MUTE],[TV/SAT]

- Nokia model 6363:

  (From: Ian Abel G3ZHI (bert@skypilot.demon.co.uk).)

  Nokia model 6363 (and probably other late model TVs) - On the remote press -/-- then menu then TV all within 1 second. When in setup mode you use channel up or down buttons on the TV set to change to whatever you need to set up. Adjustments are made with volume + and - buttons on the remote control. My advice is to make a note of all the settings before making changes then you can always go back to them.

- Some Panasonic models: A very detailed document on Panasonic Service(man) mode for some models in the GL10C family (may apply to others as well) is provided at:

  - Panasonic TV Service Modes

  This includes entering/saving/leaving, register contents and range, etc., and useful links.

- Panasonic TX-W28R3 (and similar models):

  (From: Arpad Kothai (arpadk@EUnet.yu).)

  The remote control is used for entering and storing adjustments, with the exception of cut-off adjustments which must always be done prior to service adjustment. Perform adjustments in accordance with screen display. The display on the screen also specifies the CCU variants as well as the approximate setting values. The adjustment sequence for the service mode is indicated below.

  1. Set the Bass to maximum position, set the Treble to minimum position, press the Reveal on the remote control and at the same time press the Volume on the customer controls at the front of the TV, this will place the TV into the Service mode.

  2. Press the RED/GREEN buttons to step down / up through the functions.

  3. Press the YELLOW/BLUE buttons to alter the function values.

  4. Press the STORE button on the preset panel after each adjustment has been made to store the required values.

  5. To exit the Service Mode press the Normalization button.

- Philips 29PT8303 and other similar models:

  Using the remote control, press 062596, then the MENU key.

  (From RONGYOUNG@aol.com.)

  The access code for my Philips/Magnavox model TP3281CI is: Key in 062596, then press STATUS. This will get you into the setup menu. When done exit using the MENU key back to the normal picture. (Just as you would to exit the normal menu items). To save your changes you need to turn the TV off and then UNPLUG it for 10 or more seconds.

- Some late model Philips projection (and possibly other) sets:

  (From: Keith Halonen (finearts@sonic.net).)

  1. On remote, quickly enter 062596 and press MENU. SDM will appear at top right of screen. You can enter a channel number (or select a feed with your AV button) to restore a clear picture behind the SDM menu.

  2. Go up to the set itself and simultaneously hold down BOTH front panel volume buttons for several seconds - regular menu shows up for a second or two, then the service menu appears.

  3. CLEAR ERRORS will be selected. Press your RIGHT arrow button and all error numbers will reset to zeroes. (The repairman did this BOTH times he went in to adjust my Horizontal Shift - I'm not sure it is necessary but just in case!)

  4. Press DOWN arrow button to scroll down until you get to GEOMETRY, then press RIGHT arrow button to enter that mode.

  5. Press DOWN arrow button until you see HOR-SHIFT and a number. LEFT arrow key moves the picture left (smaller number), RIGHT arrow key does opposite.

IMPORTANT! To LOCK setting in, press MENU button to back out of GEOMETRY mode. Then shut off TV and turn on again. Picture will be shifted.

NOTE: After making any changes as per the above procedure, the Closed Caption feature will be activated during normal sound settings. Enter the regular MENU mode, select FEATURES and enter CLOSED CAP to reset the CAPTION MODE to CC MUTE.

NOTE: Other features in GEOMETRY mode also influence the picture image. If you intend to tinker, first make a list of all features/numbers. Don't panic if the VER-SLOPE feature chops the screen in half when you use the L- R arrow buttons to change the number. Just press MENU to back out and the picture will restore itself as per the new setting. After backing out of GEOMETRY mode with MENU you can reenter GEOMETRY mode without having to shut off the TV - just select GEOMETRY and use the right arrow button to reenter. Backing out with MENU merely locks in the most recent setting changes.

- Some RCA models: The codes can be found pasted to the inside of the back cover. To get into the SETUP MENU, "Press and hold MENU, hit POWER and then VOL+. DO NOT set H Freq too low or you will wipe the EEPROM. Bummer. For more information, see the document: RCA/GE TV (CTC175/176/177) Solder Connection and EEPROM Problems.

  (From: David Kuhajda (dkuhajda@locl.net).)

  On the newest RCA models, the Thomson Chipper Check computer interface is required for the service mode adjustment. To get into service mode: Press and hold MENU, tap POWER, tap VOLUME UP (on TV). Then using VOLUME UP or VOLUME DOWN, move data to 200 and press CHANNEL UP.

- Some Samsung models:

  (From: Livio Belac (lbelac@efpu.hr).)

  - CHASSIS: SCT51A: PICTURE OFF (ST. BY) -> SLEEP -> P.STD -> MUTE -> PICTURE ON (PWR ON).

  - CHASSIS: SCT11A, SCT11B, SCV11A, SCV11B ST. BY -> P.STD -> MENU -> SLEEP -> POWER ON.

  Perform adjustments with VOL +/-

  Select between adjustments with CH +/-

- Some Sharp models (including 19J-M100 and 20J-M100):

  Press the 'vol up' and 'channel up' at the same time and then plug in the set to AC line. Use the 'channel up/down' buttons to select the register; use the 'vol up/down' buttons to select the values. To exit this mode, depress the 'power' button.

- Some other Sharps (e.g., model 19H-M60):

  Short TP2001 and TP2002 together momentarily to get the service menu up. The service menu shows the paramater being aligned and the value.

- Sharp 51DT-25H:

  (From: Matt (matties@btinternet.com).)

1. Power the set off.
2. Press vol- and prog+ at the same time while powering up the set. Release the buttons after 1-2 seconds (the screen is still black at this point), otherwise the television is switched on in normal mode.

- Sharp 59C5-03H and some others:

  (From: Malcolm MacArthur (malcolmm@rustic-place.demon.co.uk).)

  1. Switch on TV, get a picture up.
  2. Unplug without switching to standby.
  3. Volume down, channel up.
  4. Plug in. The TV "boots" into service mode.

  To change values:

  1. Channel up/down (on set or remote): Select value to edit.
  2. Volume up/down: Edit value.
  3. Standby button: Store value (it took an hour to figure out the last one!)

  When finished, unplug. The TV will restart in normal mode.

- Some Solar/Finlus/ITT TVs:

  (From: Janus Christian Krarup (jckrarup@image.dk).)

  Salora 28F8C: Within 6 seconds from a cold-boot press [pause],[stop],[play] and [fast forward] quickly after each other. The TV will then enter the setup mode by displaying "SA" in the LED display. The user interface for this is an absolute nightmare. You input via the remote control (the layout is in no way intuitive!) and all the feedback you get is via the small LED display. I started navigating the mode and quickly figured out that [+] and [-] are used to navigate between different entities. You always start in "SA" and can cycle through 15 different entities before you end back in "SA". There are some basic and some very hardcore functions. (At the moment I have managed to mess my TV up really well, with the primary colours mis-aligned - which also seems to affect the AFC somehow.) [VolUp] and [VolDn] adjusts the "primary property" of the entity.

  SA: Horizontal adjustment, [VolUp]/[VolDn]: position A0: Vertical adjustment, [VolUp]/[VolDn]: position Y0: Trapezoid adjustment, [VolUp]/[VolDn]: +/-

- Various Sony models: Service mode adjustments can be found at:

  - Sony Service Mode

- Another Sony:

  (From: Trygve Pedersen (trygve-p@netpower.no).)

  To enter service mode turn off power push both + and - buttons on front of TV while you powers up you get TT on screen, and then you enter 34 (TT34 on screen), press the left arrow twice on remote, and you are in service mode.

- Some Sony UK models: Fast text buttons operate service mode.

- Sony KV-X2571 and similar models:

  (From: Peter & Jolanda Faber (pfaber@worldonline.nl).)

  Switch TV off. Press and hold two switches (center & right) under front panel. Switch set on with main switch. Wait a few seconds. Release two switches again.

- Some Toshibas:

  (From: Bill A. (Lucy27@ix.netcom.com).):

  1. Press the mute button on your remote and release (put unit in mute).

  2. Press and hold mute button on remote.

  3. At the same time while holding mute button on remote, press the menu button on the TV itself.

  If done correctly an "s" should show up on the screen to determine that you have successfully entered the service mode.

  5. Now, I believe if you press the menu button again on the unit some microprocessor data should be showing up on screen i.e. current micro part# etc.

  6. Press #9 on remote to enter various modes of operation. Here is where you really need the service manual, too much info to show here.

  Once in Service mode be very careful!!!

- Zenith System 3:

  (From: Raymond Carlsen (rrcc@u.washington.edu) and jollyrgr@mc.net).

  Hold the MENU button down for about 5 seconds... until the currently displayed menu disappears. Then press 9 8 7 6, then ENTER. There are two menus in the service mode. Use the MENU to toggle between them. Press SELect until the item you want is highlighted, then the ADJ button (left or right) for the submenu or the adjustment. Press SELect for the next item and MENU for the alternate menu. Press ENTer to exit the service mode.

  Some other Zenith TVs:

  On the TV itself, press MENU until it disappears, then ADJUST RIGHT and CHANNEL UP at the same time.

Service menu caution

Even changing a parameter which results in the loss of the picture could require replacing the EEPROM if you cannot get the set to come on and view the service menu to reset!

However, it may be possible to drive the HOT with an external source so you can see the menus for setup.

CAUTION: there is some risk. Should drive the HOT with too low a frequency, it may blow due to flyback core saturation. Use a series light bulb to minimize this possibility.

Links to TV Setup Information

(From: Sidney (sidneybek@yahoo.com).)

EEPROM service mode access sites:

(In no particular order.)

- http://members.accessus.net/~090/awh/how2adj.html#5.11
- http://members.aol.com/philstv/servicemenu.htm
- http://www.tehnicaavtv.com/tvservice.htm
- http://www.members.accessus.net/~090/awh/sonypal.html
- http://intrepid-video.com/tvtech.htm
- http://orpheuscomputing.com/technicians/Sony_service_more.html
- http://www.calanan.com/panasonic
- http://www.peakpeak.com/~pnickell/panasonic.htm
- http://cellardweller.com/tw40h80/index.html
- http://www.bus.ucf.edu/cwhite/theater/ServiceMode.htm
- http://www.alientech.net/tp61h95codes.html
- http://www.keohi.com/keohihdtv/brandspecific/hitachi/servicemenu.html
- http://www.keohi.com/keohihdtv/brandspecific/thomson/thomson_servicemenu.html
- http://home.hccnet.nl/m.majoor/tv__matchline_service_mode.htm
- http://www.repdata.de/Service%20Code/service-mode.htm
- http://www.n2hifi.com/xbr100.html
- http://www.e-repair.co.uk/story4.htm
- http://www.neato.org/~page/mitsu/service.html
- http://www.artofhacking.com/files/TVMODES.TXT
- http://qualitytuner.hypermart.net/codes.htm
- http://mapage.noos.fr/tophe/tvser.html?KeohiHDTV
- http://www.infocoal.ru/rclub/schemes/guide/chip/!eeprom-code/tv-vcr/
- http://www.televideo.al.ru/tv-video/servis.html
- http://amt.ural.ru/electronics/tv-servmenu.php3
- http://es.geocities.com/Dudaelectronica/modosdeservicios.htm
- http://www.servisystem.com.ar/tutorial/tv/micro.html
- http://www.comunidadelectronicos.com/articulos/modo-serv.htm
- http://www.comunidadelectronicos.com/articulos/desbloq.htm
- http://webs.demasiado.com/kueyar/Modos.htm
- http://paginadekueyar.iespana.es/paginadekueyar/Modos1.html
- http://perso.wanadoo.es/jeli/index1.htm
- http://www.schematicsforfree.com/video/apex_secret_menu.pdf
- http://www.schematicsforfree.com/audio/products/Panasonic_Table_of_Error_Codes_for_Audio_Products.pdf
- http://www.iwaynet.net/~nesda/SonyBlink.html
- http://members.aol.com/philstv/sonyblinking.htm
- http://www.videotech.org/self.htm

EEPROM part #'s by model/chassis lookup:

- http://www.mainelectronics.com/eproms.htm

- http://www.prelcoparts.com/eepromcross.pdf
- http://www.iwaynet.net/~nesda/EEPROMS.pdf

Strange number in upper left corner in Magnavox service mode

> "When I put my Magnavox in service mode a number comes up on the top left of the screen. I see no description of it in the service manual. Is this an hours used timer? Is it actually in hours?"

(From: Mister M. (mister-m@ix.netcom.com) and zapper (zap@mhv.net).)

This is actually a usege timer in hexidecimal.

(Hey, at least it is not binary. :-) --- Sam.)

TV doesn't work after being in storage

So the TV you carefully stuffed in a corner of the garages is now totally dead. You swear it was working perfectly a year ago.

Assuming there was absolutely no action when you turned it on, this has all the classic symptoms of a bad connection. These could be cold/cracked solder joints at large components like transformers, power resistors, or connectors and connectors that need to be cleaned or reseated. By 'no action' I mean not even a tweet, bleep, or crackle from anything.

To narrow it down further, if careful prodding of the circuit board(s) and various large components with a well insulated stick does not induce the set to come on, even momentarily, check the following:

1. Locate the horizontal output transistor. It will be in a TO3 metal (most likely on an older set) or TOP3 plastic package on a heat sink. With the set unplugged, confirm that there is no voltage across C to E and then measure between them with an ohmmeter. In at least one direction it should be fairly high - 1K or more. This confirms that the HOT is probably good.

   (There is also a slight chance that there is a low voltage regulator in addition to the horizontal output, so don't get them confused. The horizontal output transistor will be near the flyback transformer and yoke connector.)

2. Trace back from the HOT collector to the flyback and through the flyback to the B+ feed from the power supply. Clip a voltmeter between this point and the HOT emitter. Make sure the leads are well insulated and can't accidentally short to anything. (This test can be performed across C to E of the HOT but if the horizontal deflection were to start up unexpectadly, the meter could be damaged by the high voltage pulses on the HOT collector. But if you can't find the B+ source, it may be worth the risk.) Plug it in and turn it on.

   - If the problem is in the low voltage (line) power supply, there will be no substantial voltage across C to E.

     You should be able to trace from the power line forward to find the bad part though a schematic will help greatly.

   - If the problem is in the startup circuit or horizontal oscillator/driver, then there will be something on the order of 100 to 160 V across C to E.

     In this case, a schematic may be essential.

   There is also a slight chance that there is a low voltage regulator in addition to the horizontal output, so don't get them confused. The horizontal output transistor will be near the flyback transformer and yoke connector.

Older TVs with multiple intermittent problems

If the set is say, a GE, with a manufacturing date around 1980, it is possible you have one of those circuit boards best described as bad solder joints held together with a little copper. In this case, prodding may get the set started. The circuit boards in these sets were double sided using what were called 'rivlets' for vias. The rivlets were relatively massive - literally little copper rivets - and they were not adequately heated during assembly so there were bucketloads of cold solder joints that showed up during middle age. I repaired one of these by literally resoldering top and bottom of every one of the darn things with a high wattage iron.

TV has burning smell

Assuming there are no other symptoms:

If this appears after extended operation - an hour or more - it may just be a build up of dust, dirt, and grime over the years. After understanding the safety info, some careful vacuuming inside may help. Just don't be tempted to turn any screws or adjustments!

Dust is attracted to the high voltage section in particular - even the front faceplate of the CRT collects a lot and should be wiped with a damp cloth from time to time.

If the symptoms develop quickly - in a few minutes or less, then there could still be a dust problem - a power resistor may be heating a wad of it but other possibilities need to be considered.

If not dust, then probably in the power supply but realize that TVs don't have a nice metal case labeled 'power supply'. It is just a bunch of stuff scattered around the main board. Without identifying the part that is heating, a diagnosis is tough especially if the set really does work fine otherwise. However, if a series regulator were faulty and putting out too much voltage, the set could appear to work properly but in fact have excessive power dissipation in certain components. If cleaning the dust does not solve the problem, you will probably need a schematic to identify the correct voltages.

Static discharge noise and picture tube quality

> "I bought a 29" TV a couple of weeks ago and I have noticed that after being switched on for > about 15/20 minutes, whenever the picture changes from a "light" scene to a darker scene, the set makes a crackling noise. It sounds as though there has been a build-up of static and it is being discharged. I have never noticed this in a TV before and I was wondering if this is normal and acceptable behaviour for a large-screen TV?"

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

It probably is normal. Whether it is acceptable is a personal matter. In some geographic areas no countermeasures are taken at all...

When the scene changes from bright to dark, the beam current is reduced to practically zero. As a result, the high voltage rises. (The high voltage supply has a relatively high internal impedance.) The high voltage is connected to the inside layer of the picture tube. A voltage change on the inside will also cause a voltage change on uncovered parts of the outside, especially on the part of the picture tube that is hidden under the deflection coils. This causes little sparks between the picture tube surface and the inside of the deflection coils and this is accompanied by a crackling sound.

On the better picture tubes, a dark "anti-crackle coating" is painted on the picture tube near the deflection coil. This is a very high impedance coating, dark black, much darker than the usual aquadag coating over the rest of the picture tube. You should be able to see the difference.

If, on the other hand, the outside of the picture tube near the deflection coil is not coated then you have a problem. Then you will hear strong crackling also at switch-on and switch-off. Normally you shouldn't see such a 'cheap' picture tube on the European market...

The area of the picture tube around the anode connector is also not coated, for obvious reasons. Normally that should not cause any significant sound. Same goes for the front of the screen and neither should the anode cable crackle.

In a dark room you should be able to see from the tiny blue flashes where the sound comes from. This is perhaps best observed at switch-on and switch-off (with a black picture on the screen). Try and keep the back cover mounted !

Revival of dead or tired remote control units

There are two types of problems with hand held remote controls: they have legs of their own and they get abused or forgotten. I cannot help you with walking remotes.

Where response is intermittent or the reliable operating distance is reduced, first check the batteries and battery contacts. If some buttons are intermittent or dead, than the most likely cause is dirty or worn contacts under the rubber buttons or on the circuit board.

If there is no response to any functions by the TV or VCR, verify that any mode switches are set correctly (on both the remote and the TV or VCR). Unplug the TV or VCR for 30 seconds (not just power off, unplug). This sometimes resets a microcontroller that may have been confused by a power surge. Confirm that the remote has not accidentally been set to an incorrect mode (VCR instead of TV, for example). If it a universal type, it may have lost its programming - reset it. Make sure you are using the proper remote if have multiple similar models.

Test the remote with an IR detector. An IR detector card can be purchased for about $6. Alternatively, build the circuit at the end of this document. If the remote is putting out an IR signal, then the remote or the TV or VCR may have forgotten its settings or the problem may be in the TV or VCR and not the hand unit. The following is just a summary - more detailed information is available in the companion document: Notes on the Troubleshooting and Repair of Hand Held Remote Controls.

Problems with remote hand units:

All except (1) and (2) require disassembly - there may be a screw or two and then the case will simply 'crack' in half by gently prying with a knife or screwdriver. Look for hidden snap interlocks.

1. Dead batteries - solution obvious.

2. Corroded battery contacts, Thoroughly remove chemical deposits. Clean contacts with pencil eraser and/or sandpaper or nailfile.

3. Broken connections often between battery contacts and circuit board, possibly on the circuit board - resolder.

4. Bad resonator or crystal - replace, but diagnosing this without an oscilloscope may be tough. Broken

connections on resonator legs are common.

5. Dirt/spills/gunk preventing keys from operating reliably. Disassemble and wash rubber membrane and circuit board with water and mild detergent and/or then alcohol - dry completely.

6. Worn or corroded contact pads on circuit board. Clean and then use conductive Epoxy or paint or metal foil to restore.

7. Worn or dirty pads on rubber keypad. Clean. If worn, use conductive paint or metal foil to restore.

8. Cracked circuit board - can usually be repaired as these are usually single sided with big traces. Scrape off insulating coating and jumper breaks with fine wire and solder.

9. Bad LED. If IR tester shows no output, remove LED and power it from a 9 V battery in series with a 500 ohm resistor. If still no output, replace with readily available high power IR LED. Otherwise, check driver circuits.

10. Bad IC - if it is a custom chip, forget it! Failure of the IC is usually quite unlikely.

    (The following is from Duane P Mantick:)

    An awful lot of IR remotes use IC's from the same or similar series. A common series comes from NEC and is the uPD1986C which, incidentally is called out in the NTE replacements book as an NTE1758. A lot of these chips are cheap and not too difficult to find, and are made in easy-to-work-with 14 or 16 pin DIP packages. Unless you have no soldering or desoldering skills, replacement isn't difficult.

There are a large variety of universal remotes available from $10-$100. For general TV/VCR/cable use, the $10 variety are fine. However, the preprogrammed variety will not provide special functions like programming of a TV or VCR. Don't even think about going to the original manufacturer - they will charge an arm and a leg (or more). However, places like MCM Electronics do stock a variety of original remotes - prices range from $9 - $143 (Wow $143, for just a stupid remote! It doesn't even have high definition sound or anything exotic). The average price is around $40.

Problems with the IR remote receiver

Although the hand unit is most likely to be the cause of any problems with the remote control, it is also possible for the IR receive module to fail or for power to it to be missing. Microcontroller problems as well can result in similar symptoms.

First confirm that the hand unit is putting out the correct code. If it is a programmable type, try re-entering the settings for your TV. Install a set of fresh batteries. Try a different remote if possible. Use an IR detector to verify IR emissions (see the section: Revival of dead or tired remote control units).

The IR receiver is often a self contained module connected to the rest of the TV's circuitry by 3 wires: Power (+12 V typical), Ground, and Signal Out.

The IR receiver module will be located directly behind the IR window. Test by confirming that DC power is present. A schematic will tell you exactly what it should be but figure on 6 to 12 V if you do not have one. If this is present and you have an oscilloscope, put is on the Signal Out. You should see the demodulated data stream corresponding to whatever key is pressed on the hand unit. It should be a logic level signal swinging between 0 and the supply or +5 volts.

If there is no power, then a bad cable connection or blown fusable resistor may be the cause. If there is correct power but no signal, a fault internal to the IR module is likely. The internal circuitry may be a combination of special ICs and discrete components. The Sams" or service manual may or may not provide the details. There may be an adjustment for the carrier frequency but don't be tempted to touch this unless you have exhasuted other possibilities - and them mark it first!

If the signal is present, then there may be a problem in the microcontroller or other logic on the mainboard. This will require a schematic to proceed further.

So you lost your original remote (or it fell in the toilet)

An exact replacement remote will be easiest to use but may do significant harm to your bank account.

For example, you cannot add or remove channels from a typical Sony TV using the common universal remotes.

(From: Ed Ellers (edellers@delphi.com).)

Universal Electronics' "One For All" remote controls can reproduce these codes, and any others on any Sony TV (among others). Typically you'd press [MAGIC] and then 1-9-4 to add a channel or 1-9-0 to erase one; to start the auto program mode you'd press [MAGIC] and then 1-2-4.

Loudspeakers and TVs

Loudspeakers incorporate powerful magnets - the larger the speaker, the larger the magnet. However, anyone who goes ballistic when the mention is made of a loudspeaker near a TV or monitor, should take their Vallium.

The fringe fields outside the speaker box will not be that great. They may affect the picture perhaps to the point of requiring degauss. The normal degauss activated at power-on will usually clear up any color purity problems (assuming the loudspeakers have been moved away). At worst, manual degauss will be needed. The CRT will not be damaged. The maximum field - inaccessible at the voice coil - is quite strong. However, even for non-shielded loudspeakers, the magnetic field decays rapidly with distance especially since the core structure is designed to concentrate as much of the field as possible in the gap where the voice coil travels.

However, keeping speakers away from CRTs is a good idea.

Now, you really should keep your superconducting magnetic resonance imager magnet at least in the next room.....

Should I replace all the electrolytic capacitors if I find a bad one?

When a bad capacitor is found in a TV, the question of course arises as to the likelihood of other capacitors going bad in short order. It might be worth checking (other) caps in the power supply or hot (temperature) areas but you could spend you whole life replacing **all** the electrolytics in your older equipment!

Sweet little old ladies and TVs from attic

Always confirm the customer's complaints first!! Then verify that everything else works or you will never know if your efforts have affected something unrelated.

(Original request from rogerj@apex.com):

> "A sweet little old lady has duped me into repairing her old GE 13" color TV. She wanted me fix a bad volume pot. "Oh it has such a good picture", she says.
>
> Stupidly without even turning it on, (big mistake) I begin to open the set. After 15 to 20 min. of travail, I discover that a previous "repairman" has glued the case shut! (I wonder the sweet little old lady was in the habit of tweaking everything inside!:) --- Sam.)
>
> Now with the set open, I turn it on and this picture is LOUSY. Bad color, and very poor convergence. But I don't know if I'm to blame for banging it around trying to open it up. Also, no horizontal or vertical hold. (fixed that with a few caps). This thing has probably been sitting around for a few years."

Well, you certainly did not kill the caps. Anything that sits for a few years - probably in a damp unheated attic - is suspect.

Did you find the adjustments on the yoke assembly tight? If so, you probably did not move anything very much either. She may remember the good picture it produced before being stuffed away in the attic.

(From: Roger.)

> "Anyway after going through all the adjustments, the convergence at the sides is still bad and the horizontal size is a tad insufficient (and no adjustment available)."

It could be that the convergence (including pincushion) circuits are still faulty - not just misadjusted.

Other things that can effect horizontal size while still giving you a complete picture:

1. Voltage to horizontal output transistor low. Is there a voltage regulator in your set? The one I have has none. I assume your line voltage is ok.

2. Increased resistance or inductance of the yoke windings. For all you know, the yoke may have been replaced with the wrong part.

3. Yoke improperly positioned on tube neck.

4. Excessive high Voltage. This is usually not adjustable.

I bet the thing hasn't worked properly in 10 years! :)

Phantom spot or blob on CRT after set is shut off

(Portions of the following from a video engineer at Philips.)

Why is there a splotch of colored light at the center of the CRT after I kill power to my TV? Why does this not happen if the plug is pulled instead? It seems to last for hours (well maybe minutes at least).

A broad diffused glow (not a distinct spot in the middle of the screen) that lasts for a few seconds to minutes is called 'afterglow' and may be considered 'normal' for your model. The warm CRT cathodes continue to emit electrons due to the high voltage that is still present even though the signal circuits may have ceased to operate.

For more sharply defined spots there are two phenomena:

1. Thermal emission from a cathode that has not yet cooled off (and this could take several minutes) gives a more or less circular spot near the centre. It is actually 3 spots from the 3 cathodes, we at Philips call them 'Christmas balls'.

2. Field emission from sharp whiskers on any electron gun part gives a much sharper spot, sometimes with a moon-shaped halo around it. Even with the filament off, there may be some electron emission from these sharp points on the cold cathode(s) due to the strong high voltage (HV) electric fields in the electron gun. I do not know how likely this is or why this is so.

The shape of the spot is an inverted image of the shape of the emitting area(s) on the electron guns cathodes.

The visibility of both effects depends in the same way on the decay time of the high voltage (HV/EHT) on the anode.

When turned off with the remote or front panel button, you are not actually killing AC power but are probably switching off the deflection and signal circuits. This leaves the HV to decay over a few minutes or longer as it is drained by the current needed to feed the phantom spot or blob.

When you pull the plug, however, you are killing AC input and all the voltages decay together and in particular, the video signal may be present for long enough to keep the brightness (and beam current) up and drain the HV quickly. Whether this actually happens depends on many factors - often not dealt with by the designers of the set.

A proper design (who knows, yours may simply have been broken from day 1 or simply be typical of your model) would ensure that the HV is drained quickly or that the other bias voltages on the CRT are clamped to values that would blank the CRT once the set is off. If the problem developed suddenly, then this circuitry may have failed. On the other hand, if it has been gradually getting more pronounced, then the characteristics of the CRT or other circuitry may have changed with age.

In most sets it is left to chance whether the picture tube capacitance will be discharged by beam current at switch-off. It may simply be due to the behaviour of the video control IC when its supply voltage drops that causes the cathodes to be driven to white and this may not be formally specified by the manufacturer of the IC. Some of of the latest sets have an explicit circuit to discharge the EHT at shutdown.

As noted in the section: Safety guidelines, the HV charge on the CRT capacitance can be present for a long time. A service technician should be very aware of that before touching HV parts!

Interestingly, most sets for the Asian Pacific market have a bleeder resistor built in that will discharge the EHT without the need for a white flash at switch-off. These will in fact drive the beam to black at switch-off via a negative voltage to the CRT G1 electrode. The AP market is very sensitive to proper set behaviour, they don't like a white flash.

In short, it all depends on the demands of the particular market, the chance of the picture tube producing a spot/blob, and the mood of the designer.

So, it may not be worth doing anything to 'fix' this unless the splotch is so bright (more so than normal video and for an extended time) that CRT phosphor damage could result. This is usually not a problem with direct view TVs but would definitely be a concern with high intensity projection tubes.

On the other hand, your phantom blob may provide for some interesting conversation at your next party!

Comments on bright spot at power-off

With really old TVs, it was almost expected that when shut off, the raster would collapse to a spot which would then gradually fade away. If severe enough, the result after awhile would be a permanent dark spot in the center of the screen. Modern sets usually avoid this by forcing the CRT to be blanked for a few seconds after power-off while the high voltage decays or unblanked as the raster collapses to discharge the high voltage quickly with a white flash. However, claiming they all do this by design may be optimistic! :)

The following was in response to questions about a Sony TV but should apply in general.

(From: JURB6006 (jurb6006@aol.com).)

I think in this case the filter for the supply to the final video outs has gotten to a point where is discharges faster than the tube. Sony designs usually use fast blanking at power down, but it can only blank while the +220 VDC line is alive. There might also be a cap between the 220V line and the G1 biasing circuit. Also Sony's almost always incorporate some sort of HV bleeder but if it opens up usually there is a convergence problem. If it's not any of the above, the plot thickens. Look for a bad diode, or even an active spot killer circuit that has failed.

You might want to look into this, as I tell customers, when it collapses to a line it is 480 times as bright, it won't *look* 480 times as bright because the phosphor simply cant put out that much light. I've also made comments in here on how fast a CRT will burn if the yoke is unplugged. It's then the original 480X multiplied by 640. If that beam is in focus that means the "drive" to the phosphor is over 300,000 X what it should be. Even if the spot is defocused to 100X it's normal size, that is still 3,000X the current on that part of the screen. Even if yours doesn't burn the screen, in time you might expect a minor purity problem in that area on a fine pitch color CRT. This is an effect known as "doming", and it happened even on some low resolution NTSC TVs! It usually happened more at the sides, and if it became permanent you could fix it up if you used enough stick-on magnets, but you can't do that in the middle.

I bet the thing is a real pain to work on too, so I might consider just never shutting it off, or a simple modification. If G1 is grounded, it is easy. One resistor, a cap and a diode, ba-da-bing ba-da-boom. Two caps if you like to be fastidious. There are some designs in which this will not work. It does work 99% though, if the vidouts are driven they will discharge the +220 VDC supply, what I do is to AC couple the supply to the G1. It can be done with three component, but there are enhancements I recommend to protect the CRT from excessive K-G1 voltage. Don't want to cause a short there. Five or six components will do it on almost anything.

Disposing of dead TVs (CRTs and charged HV capacitors)

I don't know what the law says, but for safety, here is my recommendation:

Treat the CRT with respect - the implosion hazard should not be minimized. A large CRT will have over 10 tons of air pressure attempting to crush it. Wear eye protection whenever dealing with the CRT. Handle the CRT by the front - not the neck or thin funnel shaped envelope. Don't just toss it in the garbage - it is a significant hazard. The vacuum can be safely released (Let out? Sucked in? What does one do with an unwanted vacuum?) without spectacular effects by breaking the glass seal in the center of the CRT socket (may be hidden by the indexing plastic of the socket). Cover the entire CRT with a heavy blanket when doing this for additional protection. Once the vacuum is gone, it is just a big glass bottle though there may be some moderately hazardous materials in the phosphor coatings and of course, the glass and shadow mask will have many sharp edges if it is broken.

In addition, there could be a nice surprise awaiting anyone disconnecting the high voltage wire - that CRT capacitance can hold a charge for quite a while. Since it is being scrapped, a screwdriver under the suction cap HV connector should suffice.

The main power supply filter caps should have discharged on their own after any reasonable length of time (measured in terms of minutes, not days or years).

Of course around here, TVs are just tossed intact which is fortunate for scavengers like me who would not be happy at all with pre-safed TVs!

Shock and/or spark when connecting cable or other A/V components

TVs with hot chassis - where signal ground is actually line connected and at some intermediate (and dangerous) voltage - will have an isolation block in between the tuner and antenna/cable connections. TVs with isolated power supplies may have some bypass capacitors between the power supply and signal grounds (including the A/V shields if there are A/V connectors). It is possible for a failure to result in a serious safety hazard where the RF (antenna/cable) or A/V connectors become electrically live.

However, a tingle or small spark might be normal. RFI bypass caps between the AC input and shield on the connector could result in some leakage - 50 V or more might be indicated using a high impedance multimeter. This is harmless. Reversing the plug in the AC socket (if it is not polarized or if you are using an unpolarized extension cord) might eliminate or greatly reduce the effect.

Nonetheless, it should be checked out. Measure the resistance between each side of the AC plug and the RF and AV connector shields. It should be 1 M ohm or more. Test for voltage between the cable (or other device) connector and earth ground. If there is anything significant, test the resistance on the device between its shield and its power plug as above - other devices may have RFI bypass caps or be defective as well.

What is the deal with Macrovision copy protection?

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

JVC owns the patent for VHS. JVC has made a deal with Macrovision that from a certain date in the past *no* VHS recorder licenced by JVC shall be able to record any video signal that contains Macrovision's copy protection pulses. Any video recorder from before that date (VHS or other) might well work OK on the altered video signal ! The copy protection pulses upset the video-AGC and H-sync. TV's usually don't have a video-AGC. The stabilizer box removes the extra pulses and makes it into a normal video signal again. No VCR should ever know the difference, so they should all record properly again.

At the same time, all TV's are required to ignore the copy protection pulses. As a TV-designer I can tell you that this is sometimes far from trivial. Not in the least because in the beginning we were not included in "the deal". There may be TV's around whose brightness and/or sync will be disturbed by the Macrovision pulses. Officially, this is the reason for existance of the stabilizer boxes: to view better, not to copy better. Unofficially, they are sold for copying, of course.

The next step will be that digital-TV decoders will output an analog TV signal with Macrovision copy-protection pulses so that you may watch but not record your pay-per-view program. Same problem, same solution ...

And I thought that PAL/Secam/NTSC were *standards*, sigh ...

Whether they like it or not (and from personal experience I can tell you that we don't like it) it is the responsibility of the TV set-maker (in your case Sony) to build a TV that takes the Macrovision copy protection pulses without showing any side effects on the screen. Seems like they didn't do a good job on your TV :-). But they will have to fix this, your complaint is valid. I think in this case it may be the dealer's responsibility too, maybe you can trade it for a different brand ? And do try it out first ...

Sadly, more complex TV's seem to suffer more than the simpler, old-fashioned, designs. Unfortunately, Macrovision seems to be satisfied when their pulses do not affect the majority of (mostly older) TV's. In your Sony TV, the clamping circuit seems to be affected by some ultra-black pulses in the signal. Maybe an anti-Macrovision decoder can help you, officially they are designed for *this* purpose.

AGC and copy protection

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

1. RF-AGC which compensates for different signal strength at the aerial, it measures RF amplitude and is *not* sensitive to video contents because with negative modulation the sync is the peak and is constant, this AGC will not work on CVBS (baseband video) inputs.

2. Video-AGC which normalizes baseband signals which enter *after* the tuner-IF. A.o. this compensates for different signal strengths when you connect two VCRs together. It measures peak-white, so it *is* sensitive to video content and thus to the Macrovision pulses.

And: A television does NOT have a video-AGC, unless you want to call the beam current limiter circuits an AGC. (Exception: the Secam-L system with positive modulation requires an RF-AGC which measures peak-white instead of peak-sync.)

The RF-AGC does not see the peak-white of the anti-copy pulses. If you connect the VCR to the TV via the CVBS (baseband) input, then the RF-AGC is not even in the path. Still, it may be disturbed. But the sync separator may see the extra inserted Hsync pulses, and due to the phase disturbance the video clamping may be disturbed too.

On-screen clock runs slow or fast

- If the TV was purchased in another country (most likely it is a "multi-system TV), then the power line frequency may be different. There could be a switch or menu setting for this.

- If the clock reference is power line derived, noisy power can sometimes result in erratic timekeeping though running fast is probably more common than running slow. This could be a result of a lamp dimmer or compact fluorescent on the same circuit.

- If the time reference is a separate crystal, that or its circuit could be faulty.

Now think about it: Do you absolutely need the TV's clock??? After all, there are probably a half dozen other clocks in the same room! :)

Cold problems with cold TVs - or - an unhappy Christmas

(From: Ren Tescher (ren@rap.ucar.edu).)

My Christmas repair story wasn't so happy.

I worked as TV repairman for an appliance store.

On a very cold (20 below zero Fahrenheit) evening a man bought a new 25" console for the family.

As we loaded it into the back of their pickup truck, we *told* them. "Do not plug this in until it warms back up to room temperature." They nodded and said "uh-huh, okay".

They lived about 15 minutes away.

25 minutes later we get a telephone call...

"Hey! that TV you sold us don't work!"

So we ended up loading another TV into our delivery van, drove out to their place. Unloaded it, and WAITED until the thing was warm enough to plug in.

Needless to say, I got home late that Christmas Eve and had brand new TV console waiting for my repair back at the shop.

F-connector broken off rear of TV or VCR

Sometimes this just happens due to poor manufacturing and a slight tug. However, usually, there has been some severe trauma - like the TV or VCR falling off a shelf while still attached. When else would it fall off a shelf? :-)

I recently repaired a Panasonic VCR with a dangling F-connector. It required removing the cover, main board, unsoldering the A/V block and part of the power supply, just to get at the RF modulator. Then it was a simple matter of resoldering the center conductor to the printed circuit board (fortunately, nothing else was damaged) and the shell of the F-connector to the metal box.

From: Glenn Watkins

We get a lot of sets with broken "F" connectors broken off - both VCR's and TV's. The job can be quite involved depending on the exact set. It may take an hour just to open it, remove the tuner or RF modulator and open the case. Then if you're lucky, there is no additional damage inside the unit due to people probing with pencils, screwdrivers, etc.

On some TV's including Sharp, there is a antenna(cable) isolation device that connects between the tuner and antenna. This device comes in a few flavors and is very easy to install if broken. I've seen them as cheap as $4.95 each mail order.

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3. Back to TV Repair FAQ Table of Contents.

Some Model Specific Problems

Erratic problems with older GE TVs

Older GE TVs used double sided circuit boards with poor-man's vias - rivets soldered to the traces top and bottom. These have been called 'Rivlets' and 'Griplets'. Unfortunately, whoever did the design didn't realize that (1) the the rivets did not heat adequately during soldering and (2) the expansion coefficients of the rivets and circuit board were not qutie identical.

Thus, erratic problems are almost a certainty with these TVs. Normal logical troubleshooting is useless. The only solution is to repair every !@#$ Griplet on all circuit boards in the TV.

I have repaired these with a high power soldering gun used on both sides with liberal application of solder and flux.

However, I do not recommend this shortcut unless you are willing to redo the repair every couple of years.

(From: Mr. Caldwell (jcaldwel@iquest.net).)

There are two methods of repair.

4. Method 1: Clean the paint from around each griplet on both sides of the board to expose the surrounding copper pad. Apply liquid solder flux to the cleaned copper. Solder so as to bridge the griplet to the cleaned copper.

5. Method 2: Do the above but desolder the griplet and place a wire through it so that the wire extends beyond the griplet to the copper foil and solder the wire on both sides (this was the final fix GE used in this chassis).

If done carefully Method 1 works and is reliable.

I would normally do this prior to any troubleshooting, it repairs most problems in this chassis. While you have the board out working on it be sure to also clean and resolder high temperature components and connections that look bad. These griplets can be on all boards, even the tuner control board.

Erratic problems on late model GE, RCA, or ProScan TV

Problems with bad solder connections, mostly in and around the tuner are very common with several series of late model (e.g., CTC175/176/177 chassis) RCA/GE/Proscan TVs. Ignoring these erratic and intermittent problems can lead to serious damage including failure of the EEPROM and possibly other expensive ICs. Therefore, it is essential to deal with the solder connections as soon as these symptoms appear. The repairs are straightforward though perhaps tedious. Thomson may reimburse for reasonable cost of repairs.

Some of the common symptoms include:

- Random power cycling. It may come on in the middle of the night!
- Picture shifts or changes size vertically or horizontally.
- Picture turns to snow or shows other reception problems.
- Picture turns to random display of time or other data.
- Noisy or muted sound, volume buttons have no effect.
- Remote has no or unexpected effect.

See the document: RCA/GE TV CTC175-187+ Solder Connection and EEPROM Problems for additional information on these types problems including repair procedures and approaches to getting coverage from Thomson Electronics.

Sylvania/Magnavox/Philips - no startup

Check the resistor supplying initial base current to the horizontal driver (not HOT) transistor. On many chassis, it is R502, 47 K. It opens for not good reason. Why it fails is a mystery as its power rating should be adequate.

Sony TVs/monitors and Hstat

Symptoms are that the TV or monitor will shut down possibly after a warmpup period. There can be other causes but failure of the Hstat module HV sense wire is quite likely on many Sony models.

(From: Mr. Beanz (slin01@mail.orion.org).)

If you've determined that the HV is fine, and the H-STAT is shutting down for no reason, it's possible to bypass. There is a little brown wire coming out the bottom of the H-STAT which goes to a 3-pin connector. Two wires have a jumper, and the brown wire goes to the other. Snip the brown wire at the H-STAT and the TV will continue to function normally. Measuring the regulated B+ to the flyback will give you a pretty good indication of the condition of the HV output. If it remains steady at rated voltage (I forget what it was, 130V or 135V) then HV is A-OK. If it slowly creeps up or is too high to begin with, you have a problem. The voltage will normally jump to 150V or so after HV shutdown is tripped.

Ideally, you should replace the H-STAT in this case. Although taking the poor man's route will WORK, you lose any protection in the event that the HV circuitry should malfunction.

More on Hstat

(From: Shawn Lin (slin01@mail.orion.org or lin@science.smsu.edu).)

The H-STAT is a plastic box that sits mounted to the picture tube's shield. It's red in color (for every SONY TV that I have owned) and has a single knob on it. The flyback's HV output wire goes into the H-STAT and another HV wire exists the H-STAT and connects to the anode cap on the picture tube. It has a dual purpose, horizontal static convergence (the control adjusts this) and HV overvoltage shutdown protection. Chances are, your HV is within spec and the H-STAT is bad, but you should make sure the regulated voltage to the flyback is steady and doesn't fluctuate before assuming the H-STAT is bad.

H-STAT is expensive, and may not be worth replacing. My kV-1952RS is old and as a whole, not worth the cost of a new H-STAT, so I just bypassed it and didn't bother replacing it. The TV's been working great for over a year and the picture is still excellent.

Note: On some models, the sense wires need to be connected during startup or else it will never come on.

CAUTION: On some monitors (like the Sony CPD1302), the sense signal may be used for actual HV regulation. Thus, if the sense wire is disconnected, (or the divider inside the Hstat block fails open) there is no feedback and it is possible for the high voltage (and probably B+) to increase until the HOT (and possible other components) blow. I do not know if this applies to Sony built TVs as well.

No video on late model Sony TVs

(From: David Kuhajda (dkuhajda@locl.net).)

This following assumes that the more basic TV troubleshooting has already been performed and resulted in no solution - i.e., filaments are lit up, CRT voltages are all correct but the cathodes are all in cutoff, main power supply voltages are present, etc

The 3 most common causes of no video, but good audio are as follows:

1. AKB blanking due to either a fault in the AKB circuit or the CRT has one gun that is too weak and the AKB won't unblank the CRT.

2. Loss of vertical deflection. The system control must see the vertical return pulse to unblank the video.

3. Loss of data bus communication with the Jungle IC. The Jungle IC must send the all OK signal to the micro before it will unblank the video.

To troubleshoot:

1. Try changing the volume with the volume control. If it changes the data bus is not the problem. This is assuming the TV is tuned to a good TV station.

2. Mark the EXACT position of the screen/G2 control with a marker. Then turn the G2 control up.

    - If the picture unblanks and a gray scale bar pattern is used, you can usually see which CRT gun is weak. Time to replace the CRT for a long term fix. All of the temporary fixes I have tried resulted in only a few months extra life out of the tube.

    - If the picture does not unblank and it looks kind of like there is a halo near the top of the screen. The vertical circuit needs checked for proper operation and repaired. WARNING do not continue to operate the TV set in this mode for any length of time, it will crack the CRT from localized heating!!!! (because the guns are shooting into the extreme top of the tube and possible the neck of the tube) RETURN the G2 control to the exact position that was marked before you started.

The typical failure mode of the vertical circuit in a Sony causes only one of the vertical supply resistors to open usually. Either the +15 V or -15 V. This puts a full + or -15 V on the yoke which deflects the guns into the glass envelope of the tube.

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6. Back to TV Repair FAQ Table of Contents.

Items of Interest

Various video standards

Different standards for analog component video:

- Tektronix Video Standards Overview

Scart interface definitions:

- Panellink (serial digital rgb interface standard for displays)

An informal history of X-ray protection

(The following is from: Marty).

Most of the old tube type color TV sets used a shunt HV regulator tube, usually a 6BK4. If it failed, or some component in the HV circuit failed, the high voltage, normally 25kV, could go up to 35kV or more, causing some X-Ray leakage from the CRT. In the early 70s when news of this radiation scare was first announced, there was a public outcry to immediately fix the problem. The feds hastily imposed a requirement on manufacturers of TV sets to somehow render a TV set "unwatchable" if the HV exceeded rated limits.

The manufacturers first response was to follow the letter of the law and the first "HEW" circuit simply blanked the video when the HV exceeded a setpoint to make the set "unwatchable".

It was quickly noticed that the HV was not turned off with this circuit and the CRT still could emit some radiation. Many TV sets with this feature were left on so the consumer could listen to the sound, so the feds tightened the requirement.

By this time new TV sets were all solid state and some manufacturers experimented with HV shutdown circuits, but most of these circuits were poorly designed and not reliable.

Zenith thought they had the answer by regulating the HV with a bank of 5 capacitors across the horizontal output transistor to "hold down" the HV to 25kV. If one capacitor opened, the HV would only rise about 2kV, not a dangerous situation. This wasn't good enough for the feds.

The "fix" that Zenith finally came out with, was a "4 legged capacitor". Two legs were the emitter return for the horizontal output transistor, & two legs were the HV holddown capacitor (the equivalent value of the bank of 5 caps). This "fix" was accepted by HEW and millions of TVs were produced. It worked so well, that other manufacturers soon followed the lead (Magnavox, GE, etc.).

Then the worst happened! The 4 legged monsters started failing in a large numbers. Not opening completely & not shorting out. They sometimes allowed the HV to skyrocket to over 50kV. Some of them even cut the necks off of the CRTs.

Zenith issued a recall on those models with the problem (more than one entire model year). After several "improved" versions of the capacitor, the problem was fixed but that recall almost bankrupted the company. Other companies had failures too, but usually not as dramatic as Zenith's.

Magnavox used the HV holddown capacitor, both single & 4 leg version in several 70s era TV sets and is a good candidate for fireworks as well.

(From: Roy J. Tellason (rtellason@pa.net).)

The problem was reputedly due to a capacitor maker substituting a different (cheaper) material for the one that Zenith originally specified, leading to the failures. I can't recall who the cap maker was (some company in Taiwan?) but remember hearing as to how they were the ones who ended up having to pay for all those warranty repairs, including CRT replacements.

What is this goop around some electrolytic capacitors and other components?

That goop is probably glue and generally harmless - it is there to hold down the components aganst vibration. I have heard of it sometimes decomposing and shorting stuff out but I doubt you have that problem.

Therefore, unless you find a bad cap in the focus or related circuit, we are still looking at a flyback problem.

What does the flyback (LOPT) transformer do?

The typical flyback or Line OutPut Transformer (LOPT) consists of two parts:

1. A special transformer which in conjunction with the horizontal output transistor/deflection circuits boosts the B+ (120 V typical for a TV) of the low voltage power supply to the 20 to 30 kV for the CRT as well as provide various secondary lower voltages for other circuits.

   A HV rectifier turns the high voltage pulses into DC and the CRT capacitance smooths it. The HV may be developed from a single winding with many many turns of wire or a lower voltage winding and a diode-capacitor voltage multiplier.

The various secondary voltages power the logic, tuner, video signal, vertical deflection circuits, and CRT filament. In fact, with many TV designs, the only power not derived from the flyback is for the keep-alive circuitry needed to maintain channel memory and provide startup drive to the horizontal deflection/high voltage system.

2. A voltage divider that provides the focus and screen supplies. The pots are in this divider network - and these things fail resulting poor focus, uncontrolled brightness, or fluctuating focus and/or brightness. A total short could also result in failure of other components like the horizontal output transistor. In some TVs, the focus and screen divider and/or controls are external to the flyback and susceptible to dust and problems particularly on humid days. The resistance of these circuits is so high that dirt or other contamination can easily provide a bypass path to ground especially when slightly damp.

Why do flyback (LOPT) transformers fail?

While flyback transformers can on occasion be blown due to a failure elsewhere in the TV or monitor's power supply or deflection circuits, in most cases, they simply expire on their own. Why?

Flybacks are wound with many layers of really really fine wire with really really thin insulation. This entire assembly is potted with an Epoxy resin which is poured in and allowed to cure.

In some ways, these are just short circuits waiting to happen.

Flybacks get hot during use and this leads to deterioration of the insulation. Any imperfections, nicks, scratches, etc. in the insulation contributes to failure. Temperature cycles and manufacturing defects result in fine cracks in the Epoxy potting material reducing the insulation breakdown particularly in the area of the high voltage windings, rectifiers, and focus/screen divider network.

It is amazing they last as long as they do with the stress they are under. They also physically vibrate to some extent. A whole bunch of other factors are also no doubt important.

Brief comments on testing the HOT

For a TV with no blown fuses that will not start, here are two quicky checks to see if the HOT is good and has power and drive:

- HOT tests - check across each pair of pins for shorts (preferably removed from the circuit board). No junction should measure less than 50 ohms or so. Lower readings almost certainly indicate a bad HOT. If in-circuit, however, the reading between base and emitter will be near zero due to the secondary of the driver transformer. See the document: Basic Testing of Semiconductor Devices. Don't be confused by internal damper diodes and B-E resistors.

- Power - measure across the collector to emitter with a multimeter (with the HOT removed or if there is no deflection, this is safe with it in place). There should be solid B+ - typically about 100 to 160 V (115 VAC sets - possibly higher for 220 VAC sets). If this is missing, iether there is a problem with the power supply or the emitter fusable resistor has blown (probably in addition to the HOT) and there is no return.

- Drive: put an oscilloscope on the base - there should be pulses around 0.7 V for most of the scan (~50 microseconds) and probably going negative a couple volts at least for retrace (~12 microseconds). If drive is weak or missing, determine how startup is implemented as there may be a problem in the startup power supply or deflection IC.

WARNING: use an isolation transformer for the oscilloscope tests (and whenever you are probing a TV in general)!!! This part of the circuit, in particular, is usually line connected. See the sections on safety.

CRT rejuvenation

Where one or more electron guns in the CRT have deteriorated due to wear and tear, it is sometimes possible to give them a new, but possibly, temporary lease on life through rejuvenation using a special piece of CRT service equipment.

(From: Gary Klechowitz (klechowi@execpc.com).)

When I rejuvenate a tube I inform the customer that there is no warranty on the job. Rejuvenating a CRT is like when Clatuu was brought back to life by Gort in "The Day The Earth Stood Still". When asked "How long will you live"? he replied: "no one knows".

I use a Sencore Beam Builder. If your tube is just moderately dim and blurry but still shows good cut off threshold, I would just use the auto restore mode on the beam builder rather than using the restore button. If the tube is really bad with little or no cutoff threshold, then the rejuvenator is needed but that has less than a 50% chance of fixing the tube and in many cases the tube gets worse to trashed in the process.

Memory chips in TVs

(From: Mark Zenier (mzenier@eskimo.com or mzenier@netcom.com).)

Actually, they are EEPROMs. A modern TV has integrated the circuitry so that the microprocessor that controls it also sets the various adjustments like vertical height and other characteristics. The same memory that knows what channels are valid and what the brightness and other user adjustable settings are is used for factory adjustments that are set when the TV is first turned on. It's a lot cheaper to use the remote control signals that are already there than add a handful of trimmer resistors.

For service purposes there is often a magic key sequence used with your remote control to access a service page in the on screen display than can change these. Since you can easily set something that could fry the various high power deflection circuits, getting a little too curious can void your warranty, and toast your set.

How does Picture-In-Picture (PIP) work?

A separate video input or tuner provides the PIP baseband signal which is then resized and stored in a frame buffer large enough to hold the X and Y dimensions of the PIP image. Readout is timed to place the PIP image in the selected area of the screen and it is substituted for the main video. What could be simpler?!

Tony's notes on setting convergence on delta gun CRTs

(This section from: ard12@eng.cam.ac.uk (A.R. Duell))

The older delta-gun tubes (3 guns in a triangle, not in a line) can give **excellent** pictures, with very good convergence, provided:

1. You've set those 20-or-so presets correctly - a right pain as they interact to some extent.

2. The CRT is set up in the final position - this type of tube is more sensitive to external fields than the PIL type.

Both my delta-gun sets (a B&O 3200 chassis and a Barco CDCT2/51) have very clearly set out and labeled convergence panels, and you don't need a service manual to do them. The instructions in the Barco manual are something like:

"Apply crosshatch, and adjust the controls on the convergence board in the numbered order to converge the picture. The diagrams by each control show the effect".

Here's a very quick guide to delta gun convergence where the settings are done using various adjustments on the neck of the CRT (if you don't have a service manual but do know what each control does, and where they all are - otherwise, follow the instructions in the service manual --- sam):

1. Apply a white crosshatch or dot pattern to the set. Don't try and converge on anything else - you'll go insane. It's useful to be able to switch between those 2 patterns.

2. Before you start, set the height, width, linearity, pincushion, etc. They will interact with the convergence. Also check PSU voltages, and the EHT voltage if it's adjustable. That's where you do need a service manual, I guess.

3. Turn off the blue gun using the A1 switch, and use the red and green static radial controls to get a yellow crosshatch in the middle of the screen. These controls may be electrical presets, or may be movable magnets on the radial convergence yoke (the Y-shaped think behind the deflection yoke).

4. Turn on the blue gun and use the 2 blue static controls (radial and lateral) to align the blue and yellow crosshatches at the center of the screen. Some manufacturers recommend turning off the green gun when doing this, and aligning red with blue (using *only* the blue controls, of course), but I prefer to align blue with yellow, as it gives a check on the overall convergence of the tube.

5. Turn off the blue gun again. Now the fun starts - dynamic convergence. The first adjustments align the red and green crosshatches near the edges - I normally do the top and bottom first. There will be 2 controls for this, either a top and a bottom, or a shift and a linearity. The second type is a *pain* to do, as it's not uncommon for it to affect the static convergence.

6. Getting the red and green verticals aligned near the edges is a similar process.

7. You now have (hopefully) a yellow crosshatch over the entire screen.

8. Now to align the blue. This is a lot worse, although the principle is the same. Turn on the blue gun again, and check the static (center) convergence

9. To align the blue lines with the yellow ones, you'll find not only shift controls, but also slope controls. Use the shift controls to align the centers of the lines and the slope controls to get the endpoints right. These interact to some extent. You'll need to fiddle with the controls for a bit to work out what they do, even if you have the manual.

The convergence over the entire screen should now be good....

A word of warning here... The purity is set by ring magnets on almost all colour CRTs, but on PIL tubes, there are other ring magnets as well - like static convergence. Make sure you know what you are adjusting.

Saga and general setup for large CRT TVs

(Panic from: V. K.)

> "I'm having problem(s) with a brand new 40" Mitsubishi tube (direct view) TV. I'm writing this with hopes of getting some basic information so that the dealer doesn't bamboozle me.
>
> From first viewing (5 minutes after the delivery man departed). I noticed a discoloration patch in the top right hand corner (purple when the background is blue/greenish when background is white)."

(From: Tony (ard12@eng.cam.ac.uk).)

As you probably know, a colour TV produces a red picture, a green picture and a blue picture on the screen at the same time. You eyes interpret that as a coloured picture. If you look at (a normal, non-projection) TV screen through a magnifying lens, you should be able to see red, green and blue dots, and no other colours.

Now, there are 3 basic adjustments to getting a good colour picture :

1. Purity. This means that the red picture is only red, the green picture only green, etc. This is the one that needs setting up on your set - you have a purity problem

2. Convergence. This means that the 3 pictures line up over the entire screen (or as much of it as possible). If this one is wrong, you'll see coloured fringes around objects in the picture.

3. Grey scale. This sets the overall colour of the picture - it means that white is really white, etc. It varies the relative intensities of the red, green and blue pictures.

(From: VK.)

> "I called the store in a panic and they calmly told me to press the "degauss" button to eliminate the problem (which I quickly learned was spurious magnetization, caused perhaps by storage near a speaker in the warehouse?). Result? Better but not cured."

(From: Tony.)

Yes, spurious magnetization (or more correctly a different magnetic field around the tube from the one present when it was set up) will cause purity problems.

(From: V. K.)

> "The next day I visited the store, and the manager said (again) that this was an easily fixable problem, requiring a few waves of a degaussing coil. To appease me, he sends the salesman home with me with small (1 foot diameter) coil in tow. Salesman (boy, actually) waves the coil in front of and around set but can't seem to remove the discoloration."

(From: Tony.)

Argh... Here's what should have been done IMHO.

1. The set should have been degaussed (a fancy word for demagnetized).

2. They should have connected a 'pattern generator' to the set. This is a piece of equipment that generates various test signals. They should have selected 'red raster' (which will appear to you as a pure red screen), and set up the purity adjustments on that. You should ask to see the pure red raster (and pure green and pure blue if the generator will allow it), and make sure there are no strange-coloured patches. If you like, you can examine the screen through a magnifying lens to check that there are no dots of other colours appearing - I do that when I'm setting up a new TV or monitor.

3. They should then have displayed a 'cross hatch' on the screen. This is a grid of white vertical and horizontal lines. Convergence errors are shown by the lines splitting into 2 or more colours (normally one of the 'primary colours' - red, green, or blue, and its complementary colour (cyan, magenta, and yellow).) Note, however, that it's _very_ difficult or even impossible to get perfect convergence over the entire screen on a modern tube, and that you'll not notice small errors near the corners on a TV screen. Note that some engineers prefer to set up the convergence on some other type of display (dots, for example), but you should at least be able to see a cross hatch pattern (all pattern generators provide that one)

4. They should have then displayed a 'grey scale' test display. This is a pattern of vertical grey bars of different brightnesses, from black to white. They should all have been a neutral grey, without colouration.

Note that convergence and purity interact to some extent, and thus if either is adjusted, both must be checked (and rechecked). Grey scale adjustments interact with nothing else.

I would want to see the set on a pattern generator (at least the patterns I've mentioned above) and identify the problems.

(From: V. K.)

> "To demagnetize the TV, he says that a large coil is required, that encompasses the whole unit; service rep will 'be in touch'."

(From: Tony.)

I've never heard of that - the correct procedure is to wipe the coil around the front, top, sides and bottom _NOT the back_ and then move it 2-3m from the set before turning it off. It doesn't matter whether the set is on or off for this, btw. I've not heard of putting a large coil round the entire set. (See the section: Degaussing (demagnetizing) a CRT.

(From: V. K.)

> "After the sales boy leaves, I could SWEAR that the picture quality in general is decreased, with people (especially their extremities like lips and ears) appearing pinker than before, and also more general interference (fringes/noise) noticeable."

The convergence and purity are set by ring magnets on the neck of the tube. It's possible that the degaussing procedure has slightly demagnetized these, and if so, the whole set will need to be set up. Similarly, if any part of the set was magnetized at the factory, then the adjustments may have been set up to compensate, and then after demagnetization, they'll need to be reset.

(From: V. K.)

> "So my questions are these. Can the original problem truly be FIXED with proper sized coil and application?

(From: Tony.)

I don't think the size of the coil will make any difference. I would want to see that set on a pattern generator, so I could be _sure_ as to what the problems are. If the dealers don't have a pattern generator, then they're not fit to be fixing TVs IMHO.

(From: V. K.)

> "Could I be imagining that the waving of the small coil degraded the picture quality?"

(From: Tony.)

It's possible, but fairly unlikely. See above

(From: V. K.)

> "Should I demand replacement to a new set? Can I legally ask for this, or is it like a new car...you own it, now you deal with the service guys forever.

(From: Tony.)

I don't know US law, but in the UK, if a product is defective, you can demand a refund of the money paid (not a replacement or a repair, a refund). IMHO, a TV with incorrect colours is defective...

Liquid coupling fluid for projection TVs

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The liquid serves two purposes:

1. It conducts the heat away from the surface of the tiny picture tube.

2. It couples the light from the glass surface of the picture tube to the glass surface of the projection lens. Using air instead of liquid would give too much unwanted refraction at the glass-air interfaces

I believe that the composition of the liquid is mostly water + glycol, quite similar to the anti-freeze liquid in your car's radiator, but without the colorants added that should warn you against drinking it.

A good replacement kit contains not only a plastic bottle of liquid but also new rubber sealing rings to keep it in, where it belongs. It's always recommended to buy the original stuff, if you can find it.

(From: markmtf@earthlink.net). I just wanted to throw my $.02 in since I was one of the original members of the design team for the first Magnavox and Sylvania PTVs.

I don't recall the models, but essentially, there are several generations of liquid cooled/coupled PTV designs. One type consists of a set of CRTs with a liquid cell as part of that component. The other type consists of a liquid cell that directly couples the CRT faceplate to the lens.

The liquid is a solution of DI (deionized) water and propylene glycol, with a small amount of surfactant to eliminate bubbles sticking to the glass and plastic surface. Distilled water can be used. The propylene glycol is USP grade, not commercial grade for clarity reasons. You need to order this through a lab supply company and specify USP grade. If you use a cheaper grade, the solution may become cloudy. The mixture of your solution should be somewhere between 50/50 to 80/20 water/glycol. The are many kinds of surfactant which can cause cloudiness or foaming. You should probably leave this step out if you are just adding rather than replacing liquid. If you want to experiment, you might try some fluid from a photographer darkroom supply store that is used for eliminating water marks during the film drying process. Just add a few drops to 1/2 liter. Then heat it up to check for cloudiness. If it works, then you are in business. Again, if you are careful with filling the cell so that you don't mix in air, you probably don't need any surfactant.

I probably can't help you too much on the seals or gaskets. It is very dependent on the specific model. Both types of liquid cells loose the liquid over time due to vapor traveling through the silicone seals. The CRTs with the cooling cell used a special RTV for a seal. The CRT/Lens cooling cell used silicone gaskets. There is a tradeoff on how tightly the gaskets can be tightened down due to CRT specifications. Some manufacturers were also working on a expandable chamber to reduce buildup of pressure when the liquid expanded due to heat. The higher the pressure, the faster the liquid would evaporate through the gaskets.

Origin of burn spot/line on projection set

This may be an issue where a set was repaired but with a blemish that you didn't think was there before.

(From: JURB6005 (jurb6005@aol.comtere).)

1. If you fire a projection set up with one yoke disconnected AND the yoke windings are in series, unless you are quick, you will have a horizontal line burnt in all three tubes.

2. The shop may have been less than 100% competent, and even if they were 100% competent, it could have happened at the actual time of the failure, before they ever saw it.

3. If the set was fired up by ANYONE with any of the yokes disconnected, the vertical blanking circuit should have cut off ALL beam current, preventing the burning of the CRT screens. Two exceptions apply;

    - YOU were already watching the TV with a fault, or the burn happened really quickly and you didn't notice the spot.

    - The technician turned up the G2 to the point where it overrode the blanking.

Blue focus different for projection sets?

On some 3-tube projection sets, you may find the blue tube to have poorer focus than red and green. Don't touch it!

(From: Dakuhajda (dakuhajda@aol.com).)

What you are describing is completely normal. The manufactures design in the blue picture tube so that it will not focus completely.

In fact the service literature lists exactly how much and which way it should be out of focus. In fact the picture generally looks better with the blue CRT slightly out of focus per specification - slightly wider than the scan lines so that it completely fills in the scan lines. The slight out of focus is designed to blend in the scan lines so they are not as noticeable on the big screen.

This is because when the standard TV signal with 262.5 lines being displayed at any given time, it looks bad to see the scan lines. The standard TV signal was never designed to be viewed on a screen larger than 25".

It also is the nature of the phosphor that makes blue not to allow a good focus. Especially in the older sets. I have not seen any early blue projection tubes focus well even when they were new.

Comments on color purity, set orientation, and doming

> "The problem with my TV is that bright parts of the picture change color. For example, white areas may shift towards yellow or blue depending on the orientation of the set.
>
> What are the possible causes of doming? I have noticed that the magnitude of the doming effect varies with TV orientation even after degaussing several times at the new orientation. Does this help identify the cause of the doming in my case?"

(Portions from: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The problem with regular shadow masks is 'doming'. Due to the inherent principle of shadow masks, 2/3 or more of all beam energy is dissipated in the mask. Where static bright objects are displayed, it heats up several hundred degrees. This causes thermal expansion, with local warping of the mask. The holes in the mask move to a different place and the projections of the electron beams will land on the wrong colours: purity errors. The use of invar allows about 3 times more beam current for the same purity errors.

Both local doming and magnetic fields compete for the remaining landing reserve. Due to improper degaussing, the doming problem may be more visible. And applying a tube designed for the wrong hemisphere may very well increase the doming complaints. It is possible to deliberately offset the nominal landing in order to get more doming reserve (the shift due to doming is always to the outside of the tube). You would do this using spoiler magnets put in the right places.

Permanently setting the contrast lower is not a real cure because the customer might not like such a dark picture. A better picture tube (Invar shadow mask) *is* a good cure (in most cases) but there is the cost price increase. (This is mainly due to the fact that Invar metal is harder to etch.)

Also see the section: Comments on color purity, set orientation, and doming.

About instant-on TVs

Most TVs built since, say, 1980 have only the microcontroller powered from a small transformer when the set is off. This permits the remote control or front panel pushbutton to switch the set on. This circuitry should be no more prone to catastrophic failure than what is in a VCR or digital clock.

Historically, there were 'instant on' TVs which kept a substantial portion of their circuitry live all the time - especially those using vacuum tubes in at least part of the circuitry (other than the CRT). In these, there was a lot more to fail. Those tubes would continue to change their characteristics for many minutes when warming up. Circuits were also much more touchy - remember all that constant tweaking! Thus, it made sense from the users's perspective to eliminate the warmup period and keep those tubes toasty all the time.

In modern solid state TVs, the only component to really need a warmup period is the CRT. All this means is that you have to wait 20 seconds for the picture to appear.

About gadgets to use house wiring as TV antenna

Note that these $10 devices usually contain a single 5 cent ceramic capacitor as their 'sophisticated electronic circuitry'. The rest of the fancy plastic case is just for show.

(The following is from: Greg Smith (LiveTV@en.com).)

Most people mistakening believe that the larger the antenna the better the received signal. The truth of the matter is that each element of the antenna must be cut to a precise length depending upon the frequency of the signal you are attempting to receive. Further more, each element must also be spaced a precise distance away from the others. This creates what is commonly called a "directional array". (see diagram below) By providing enhanced reception (gain) in the direction the antenna is pointed, it also provides decreased reception from the sides and back. (directivity) This prevents "ghosting" which is caused by the same signal arriving at the TV at a slightly different time because the signal bounced off of some structure on it's way to your set.

If you use the house wiring as the antenna, the length will be random and the orientation to the received signal will also be random. Therefore it will pickup the bounced/reflected signals just as well as the primary signal. IE: lots of ghosting = very poor picture quality.

Any kind of directional antenna, even a small one, whether inside or outside, should provide a superior quality picture to that from the device you are talking about. Even a cheap "rabbit ear" antenna mounted on top of the set allows you to orient it in the best direction.

If you only receive the VHF channels (2-10) in your area then buy a VHF ony antenna. If you only receive the UHF (19-60+) then buy a UHF only. If you get some of each then make sure that it is a combination antenna. If your set has separate inputs for VHF/UHF make sure you also get one with the proper splitter.

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Can I add an S-Video input to my TV or VCR?

Possibly, but why bother? You will most likely be limited by the TV or VCR's circuitry anyhow.

All S-Video means is (1) a special connector and (2) separate luminance (Y) and chrominance (C) rather than composite video.

In a VCR, you will need to bypass the input circuitry and get to the place where Y and C are separate. This may or may not be possible depending on its design.

In a TV, they may never be separate and you will need to substitute your own circuitry for the chroma demodulator.

It is probably not worth it as you will likely not gain much in picture quality but if you really are determined, a schematic will be essential in either case.

If all you want to do is allow for an S-video input, there are single chips which will combine the Y and C into a normal composite video signal.

Also, see the section: How do I add A/V inputs or outputs to a TV which does not have them built in? since there may be safety implications in the case of adding S-Video to a TV without any A/V jacks.

How do I add A/V inputs or outputs to a TV which does not have them built in?

For A/V inputs (video and audio) The place to do this is after the video and audio IF where baseband signals are normally separate.

For audio, in particular, an alternative is to tap into the audio circuitry which may be elsewhere. Even the loudspeaker outputs can be used but then without additional switching, you cannot disable the internal speakers when you are using your stereo system.

Depending on the model of TV, doing any of this may be trivial to impossible - or a serious safety hazard.

- Trivial: many low-end models use the same chassis (read this: circuit board) as the high end A/V receivers. Either there will be some parts missing, a cable connection to the missing A/V panel, or a missing auxiliary board which would have the A/V interface and jacks. If this is the case with your model, then it should be straightforward and safe to tap into the circuits at that point.

  A service manual or Sams' Photofact for the set will probably even identify the additional circuitry present in the higher priced models with A/V inputs.

  If, on the other hand, everything is crammed onto a single circuit board with no evidence of A/V signals, it may be very difficult as suitable tap-in points may simply not be available.

- Hazardous: many TVs have circuitry which is not isolated from the AC line. If this is the case with your set, then it may be more trouble than it is worth to provide the essential isolation barrier between the TV and your external A/V equipment. The only 'easy' solution for audio at least is to include an isolation transformer RATED FOR LINE VOLTAGE ISOLATION in each signal path to the outside world. A means of isolation can be provided for video as well but it has to be able to handle the 6 MHz or so bandwidth of the video signal. A simple capacitor even if rated for sufficient voltage will probably not work and could be hazardous since it would need to have a high uF value to pass the lower frequency end of the video signal.

If what you are really after is replacing a dead tuner/IF with your own tuner or converter, this may be possible but, again, may not be worth the trouble. The antenna isolation circuitry is probably external to the TV's tuner so yours could be substituted in its place. Of course, any user contact with the transplanted device would then have to be TOTALLY prevented since a serious shock hazard would be present for all metal parts and connections including shield grounds. In addition, many components would likely blow the instant power was applied if this were not done perfectly.

Unless you intend to always use the direct A/V inputs and forgo the tuner, you will need some way of selecting between them - a switch or relay. This could be manual - you push a button or flip a switch - or automatic. There are all kinds of ways to doing the detection - mechanical, checking for a low impedance connection, looking for a signal, using a switch, etc.

You will need a schematic - don't attempt this without one (for safety, if no other reason). Even some TVs that have A/V jacks use a live chassis and provide isolation for each signal (though this is the exception rather than the rule). So, even adding another A/V jacks to one of these would be hazardous!

Can I add direct RGB inputs to a TV?

The signals going into the CRT neck board are separate RGB, possibly a somewhat higher voltage level, but otherwise similar to those sent to a computer monitor. So, would it be possible to bypass the tuner and color decoding and go direct for better picture quality? After all, RGB SCART inputs are common on PAL TVs.

Assuming the scan rate of your source is NTSC (or PAL as appropriate), in principle, yes. The RGB signals may have to be amplified from the normal .7 to 1 V p-p used for monitors to whatever is required by your TV's final video amps (unless you can find a location on the mainboard where the levels are lower) and composite sync would need to be injected separately.

However, there are some serious safety issues. Many TV are designed with a chassis that is electrically live - not isolated from the AC line so unless an isolation transformer is used to power the TV or some means of isolation is used in the coupling of the signals, you could end up with a very shocking situation and/or blown parts all over the place. I wouldn't recommend it unless you have the complete schematics and really know what you are doing.

Adding variable volume headphones to a TV

> "My Mother-in-Law is hard of hearing. He is not. Is there such a thing as a variable volume headset that can hooked up while maintaining normal volume on the main speakers?"

(From: Filip "I'll buy a vowel" Gieszczykiewicz (filipg@repairfaq.org).)

Greetings. But of course... The cost is $9-ish per set and it includes a 9 foot (yup, 9 foot) cable and a handy, in-line volume control. The setup requires an audio output somewhere on the TV itself - is there a headphones jack? If yes, all you need is a "Y" (splitter) and two sets of headphones. If not, hmmm.... Either you or the local TV repair shop will need to add one. Depending on the circuitry of the speaker amplifier inside the TV, this may be as easy as splicing in a headphone jack and drilling a hole for it on the case, or as hard as somehow matching the impedance of the speaker to that of the headphones. You *will* need to look at the schematic or measure the speaker/signal. See the section: How do I add A/V inputs or outputs to a TV which does not have them built in? for the very important safety issues.

First, however, make sure they have a TV with a headphones jack or have one put in (or get a TV that *does* have one). The 'Y' adapter can be purchased in any Radio Shack. Any cheapo one will do - no need for gold plating (they will try to sell it to you ;-) should be under $5.

Building a Frankenstein TV

Here is an interesting questions:

> "I got a lot of partially gutted TVs at an auction (All the same brand) and I'm trying to build a 'Frankenstein TV'.
>
> I have a 13" unit with a working power supply board and tuner board in one set. I have another set with a 25" picture tube in it. I'd like to drive the big tube with the guts from the small TV. Does anyone know If I'll blow up my workbench if I attempt this sort of transplant?"

It won't blow up your workbench but the differences are probably significant enough that the performance would be unsatisfactory if it worked at all.

In addition, this may blow up the power supply board - kill the horizontal output transistor and/or low voltage power supply itself - as the required power levels are higher. If you have nothing to lose, power your Frankenstein initially through a series 100 W light bulb and Variac. Then you will be able to tell if you are even close with less risk of blowing expensive parts.

Of course, this does assume that all the organs your are merging are actually good to start with. Why do you you think they unloaded those TV carcasses?

While the same chassis may be used for 19" and 25" sets, going from 13" to 25" is likely to have many differences.

Turning a TV (or monitor) into an oscilloscope?

This question comes up so often and it does sound like a neat project to give a defunct TV a second life. Don't expect to end up with a Tek 465 on the cheap when you are done. However, it could be a fun learning experience.

CAUTION: See the safety recommendations below.

You will be severely limited in the performance of such a scope. TVs and monitors are designed to operate at a very narrow range of horizontal scan rates and the high voltage is usually derived from the horizontal deflection. So, you would need to retain the original deflection system for this purpose at least.

1. You will need to disconnect the deflection yoke from the horizontal and vertical deflection circuits of the TV or monitor without killing the HV. (also, doing all this without killing yourself as well). Depending on the design, this may be as simple as unplugging the yoke connector. More than likely, you will need to substitute a load for the horizontal deflection coil. A coil from another sacrificial similar TV or monitor would probably suffice.

   Warning: at this point you have a really bright spot in the middle of the screen which will turn to a really black spot if the brightness is not turned way down really really quickly.

2. For the horizontal, you need a ramped current source. You are driving a non-ideal inductor (the deflection coil) so it has both inductance and resistance. Thus the waveform is a trapezoid - a voltage ramp (for the resistive part) superimposed on a voltage step (for the inductive part). This should not be too difficult. Don't expect to be able to achieve really fast sweep. Even running at normal TV rates is non-trivial.

3. Similarly, for the vertical you need to drive with a voltage (your signal) controlled current source. However, if you are just screwing around, then the linearity etc. for the vertical may not be that important. In this case, one way is to put a current sensing resistor in series with the deflection coil and use this in a power op amp type of feedback arrangement. (You could do this for (2) as well.

4. There is a good chance that the original brightness control will work as an intensity adjustment. However, with some TVs and monitors, this depends on receiving a valid video signal. You may need to improvise. If you do want to control the intensity from a signal source, you should be able to tap into the drive signals going to the little board on the neck of the CRT.

5. Don't expect high bandwidth, uniform response, or any of the other things you take for granted with a decent scope. That takes work. However, as a fun project, this certainly qualifies. Interchanging the functions of the horizontal and vertical deflection yoke (and rotating it 90 degrees) may provide a better match of horizontal and vertical bandwidth to your intended applications or experiments.

6. With a color TV or monitor, these experiments could be quite interesting and educational but there may be color fringing effects since you are not compensating for certain aspects of dynamic convergence at all.

7. SAFETY: Once you disconnect the deflection yoke from the TV or monitor's circuits, move the original circuits out of the way and put a barrier between between you and the rest of the TV or monitor. All you will need are connections to the deflection yoke on the CRT (unless you want to do intensity modulation in which case you will need to drive the video output(s) to the CRT cathodes. I would recommend against doing this if your unit is one of those with a totally 'live' chassis as there would be additional safety hazards and circuit complications).

(From: Chris Crochet (ccrochet@premier.net).)

Hehehe... Actually, I've done this one. :)

I've got two old IBM mainframe terminals, painted like charred metal, hooked up to each channel of the 'B' speaker outputs on my stereo. It's strange looking and always an attention getter when I have guests. Not to mention, the long-persistence phosphor they use makes interesting tracers :)

One caveat, at least on these monitors (I don't know what other monitors this might apply to). When you turn them off, the circuitry shuts down in the following order: horizontal drive first, electron gun second, and vertical drive last. Therefore, if there is no vertical deflection, which would be the case if the stereo is quiet, the active electron beam becomes perfectly stationary during the course of shutdown, thus burning a hole in the phosphor. Oops :) I found it more effective to hook the stereo into the HORIZONTAL drive, thus avoiding this problem. Not quite like your average oscilloscope.

Another interesting effect -- if the electron gun is active during vertical blanking interval, it seems to deflect so far that it bounces off the SIDES of the picture tube, and sprays all over the phosphor, making some interesting images.

(From: Lance Edmonds (lanceedmonds@xtra.co.nz).

Some years ago ELEKTOR and Electronics Australia magazines published articles on a design for this. Dick Smith Electronics in both NZ & Australia used to sell the kit.

Max Bandwidth was a startling 10 or 15Khz. Enough for elementary audio servicing.

Those magazines also published designs for delayed sweep & trigger modules as additions to any basic 'scope. Plus, a storage scope design, logic analyzer design, and a Dual trace emulator design.

Enough to keep the average hobbist/experimenter happy for quite a while (g).

(From: Dale H. Cook (dhcook@rev.net).)

Every few months someone will pop up with this question. A TV would not make a very good scope. Bandwidth would be limited and the amount of work needed to build the horizontal and vertical amplifiers, sweep and triggering circuits and so on wouldn't be worth the effort. You'd need even more work to add modern features such as delayed triggering and variable hold-off. Don't even think about multiple channels and the advantages they offer. In a time when I see used Tek 465s offered for $200 it certainly doesn't pay to try to convert a TV. If you are just looking for a challenging electronic project I can think of several that have a far better chance of yielding something useful. Now, if you were starting with an antique set that used an electrostatic CRT you might do a bit better, but a 1937 Dumont will set you back about $3,000.00 or so - a little too much of an investment.

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

I've worked on the vector monitors that were used on some of the 1970's minicomputers. These are essentially X-Y displays (not raster scanned), and would make audio-bandwidth 'scopes if given a timebase. I would guess at a bandwidth of the order of 100kHz.

Some of them (DEC, certainly, maybe Tektronix) were electromagnetically deflected like a TV. However, there are a couple of things to be aware of. Firstly, the output amplifier, which drives the yoke at constant current, is pretty complex. Secondly, the yoke is specially made - the 2 sets of coils are pretty similar (unlike those in a TV), and the inductance is critical.

So, while I'll keep these monitors running, I'd not want to have to covert a TV into one :-).

(From: David Katz (DAVEkATZ@prodigy.net).)

If by chance what you want is an X-Y display for audio, not a (more typical) X-T, it's easy. Just put a resistor in series with each yoke (about 100 ohms, 5 W) and drive them with a stereo amp.

(From: Steve Roberts (osteven@akrobiz.com).)

Your best hope might be to get a older generation heart monitor from a hospital, these have a professional X-Y display module to begin with, and are surprisingly easy to hack, mine was $10 at the local surplus shop. The ultra long persistence phosphor is a pain/blessing depending on what you are doing.

For a description of what one person did, see: Dan's Home-Built O-Scope Page.

(From: Alan (revidyks@rocketmail.com).)

Apparently it's pretty hard to produce a decent scope.

It is, however, pretty easy to use the CRT as something like a scope, which I did recently with the built-in green screen monitor of a thing called a Kapro 2X. It was being thrown away, so I said I'd take it and have a look inside before throwing it away.

I wondered what if it was possible to drive the CRT from a source other than the computer video circuitry, so I did some tests, worked out how and by what voltage the deflectors were driven, (about 1v, 0.3A measured as an AC voltage).

Once I'd worked out that this was about the same as the output from a small stereo amp, I removed the horizontal signal from the CRT and hooked one channel of my stereo across the horizontal deflector , left the vertical deflector hooked up to it's (60Hz?, 30Hz?) signal, and switched it on. The results look pretty good, I get a full-screen moving trace of the sound wave. One other thing that I did was make the beam intensity constant by turning a knob marked 'B-SUB' a bit, this would have flooded the screen with 'white' ordinarily, but was perfect for me as I could now remove the computer motherboard all together.

I also tried connecting the left and right channels across the horizontal and vertical deflectors respectively (first disconnecting them from their normal inputs), which produced some really cool looking lissijous (sp?) figure type things, that change and throb with the music- each CD seemed to have distinctive characteristics. Maybe I'll try two different pieces of music across the axes, could be interesting...

I'd love to try throwing some different signals of different frequencies and shapes across the axes too, especially in combination a with musical one. The 'best' results so far, have been from music with a strong bass, simple beat (cymbals with a bass drum look great), and not too many layers of guitars, vocals, etc. (too many sounds and it's an uninteresting mess...)

If you want more information or have any advice on or experience with this sort of thing, mail me...

If you're thinking of trying any of this, remember (in case you don't know) that TVs/Monitors can be REALLY dangerous even when switched off and unplugged. See the section: SAFETY.

Displaying a video signal as a picture on an oscilloscope

I am not sure why anyone would really want to do this other than as an experiment - it would be interesting one.

If a composite video signal is the input, you will need a sync separator.

You will have to construct a vertical deflection voltage ramp generator which can be locked to your vertical sync signal.

The horizontal timebase of the scope will be fine for the horizontal deflection and should easily lock to your horizontal sync pulse or (if the scope has a TV trigger mode) directly to the video signal.

A video amplifier will be needed if your Z axis does not have an internal amplifier (you need .7 V p-p to be full brightness range.) Unless you provide automatic gain control, this will need to include offset (brightness) and gain (contrast) adjustments. Even if there is an internal amplifier, it may not have the required bandwidth for the video signal.

However, the overall brightness may be disappointing - a scope is not designed for overall high brightness. The beam focus will not be as good as that on a little TV either.

Use of surge suppressors and line filters

Should you always use a surge suppressor outlet strip or line circuit? Sure, it shouldn't hurt. Just don't depend on these to provide protection under all circumstances. Some are better than others and the marketing blurb is at best of little help in making an informed selection. Product literature - unless it is backed up by testing from a reputable lab - is usually pretty useless and often confusing.

Line filters can also be useful if power in you area is noisy or prone to spikes or dips.

However, keep in mind that most well designed electronic equipment already includes both surge suppressors like MOVs as well as L-C line filters. More is not necessarily better but may move the point of failure to a readily accessible outlet strip rather than the innards of your equipment if damage occurs.

Very effective protection is possible through the use of a UPS (Uninterruptible Power Supply) which always runs the equipment off its battery from the internal inverter (not all do). This provides very effective isolation power line problems as the battery acts as a huge capacitor. If something is damaged, it will likely be the UPS and not your expensive equipment. Another option is to use a constant voltage transformer (SOLA) which provides voltage regulation, line conditioning, and isolation from power spikes and surges.

It is still best to unplug everything if the air raid sirens go off or you see an elephant wearing thick glasses running through the neighborhood (or an impending lightning storm).

Comments on lightning damage

Unfortunately, lightning or similar surge related damage can happen to any equipment that is plugged into

ANYTHING - AC line, antenna, cable, phone. Symptoms can be almost anything but often run along the lines of the following:

> "I just recently bought a new JVC TV, about 5 months ago to be exact. A few weeks ago it got hit by lightning. Not directly though. I am trying to figure out why it will not power up now. I traced as far as I could into the power and it seems to be getting 120 all the way to some sort of parts. I know at least that it is going past the fuse, and the fuse did not even blow. But when I press the on switch still nothing happens. The switch is good, as is the wiring leading to the mainboard. From there I don't know. Does anyone know of any VERY common things to go when hit by lightning? I really don't know much about TV repair, but I feel like trying to fix it myself. I just have no idea where to look now. It is getting power, but I don't know where exactly it is stopping. Any ideas would be greatly appreciated."

(From: Brian Frank" (jambfrank@erols.com).)

When I was in trade school the instructor who taught the TV/VCR. repair course also had a fixit place on the side. This man knew everything about TVs, he could almost tell you what was wrong with a set by just smelling it. Once I brought a set to class that had been struck indirectly as well, the instructor told me the best thing to do was to tie a rope around it an use it as an anchor for a boat. He further went on to explain that a set struck in any way usually has so many problems that it is not worth getting in to. The one time he did try to fix a particularly expensive set it took him and two other employees three weeks to get it going. And he said there were still some problems.

As for tips on actually fixing it you might want to ask around for junkers and cannibalize them into one set.

GFCI tripping with TV, monitor, or other high tech equipment

Ground Fault Circuit Interrupters (GFCIs) are very important for minimizing shock hazards in kitchens, bathrooms, outdoors and other potentially wet areas. They are now generally required by the NEC Code in these locations. However, what the GFCI detects to protect people - an imbalance in the currents in the Hot and Neutral wires caused possibly by someone touching a live conductor - may exist safely by design in high tech electronic equipment. The result - false tripping - is mostly a problem with 3 wire grounded devices with built in line filters having capacitors between Hot and Ground but may also occur with 2 wire ungrounded TVs due to the power-on surge into the highly capacitive or inductive loads of their power supplies.

However, it's also possible for this to happen when a TV is hooked to a cable system because it's cable shield is connected to Earth ground. In such a case, this may or may not be a cause for concern.

TVs using Hot chassis designs couple the antenna and its cable shield to the tuner with small coupling capacitors. A side effect is that some AC leakage current can flow through these capacitors, possibly enough to trip the GFCI. If the TV's plug isn't polarized, try reversing it and see if the problem goes away. If it is polarized, make sure your outlet is wired properly and you aren't using a non-polarized extension cord with the TV plugged reversed.

It's also possible the TV is faulty and the tripping is actually taking place as a result of a legitimate problem.

To assure the set is safe, (whether reversing the plug helps or not), a leakage test should really be performed by measuring the AC current between the TV's antenna shield and an Earth ground. Try it with both polarities of the wall plug. Anything over about 8 mA will trip a GFCI. If the leakage current is less than this with either polarity of the wall plug, the GFCI is overly sensitive. If the leakage current is much more with either polarity of the wall plug, the set is defective and should be serviced immediately. It should not be used until the problem is corrected as a serious shock hazard exists.

Multisystem TVs

The question often arise: can my NTSC TV modified to display PAL signals (or vice-versa). Unlike a VCR where there are substantial differences between recording of NTSC and PAL, the problem of displaying the picture is much simpler.

The following assumes 525 line NTSC and 625 line PAL:

The horizontal scan rates are nearly identical (15,734 Hz for NTSC and 15,625 Hz for PAL), so this is not likely to be a problem. If these differed significantly, then there would be design issues similar to those for multisync computer monitors and this would drive up cost.

The vertical scan are slightly more of a problem with 525 line/60 Hz NTSC and 625 line/50 Hz PAL. But it is a lot easier to design vertical deflection to accommodate a modest variation in rates. TVs could be easily designed or modified to accept either.

The color encoding techniques differ but inexpensive ICs exist that can deal with either standard. In fact, many are programmable to do either with a jumper and slight modifications to the external components.

Displaying a monochrome - B/W - picture on the other kind of set is usually possible if the set has a vertical hold control or enough vertical range. Modifying the chroma circuitry is more complicated but it should be possible to substitute a second IC and patch it into the existing video chain.

As far as commercial multisystem TVs are concerned, the real reason we do not see many of these (at least in the U.S.) is lack of demand. They are available if you look hard enough and are willing to pay a premium. They are readily available on the international market.

Playing NTSC videotape on a PAL TV

Note that you will probably need an adapter at the very least to connect a PAL TV to an NTSC RF cable. This, at least isn't a problem as suitable devices should be readily available for a couple dollars. However, that may be the easy part if the VCR doesn't do enough of a conversion!

> "Does anyone know if NTSC VCRs (NTSC is a special feature in Ireland) require an NTSC capable television too, or can they convert NTSC signals to PAL (seems unlikely)?"

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

There are 4 possible answers:

1. The VCR does not convert an NTSC signal to PAL, it outputs pure NTSC and you need an NTSC-compatible TV to view it.

2. The VCR converts NTSC 3.58 to NTSC 4.43 and you need a PAL-TV adapted to NTSC 4.43 to view it (relatively minor adaptation).

3. The VCR converts NTSC 3.58 to PAL 4.43 but keeps the field rate at 60 Hz. That is definitely not a standard signal! Some standard PAL-TV's will permit viewing it, and some Won't! At least be prepared to see interesting artifacts and crosstalks.

4. Conversion to real standard PAL is very expensive, thus unlikely.

The most likely answers are (1) and (3), check the spec of the VCR. The NTSC 4.43 system has been sold to middle-east and maybe US-military.

Buying a TV in Europe

> "I have the following question for you specialists:
>
> Can I buy a TV in any west-european country and use it in any other west-european country? For example, buying a TV in the Netherlands and use it in Greece or buying in France and using in England."

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The general answer is: NO.

There are multi-standard TV's that cover more countries, but a TV that covers them all is extremely rare. Most countries now have PAL-BG, including all of Germany. England has PAL-I, the analog sound is at a different frequency and the digital sound is their own variety of Nicam. France has Secam L-L', mostly incompatible with anything else. I don't know about Greece, probably PAL-BG. Most Philips high-end sets can do PAL-BG, Secam-BG and NTSC (the latter from the baseband video inputs only).

(From: Allan Mounteney (allan@amounten.demon.co.uk).)

The answer is YES. Well, at least one.

Reason I know is that I was with a company that made computers with TV-OUT for world wide use and wanted something that could show that the TV Out worked for various countries.

This ONE and ONLY one we could find Three years ago came from Germany and covered PAL, SECAM and the American NTSC systems and came with a note that said from the time of making/selling that set it would not work in just one small country in South America. All features (including audio) were adjustable from the front panel Menu and it was a Grundig 17" job. I am advised that there is a load of others on the market now.

The company who seemed to know all about these international sets and gave us good service at that time was Andrew McCulloch Ltd in Cambridge UK. Phone #44(0)1223-351825

Could a TV be modified for 3D (stereo) display?

The whole idea of stereo 3-D vision to put the left and right views to the appropriate eyeball. There are two common ways of doing this:

1. Use different colors for the two views with color filters in from of each eye to separate the views. This is what were often used for the really bad (content wise) sci-fi movies of the '50s.

2. Display alternate views on the same monitor screen but use LCD shutter glasses to allow each eye to only see the appropriate view. This requires increasing the refresh rate to avoid unacceptable flicker.

The first approach can be used with any TV and a pair of monochrome video cameras. Of course, true color cannot be used since pure colored images are needed to separate the stereo views.

Alternating views with synchronized LCD glasses is a possibility but on a standard TV, the resulting refresh rate would be 30 Hz with a 50% duty cycle which is likely to be useful only as a short experiment - else your viewers will likely develop splitting headaches.

Displaying TV on a computer monitor

My general recommendation is that if you have the space, buy an inexpensive TV - the quality in the end may in fact be better. And, it will be usable without tying up your expensive monitor and (maybe) PC.

While various convertors are advertized to use a computer monitor with video from a VCR or other source, keep in mind that if it sounds too good to be true, it probably is like the claim of a $200 box for this:

OK, let me get this straight - this card/box will enable a 31.4 kHz horizontal scan rate monitor (VGA) be used as a TV - yes or no? It thus includes a video A/D, full screen frame buffer, D/A, and all the other tuner stuff for under $200? I don't think so. A scan doubler - which is a subset of the above - will not result in a high quality picture since it will display pairs of lines interleaved. Or does the impressive advertisement leave out the key requirement that the monitor sync at the NTSC horizontal scan rate of 15.734 kHz (most newer monitor do not)? Or is it a board that plugs into a PC and indeed does use the resources of the PC including the VGA card and bus?

In any case, get a written money back satisfaction guarantee.

Displaying computer video on a TV

Assuming this means NTSC:

1. You need to convert RGB to NTSC - there are single chips for this. Try Sony, Philips, Motorola, and others. These will combine the R, G, B, H sync, and V sync into a single composite video signal using a minimum of additional components.

2. You need to match the scan rate to NTSC - 15.734 kHz horizontal. Even basic VGA is twice this - 31.4 kHz. If your video card can be programmed to put out interlaced NTSC rate video then this is easy. If not, it is more difficult. If you want to use anything higher res than VGA, it is a very non-trivial problem requiring the construction of a scan convertor which includes a video A/D, full frame store, interpolator/readout timing, video D/A. Unless you are an experienced digital/analog designer, you really do not want to tackle any of this.

For the special case of VGA->NTSC, you may be able to get away with just storing a single scan line since the horizontal frequency is (almost) exactly twice the NTSC horizontal of 15.734 kHz. A double buffer where one buffer is storing while the other is reading out at approximately half the VGA pixel rate should work. With appropriate timing, even lines become the even field for NTSC and odd lines become the odd field (I may have this backwards). It is still not a trivial undertaking. Also, keep in mind that the quality you will get on NTSC will be poorer than the VGA due to fundamental NTSC bandwidth limitations. Also, flicker for line graphics will be significant due to the interlacing at 30 Hz. Even this is a non-trivial undertaking.

The requirements for PAL are very similar. For 625 lines systems, the 800x600 is the format that most closely matches the TV resolution.

You can also buy little boxes to do this. Quality is general not great as you are seriously limited by NTSC/PAL and the VCR. Except for presentations on existing TV rate equipment, it is probably not worth the effort. This is totally useless for any serious computer applications.

For professional presentations, modern video projectors are available that use high resolution LCD panels and real-time scan conversion. However, they are still relatively expensive).

How can I couple 4 TV screens to make them act like only one?

> "I've being thinking about how people do these kind of things? Is this analog stuff or do they use some kind of digitized signal which is then divided to each TV?"

It is mostly digital. The original master signal is digitized and stored in memory. Control codes specify the readout of a (probably double buffered) frame store. 9 and 16 screen versions are common. If you look closely, you will note that the resolution of pictures that differ is always lower indicating that the whole affair is driven from a single tape source with appropriate decoding. Where the pictures are the same, they may be at full resolution. Sub blocks of identical pictures may be at some intermediate resolution.

What is Scan Velocity Modulation?

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

Scan velocity modulation occurs around the transients in the luminance signal. The beam is sped up just before and just after the edge and it is slowed down during the edge. This makes for a sharper edge. On an alternating B/W pattern (stripes, checkerboard) you will see that the white parts get smaller and the black parts get whiter. This geometry error is a side-effect. Some say that this is the main intended effect of SVM.

SVM is *supposed* to be used to compensate for the spot blowup at high beam current. Peaking does not help to improve sharpness because the higher peak beam current also gives a fatter spot. SVM *can* work in that case. Unfortunately it is often misapplied, too much SVM will give a very unnatural picture, with obvious horizontal geometry errors.

If applied properly, SVM can improve the picture. Unfortunately there has been a rat race, led by Japanese, suggesting that more is better.

Some people will simply advise turning the contrast down. At low beam current the spot size will be acceptably small and SVM is not needed. In most, if not all, cases they will disable the SVM circuit, usually by pulling the supply connector to the SVM panel. That panel is often fixed to the neck of the picture tube, behind the video amplifier panel.

About Automatic Black Level Stabilization and possible problems

This is how some Philips TVs automatically compensate for component drift.

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

Check datasheets of TDA4580, TDA4680, TDA4780, TDA8390:

These video control ICs have automatic black level stabilization. At the top of each field it generates 3 measurement lines (R,G,B). Through a BCI beam current info wire it measures the beam current. It adjusts the amplitude of the measurement pulses so that it gets a fixed current level back, usually around 10 uA. Actually it measures a delta-voltage, the current is determined by resistors on the picture tube panel. The result is used as an offset for the video signals so that black voltage is put at zero beam current. (3 capacitors near the IC store 3 voltages, a 4th capacitor is used to store an ultra-black reference to compensate for leakage current.)

The pulses are easily seen on the screen if you turn down the vertical amplitude (height), you'll see 3 dim lines at the top.

When the set first starts up, the measurement loop can not close because cold cathodes can not produce any beam current. That would cause the loop to increase the black level to maximum. To prevent that, first it is measured whether the cathodes are warm yet. Instead of the 3 small measurement pulses a much larger (peak-white level) warm-up pulse is generated. This looks like a big fat white line at the top (above the screen edge).

The video control IC waits for the beam current to increase (to approx. 5 mA for the 3 guns together) before it will release the black level control loop. This is measured over the same BCI line, a diode adds an extra load resistor to this line so that a large beam current is required to cross the detection level. After this level is reached (was it +8 or +9 V ?) the black level stabilization starts, and after almost a second the picture is unblanked. It should be correct at once.

(I have often argued that this long delay is not pleasing to the customer who would rather have a faint picture earlier.)

Reasons why the warm-up trip level may not be reached are:

- The pulse is not strong enough, sometimes it can be adjusted via the same pin on the IC that adjusts the peak drive limiter,
- The emission of the cathodes is not enough (too cold, worn out cathode surface or too low VG2 voltage = screen voltage),
- The measurement resistor is too low value (via that diode),
- The beam current info circuit at the video output amplifiers does not work well, often because the CRT cathode voltage goes too low and the voltage on BCI can not be higher than that.

If there is too little beam current in general then I would start with re-adjusting the VG2 screen voltage. Because of the automatic black level stabilization this will NOT have any obvious effect on the picture. The stabilization just follows the VG2.

If VG2 is too low then the peak drive limiter will kick in too early and you can't get a decent contrast. Also the picture will be less sharp because at a lower cutoff voltage a smaller cathode area is used plus there's your problem with the warm-up detector.

If VG2 is too high then the video signal can not achieve blanking level anymore and you will see retrace lines. Also the cathodes will wear out faster because at a higher cutoff voltage a smaller cathode area is used, you'll have a sharper picture but not for long.

The proper adjustment procedure for VG2 is in the service doc, you need to observe the measurement pulses on an oscilloscope. But a little twist won't hurt too much, especially if you have already written off the CRT.

(I have the advantage of having known the people who invented this system many years ago, they were once my teachers.)

What is Kell factor with respect to interlaced displays?

(The following is from Bob Myers (myers@fc.hp.com).)

The Kell factor - which has to do with the fact that we're often undersampling an image from the standpoint of the Gospel According to St. Nyquist - IS a factor in the reduction of vertical resolution, but interlacing plays a part as well. This comes from at least two factors:

1. The receiver usually cannot precisely interleave the two fields.

2. More importantly, there are steps taken to reduce the interline flicker which reduce the effective vertical resolution. This includes running the line width of the display somewhat larger than would otherwise be the case, and in interlaced cameras, discharging the entire screen (including the lines from the "other" field) after every field scanned.

Interlace is particularly troublesome on moving images, where you will often perceive momentarily "missing" details. There was a LOT of discussion regarding the gory details of interlacing in the recent HDTV debates within SMPTE and other groups.

Homemade V-chip (or at least viewing limiter)

Here is an interesting questions:

> "I would like a control box of some sort that controls the cable signal that comes into the TV. I want to be able to control the total time a particular child has in his account to watch, plus the actual channels that he is allowed to watch (no Playboy or MTV), PLUS the time of day that he can watch (not during home work time). Programmable by channel, cumulative time, hour of the day, and day of the week. I also need a master pass word for parental programming of the kids accounts, plus be able to watch what I want to at any time. The kids could use either an individual account number or an individual "card" of some kind with a PIN like our ATM cards. This "box" should be secure so that a 14 year old boy can't bypass it very easily. At least without doing come major damage so that I'd know it when he did it. I know that this is a lot to ask, but I'm very familiar with computer programming and chipset technology, I do know that such a thing can be done. I just don't have the electronics knowledge to do it."

The following probably won't help you build such a gizmo but here are some thoughts:

First, I would not attempt to build any of the RF/cable switching stuff - there are too many variations. I would suggest trying to control the control of what you have. With a cable box, this would be relatively easy - just put the box and an IR transmitter in the same sealed enclosure. If you have only a cable ready TV, you could substitute or intercept the remote detector signal inside the set and disable the front panel controls.

Then you need:

- An input devices - keypad for example.

- A display - a 1 line LCD.

- A microprocessor. This doesn't need to be much - just to store the 'account information' including balance, allowable channel and time slot map, passwords. It would need a real time clock.

- An IR remote code transmitter. This could probably be directly programmed by the micro to control your cable box.

Each account would have a means of adding to the balance, password authentication, etc.

You would have a superuser account for your own watching as well as changing any of the individual account settings.

Too bad I don't still teach my intro to computer design courses - this would make a nice term project.

If you have a junker PC, this would be a simple bit of programming (but quite wasteful of power even for an 8088 based PC).

What is Aquadag?

You may see the term 'Aquadag' referring the the black paint covering the outside of most of the funnel section of the CRT.

(From: Nicholas Bodley (nbodley@tiac.net).)

Aquadag used to be a trademark of Acheson Colloids [Corp.?], I think around Niagara Falls or Buffalo, NY. It was one of many "-dag" colloidal graphites; they also made Oildag, Gredag (grease), and Alcoholdag, as I recall. Unfortunately, it's probably sold in 55-gallon drums minimum. I hope you can find smaller quantities. Are there any CRT rebuild shops around the USA? See the Thomas Catalog (ThomCat) in a library to find Acheson.

I am pretty sure there's nothing magic about the graphite. If you can find some reasonably-priced nickel-flake or copper-flake paint (be sure it's conductive!), you might have an affordable (?) coating. How about plain metal foil, maybe even ordinary aluminum foil? You surely don't need current-carrying capacity; you would need a decent adhesive, though. How to make sure you have continuity between pieces, I'm not so sure; shoot for really tight crimps that deform the metal and are gas-tight. (This might, however, be quite unnecessary.)

Combined computer monitor and TV

> "This is a 27" VGA monitor which should also be able to be used as an NTSC television monitor. Can anybody comment on it?"

IMO, I think the entire idea of a combined TV/computer monitor is silly especially when the likely cost premium is taken into account. Watching the boob tube will tie up your entire PC. The optimal size for TV and computer use is not the same nor are the requirements in terms of scan rate, resolution, brightness, and sharpness. Thus, the design will be inherently more expensive and include more compromises. So, I will probably be proved wrong by record sales of these things but my only justification for such a hybrid would be if there were absolutely no space for both.

Interesting TV Switch Mode Power Supply

The following was found in a Sony TV:

```
                         Q1 switching/reg
                            transistor
                 (+)             ---
              +---+-------------| |---------------+-----------+
        +--+  |  _|_             ---              |          _|_
  AC >--|  |--+  --- C1           |               |    diode /_\ D2
        |  |      |               |               |           |
  AC >--|  |------+---+    +-----+------+         |           |
        +--+     (-)  |    | Reg. Drive |         C           |
         D1           |    +-----+------+         C choke     +---- gnd
```

```
                |          |                C           _|_
                |          |                | +135 cap --- C2
                |          |                |  I--->    |+
                +----------+----------------+-----------+---> + 135
```

Although at first this appears to short out the line supply, when drawn like this it turns out to be a valid switching regulator:

- Q1 is driven by a pulse width modulated signal a the horizontal rate.
- Q1 turns on putting 150 V across choke. Current ramps up in choke - more or less linear until saturation which should not occur. This time increases with increasing load.
- Q1 turns off. Since current in an inductor cannot change instantly, current continues to flow, now through D2, C2, and +135 load. LCR (R of load, diode) time constant - charges capacitor and powers load.

It would appear to fail and run away under the following circumstances:

1. Inductance is too low and choke cannot store enough energy even at high duty cycle to supply load. Too high a duty cycle and core saturates at which point transistor blows up.
2. Inductance is too high relative to switching frequency so that choke does not have time to discharge (its current) before next current pulse - DC current will just keep increasing until core saturates. This could only really happen if the switching frequency were too high for some reason unless someone changed core material or something like t.
3. Load is too great due to fault elsewhere.

Unfortunately for reliability and troubleshooting, many modern power supply designs have similar failings.

When attempting to diagnose problems with these types of circuits where the natural outcome of a fault is for one or more expensive parts to fail catastrophically, it is wise to either use a Variac to bring up the input voltage slowly and carefully observe the behavior hopefully before too late or put a load in series with the line such as a 100W light bulb to limit the current (though this will change the behavior in various ways).

The horizontal output transistor substitution jig trick

(From: penguin@datastar.net).

Okay, here's a good trick you can use for almost all TV work. Mount a TO-3 transistor socket on a heatsink that has about as much surface area as the skin of both fists balled up, actually the bigger the heatsink the better. Then mount a horizontal output transistor in the socket. Use an ECG238 or equivalent. Make sure you use a good mica insulator, as there will be over a thousand volts on the collector.

Solder a 1.5 foot red wire (18 gauge or bigger) to the collector, an equal but yellow wire to the base and an equal but green wire to the emitter (or use your own color codes). You may be able to salvage a ready made heatsink with socket out of an old receiver or TV. Mine came out of some old Curtis Mathes TV's. Solder a damper diode with the cathode to the collector and the anode to the emitter. Add a 200 ohm 1/4 watt resistor from base to emitter. Add these parts to the socket not the transistor, so the transistor can easily be changed if you ever need to.

Now you have a very useful test jig. If you are ever working on a TV that has a blown HOT (horizontal output transistor) you can pull out the bad part and connect this jig. Then you can run the set at low voltage.

If you have a set where the HOT is running too hot, this method often will give you some running time, hopefully enough time to find out what the problem is. Often the bad parts themselves will self destruct or heat up to where identifying them is easy. Usually a bad flyback will crack and smoke proving itself to be bad. Once your satisfied that the problem is cured, you can put the original HOT in knowing it will be safe.

Usually when I power a TV in this way (using a Variac) I'll bypass the series pass regulator with a jumper. This is easily done by finding the 180 to 330 ohm 15 to 20 watt regulator bypass resistor and putting a jumper across it. With the regulator bypassed the power supply will go to 160 volts this is why it is necessary to use a Variac and only run it at about 60 volts. It is necessary when using this brute force approach, to make sure that all of the low voltage supplies coming off the flyback are fused with fusible resistors. Most models do fuse the LV supplies, but some don't. (One particular RCA comes to mind.) Another good trick, if your out in the field and don't have a varactor handy, is to simply pull the series pass regulator (e.g. STR30130 etc.) and let all the power just come through the 20 w bypass resistor. If the flyback is okay the B+ to the flyback will come up to about 60 to 90 volts, and in many cases you can even see a dim picture. Anything less than 50-60 volts and the flyback is probably bad. Don't run it this way for more than a minute or two as the the resistor will be dissipating close to or more than its rated power under these circumstances. Of coarse you obviously can't use this method with switching power supplies.

Here's a good trick for the Sony TVs that use the SG-613, even though this device is a gate controlled SCR you can sub a regular HOT like the ECG238 on your test jig. I used to blow out these buggers to the tune of about $20 dollars a pop til I figured out how to use the "HOT Heatsink Jig". Now with the jig connected, the horizontal width may not open up all the way, but you can run these old Sony's like this for about 5 minutes before the HOT jig starts to get too hot. Usually if they run this long they're ok and then you can put the SG-613 in knowing that you aren't going to see a bunch of $$$ go up in smoke. I had a Sony that would run for weeks then blow the SG-613 finally put this one to rest when I changed out the horizontal output transformer which was separate from the flyback on this oldie.

Always be cautious of the high voltage on the collector of the HOT JIG.

Ken's comments on (TV) SMPS repair

(From Kenneth Aaron (kennetha@geocities.com).)

1. NEVER NEVER NEVER power on a SMPS without load, the newer ones especially in TVs (not so much VCRs) self destruct when not loaded.

2. The light bulb test is great to see if your SMPS can handle the load of the horizontal circuits - when the set does not turn on - you get the initial power on then it goes off - best is to disconnect the collector of the horizontal output transistor and plug in a light bulb and see if it goes on.

3. Chinese TVs have poor quality capacitors - the latest models mostly have the same SMPS so this applies for all. There is a small electrolyte cap in the supply feedback about 22 to 47uF at 50V. This dries up real fast and after 2 years or so the voltage B+ goes up from 110 V to anything up to 300 V! (not joking here). I got a TV where the end of the tube was blown off from a supply that reached 296 V instead of 105 V. that's over 75kV into the screen!

4. The newer Philips and copycat Chinese models use the main supply to power the horizontal. The flyback is driven by a transistor which has over 2500 V on it's collector. The flyback is built differently as well. These transistors are called 2DS... - do not use a replacement - I did use one with a higher voltage and it fried - this

is because the ceramic capacitors around it along with it's different characteristics changed the 'on' time and it overheated after a few minutes.

5. You can always use a BU208D instead of a BU208A, BU508D instead of BU508A, etc, the extra diode will do no harm.

IR detector circuit

This IR Detector may be used for testing of IR remote controls, CD player laserdiodes, and other low level near IR emitters.

Component values are not critical. Purchase photodiode sensitive to near IR - 750-900 um or salvage from optocoupler or photosensor. Dead computer mice, not the furry kind, usually contain IR sensitive photodiodes. For convenience, use a 9V battery for power. Even a weak one will work fine. Construct so that LED does not illuminate the photodiode!

The detected signal may be monitored at the collector of the transistor (Q1) with an oscilloscope.

```
 Vcc (+9 V) >-------+---------+
                    |         |
                    |         \
                    /         /  R3
                    \ R1      \  500
                    / 3.3K    /
                    \       __|__
                    |       _\_/_  LED1 Visible LED
                  __|__       |
      IR ---->   _/_\_ PD1    +--------> Scope monitor point
        Sensor      |         |
      Photodiode    |     B |/ C
                    +-------|    Q1 2N3904
                    |       |\ E
                    \         |
                    / R2      +--------> GND
                    \ 27K     |
                    /         |
                    |         |
     GND >----------+---------+
                   _|_
                    -
```

UK Satellite TV information

(From: Martin Pickering).

Here is a list of the FAQs and other documents related to UK satellite TV available at:

- Satcure Web Site

by adding the appropriate file name to the URL, above, or following the links.

aegir.htm	The Aegir/Dixi/Lenco/Oritron Jupiter D2Mac decoder FAQ
churchil.htm	The Alfaglade Churchill D2Mac decoder FAQ
d2mac.htm	A general discussion about buying D2Mac decoders
digifaq.htm	Chris Moore explains Digital Satellite Receivers
diseqc.htm	An explanation of DiSeqC
dummies.htm	Satellite TV for the beginner
filmnet.htm	Philips BBD-901 FilmNet D2Mac decoder FAQ
galaxis.htm	Galaxis digital receiver specifications
grd150.htm	Grundig GRD150/200/280/300 receiver FAQ
interf.htm	A discussion about picture interference problems
jack.htm	Lots of humorous stories originally published in magazines
lnb.htm	A discussion about various LNBs and frequencies
money.htm	How to make money from Satellite TV!
mrd920.htm	Pace MRD920 D2Mac receiver FAQ
mss200.htm	Pace MSS200/Apollo receiver FAQ
mss500.htm	Pace MSS500/1000 receiver FAQ
nimbus.htm	Mimtec Nimbus receiver FAQ
prdkits.htm	Upgrade kits for Pace PRD receivers explained
products.htm	Index page for SatCure products
reliable.htm	A discussion about making your receiver more reliable
sat1700.htm	Nokia SAT1700 receiver FAQ
sataccs.htm	SatCure accessories page
satbooks.htm	SatCure books page
satfaqs.htm	Index page for all FAQs
satkits.htm	Satcure repair/upgrade kits page
satwalk.htm	A discussion about the SatWalker and other motorised units
scarts.htm	A discussion about Scart connectors - which is best?
spares.htm	A complete price list of SatCure component spares
sparkly.htm	A discussion about "sparlies" ("fischen") and the cures
sr5500.htm	Echostar SR5500 receiver FAQ
srd400.htm	Amstrad SRD400 receiver FAQ
srd500.htm	Amstrad SRD500 receiver FAQ
srd510.htm	Amstrad SRD510 receiver FAQ
srd600.htm	Amstrad SRD600 receiver FAQ
srx200.htm	Amstrad SRX200 receiver FAQ
ss9kits.htm	Upgrade kits for Pace SS9xxx receivers explained
svs250.htm	BT-SVS250 receiver FAQ
tools.htm	A discussion about repair tools
uniden.htm	Uniden UST- receiver models FAQ
which.htm	Which receiver shall I buy?
advice.htm	What to do if your receiver will not work?
ard200.htm	Cambridge ARD200, BT-SVS200, JVC TU-AD1000 receiver FAQ
ctu900.htm	Philips CTU900 D2Mac decoder FAQ
mss100.htm	Pace Prima/MSS100 receiver FAQ
prd.htm	Pace PRD800/900 receiver FAQ
rd480.htm	Cambridge/Matsui RD480 Extra receiver FAQ
srd6.htm	Ferguson SRD6 receiver FAQ
srd700.htm	Amstrad/Fidelity SRD700, SR950, SR950+ receiver FAQ
ss9.htm	Pace SS9xxx receiver FAQ
svs300.htm	BT-SVS300 receiver FAQ
why.htm	"Why am I in business" - a discussion for when you're down!
yourfaqs.htm	Copies of questions and answers - let's have more!

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International Color Television Standards

Brief description of international color TV standards

(The following is from Bob Myers: (myers@fc.hp.com).)

Well, the joke was that SECAM stands for System Essentially Contrary to the American Method....:-)

The basic, oversimplified description of the three common encoding methods is as follows:

NTSC: Used in North America, Japan, and a few other areas. Luminance ("black and white" information) is sent just as it was before color, and color information is provided in two "color difference" signals (actually, derived along with the luminance (Y) signal) via matrix multiplication) which are carried on a "color subcarrier". The chroma (color) signals are severely band-limited compared to the luminance signal, which is one reason you can never fully recover proper RGB from an NTSC-encoded signal. The color information itself is encoded such that the PHASE of the chroma signals, relative to the reference signal, is important in recovering the color. As used in the U.S., the broadcast standard provides a line rate of approx. 15,734.26 Hz, and a field rate of 59.94+ Hz*

PAL: Very similar to NTSC, with the exception that the phase of the color subcarrier is reversed on alternate lines; this tends to cancel some of the more common color errors seen in the NTSC system. (The color signals of PAL are also simple color-difference signals, rather than using the more involved RGB -> YIQ matrix of NTSC). In the most common European PAL broadcast systems, a line rate of 15,625 Hz and a field rate of 50.00 Hs are used*.

SECAM: This system is very different from both NTSC and PAL. Luminance and color-difference signals are still used, but the color difference signals are sent separately, on successive lines. This requires at least a one-line memory or delay line be provided in the receiver for proper color decoding. The broadcast SECAM systems usually use similar line/field rates as for the PAL broadcast standards noted above*.

Note: In all three cases, the terms "NTSC", "PAL", and "SECAM" technically refer only to the COLOR-ENCODING systems described above; they do not specifically imply a set of timing standards or frequencies. The one possible exception to this is the use of the term "NTSC", since the U.S. National Television Standards Committee ALSO came up with various timing standards for U.S. television. But in all cases, the color encoding method is not *strongly* tied to a specific line/field timing. For example, there is at least one broadcast system (Brazil's) which uses NTSC encoding, but at the line/field rates more commonly seen in the European systems.

Some questions and answers about TV standards

(Responses from: Steve McKinty: (smckinty@france.sun.com))

1. What are the most common TV standards in the world?

NTSC: National Television Standards Committee PAL: Phase Alternate Line SECAM: SEquential Couleur Avec Memoire (Sequential colour with memory)

There are other differences though. Strictly they are just different colour systems, but most countries which use PAL have 625 lines in a picture and send 25 full pictures/second, most NTSC countries have 525 lines and send 30 full pictures/second (mostly for historical rather than technical reasons). That complicates things.

2. Who devised them, and when? and why? Are they as old as television?

The first serious TV experimenting was done in several countries around the period 1900-1930, mostly black & white. The BBC started a regular service in 1936, other countries followed soon after, but since the technology was developing very rapidly there were always improvements being made. The BBC started with 405 lines, the US started a service a couple of years later with 525, by the time other European countries started the technology allowed 625 lines. France even tried 819 lines.

All those system were black & white, but people wanted to have colour. During the 1940's much of Europe was at war, and technological development for entertainment slowed down, but in the US they were able to continue and devised a colour system which was compatible with the existing black & white one.

By compatible I mean that a black & white TV got a black & white picture, a colo(u)r one got a colour picture. No need to make people throw away their B&W TVs. This system was endorsed by the American National Television Standards Committee, and was named after it => NTSC.

After the war other countries started to look at colour. NTSC was a very clever system, but it had some flaws. Engineers in various countries tried to improve on it, and Telefunken in Germany came up with a simple modification which improved colour stability. It was named PAL because they reversed the Phase of the colour signal on Alternate Lines.

At the same time Henri de France, in France, fixed the same flaw in a different way. His design (SECAM) needed a memory inside the set which made it more expensive. PAL gave as good a result, so most countries opted for that. France stayed with SECAM, possibly because in the De Gaulle era of the 50's memories of German occupation were still fresh, and dropping a French system in favour of a German one would have been unpopular. Rumour has it that the French government subsidized Thomson to make memory affordable.

Since Britain went PAL, France went SECAM, and the US went NTSC, any colonies or dependencies of those countries tended to get the same system. India/Pakistan got PAL, Algeria got SECAM, and since the US helped rebuild Japan after WW2 it got NTSC, etc.

3. What's the difference?

To squeeze a colour signal into the same space as a black & white one, and stay compatible, the NTSC designers separated the colour and brightness information. The human eye is less sensitive to colour, so they were able to reduce the bandwidth of that signal (make it take up less space in each channel), 'hiding' it at the high-frequency end of the video. That meant they didn't need to make the channels bigger, and incompatible.

To do that, they used the fact that you can represent most colours with a combination of Red, Green and Blue. If you film a scene with three cameras, one for each colour, then add all the outputs together you get a black & white image. This signal is called luminance, usually represented by 'Y'. Mathematically Y = R + G + B. (Actually, not all the contributions are equal).

They then transmitted the Y signal just as for a black & white TV, and also transmitted the R and B in the extra colour signal. B&W TV's only saw Y, and colour TV's got Y, R and B. Since Y = R + B + G, G can be obtained as Y - (R+B), so they didn't need to transmit all three.

To get both R and B into one signal, they use a combination of Phase and Amplitude modulation (think of it as AM and FM at the same time). Its called quadrature modulation, and works very well, but is susceptible to phase changes as it passes along cables, etc. If the signal gets +10 degrees phase change the colour will visibly change, which is why NTSC TV's have a tint control.

PAL overcomes that by sending R and +B on one line, then R and -B on the next. That way a +10 phase shift on one line becomes -10 on the next, and small differences will cancel out. PAL TV's don't need tint controls. (Some old PAL sets may have a one, however).

SECAM doesn't send both R & B together, it sends R on one line, B on the next. No fancy modulation, so no phase problems, but you need a 'memory' in the set to save up the signal from the previous line, since both R & B are required together for processing.

4. Why do you need different TVs?

Mostly because of the different numbers of lines. Its quite easy to make one colour decoder which can cope with all the systems, but making a TV which can do 625 and 525 lines, 25 and 30 pictures/second, gets expensive. Consumers shop on price, no-one will buy a SECAM TV in the USA even if it only costs $20 more, since there aren't any SECAM channels.

5. Why do you need different VCRs? Why can't one VCR record the same "output"?

Some can, but like TVs it costs more to make them adjust. The motor speed varies with the number of pictures transmitted per second, for example. (This is covered in more detail in the document: Notes on the Troubleshooting and Repair of Video Cassette Recorders.)

6. Why did different systems evolve? Is one cheaper? Is one better?

When originally developed, expense was considered based on contemporary technology. As noted, politics may have been equally important.

As to which has better quality, its all rather subjective. The 625-line system adopted in Europe has better vertical resolution than the 525-line US system, but some people find the 50Hz field rate still produces some flicker. NTSC/PAL/SECAM are all equally capable of excellent colour reproduction, but under poor signal conditions NTSC can degrade more quickly.

7. Are there other systems besides the ones I've mentioned? Why?

Some others, like MAC where the colour and luminance are completely separated. That gets rid of interference (ever see the strange colours which appear on very fine check patterns?) but is more expensive and really only possible due to modern electronics.

8. Are there going to be more or less systems in the future?

That is THE question! There are certainly going to be different systems, more lines, better sound, etc.

9. Is there any way to convert a PAL tape to NTSC or vice versa?

Yes. If the PAL tape has 625 line pictures and the NTSC one has 525 line then you normally need a computer which can read in one format and re-adjust things. Not cheap, but becoming cheaper, several companies offer that sort of service. Some PAL VCRs can do a half-conversion, enough to fool most PAL TVs into thinking its got a PAL signal.

10. Do they teach this stuff in electrical engineering courses?

Sometimes. Some of it, depends a lot on the course and school.

Politically Correct TV Standards

(The following is from: Robert Rolf).

```
    SECAM:
            Used by France and the former Soviet union.
            No tint control. No color control.
            Full socialism. The state knows exactly what color you
            should see, and how strong that color should be.

    PAL:
            Used by Germany & UK, Australia etc.
            No tint control. A color control.
            Partial socialism. The state knows exactly what color you
            should see, but you get a choice as to how strong it can be.

    NTSC:
            Used in USA and Canada, Japan etc.
            A tint control, A color control.
            Uncontrolled socialism. The state lets you chose what color you
            see and how strong it can be. They then tax you regardless.
```

Just another way of looking at it....

Variations on a 'standard' - the PAL system

In the U.S., when PAL is mentioned, it is usually assumed to be 625 line/50 Hz as used in the UK and man other places. However, there are several variations on the PAL system.

(The following from: Ed Ellers I can think of five major groups right off:

PAL B/G/H - 625-line 50 Hz systems used in most European countries and many countries in Africa, the Middle East and Asia.

PAL I - Again 625 lines at 50 Hz, but with a different sound carrier frequency. Used in the United Kingdom, the Republic of Ireland, Hong Kong, South Africa and a few other places I've forgotten.

PAL D/K - Yet another 625-line system with a different sound carrier. Used in some former Warsaw Pact countries as well as mainland China; this may become more popular as PAL/SECAM receivers become common in the CIS republics and other former Soviet bloc countries, since those countries now use SECAM D/K.

PAL M - This one's 525 lines at 59.94 Hz; it's just like NTSC except for PAL-type color encoding. It's used mainly in Brazil.

PAL N - A real oddity, with 625-line 50 Hz video but a *lower* sound carrier and a lower color subcarrier than the B/G/H, I and D/K varieties. It's used in Argentina and a few other places.

What about PAL sets WITH a tint/hue control?

Here is one for the record books - a Sony PAL TV that really wants to be NTSC!

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

Although this very old Sony set (KV-1300) receives PAL signals, it's much closer to an NTSC set inside. In fact it's one of the strangest PAL decoders that I have ever seen. As you know, in the PAL system, the phase of one of the colour signals is inverted on each line, and in the receiver there's a bistable which switches at half the line rate to re-invert the colour signal on alternate lines. Well, to avoid a patent, the Sony set only uses (say) the in-phase colour signal that's received on alternate lines. For the lines in between it uses the previous line's colour signal (ignoring the incoming inverted one), which has been stored in a delay line.

This approach avoids the main patent on the PAL system. It also means that this set doesn't automatically correct for phase errors in the colour signals - it's almost an NTSC decoder. Hence the hue control (which is also on my kV1320UB schematic). It's just about the only set like that.

TV, shortwave, power worldwide

(From: Mark Zenier (mzenier@netcom.com).)

A book, "The World Radio TV Handbook" published by Billboard that covers TV, along with where all the world's shortwave radio transmitters are, and what sort of power comes out of the wall plug all around the world. It has a new edition each year and costs around $25 to $30.

Color television standards worldwide

(The following is from EDMUNDO, Design Engineer Ten-Lab. This and additional information are available at: http://www.tenlab.com/format.htm).

We at Ten-Lab have put together the following chart listing countries and their corresponding color TV standards.

We are trying to be as accurate as possible, but we need your feedback to refine and correct the information. We are doing the best we can in spite of inherent problems such as:

1. Some of the literature and charts are contradictory; even some books and manuals contradict each other more than they agree.
2. Many countries have changed their names during the last few years.
3. Some countries have one broadcast TV system, but also receive programs in a different system from beyond their borders. This creates some confusion about the format(s) used locally.

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INTERNATIONAL TV STANDARDS CHART by TEN-LAB  (UPDATED Jan 19, 1996)
COUNTRY                  VHF STANDARD    UHF STANDARD


AFGANISTAN               PAL/SECAM B
ALBANIA                  PAL B           PAL G
ALGERIA                  PAL B           PAL G
ANGOLA                   PAL I
ARGENTINA                PAL N           PAL N
AUSTRALIA                PAL B           PAL G
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AUSTRIA	PAL B	PAL G
AZORES	PAL B	
BAHAMAS	NTSC M	
BAHRAIN	PAL B	PAL G
BANGLADESH	PAL B	
BARBADOS	NTSC M	
BELGIUM	PAL B	PAL H
BERMUDA	NTSC M	
BOLIVIA	NTSC M	
BOTSWANA	PAL I	
BOURKINA FASO	SECAM K1	
BRAZIL	PAL M	PAL M
BRUNEI	PAL B	
BULGARIA	SECAM D	SECAM K
BURMA	NTSC M	
BURUNDI	SECAM K1	
CAMBODIA	NTSC M	
CAMEROON	PAL B	PAL G
CANADA	NTSC M	NTSC M
CANARY ISLANDS	PAL B	
CHAD	SECAM K1	
CHILE	NTSC M	NTSC M
CHINA	PAL D	
COLOMBIA	NTSC M	NTSC M
COSTA RICA	NTSC M	NTSC M
CUBA	NTSC M	NTSC M
CYPRUS	PAL G	PAL G
CZECHOSLOVAKIA: now		
CZECH REPUBLIC PAL	PAL	
SLOVAK REPUBLIC	PAL	PAL
DAHOMEY	SECAM K1	
DENMARK	PAL B	PAL G
DJIBHOUTI	SECAM B	SECAM G
DOMINICAN REP	NTSC M	NTSC M
ECUADOR	NTSC M	NTSC M
EGYPT	SECAM B	SECAM G
EL SALVADOR	NTSC M	NTSC M
EQUATORIAL GUINEA	PAL B	
ETHIOPIA	PAL B	PAL G
FIJI	PAL B	
FINLAND	PAL B	PAL G
FRANCE	SECAM L	SECAM L
FRENCH POLYNESIA	K1	
GABON	SECAM K1	
GAMBIA	PAL I	
GERMANY	PAL B	PAL G
GHANA	PAL B	PAL G
GIBRALTAR	PAL B	PAL H
GREECE	SECAM/PAL B	SECAM/PAL G
GREENLAND	NTSC M/PAL B	
GUADELOUPE	SECAM K1	
GUAM	NTSC M	
GUATEMALA	NTSC M	NTSC M
GUANA (FRENCH)	SECAM K1	

GUINEA	PAL K	
HONDURAS	NTSC M	NTSC M
HONG KONG	PAL I	
HUNGARY	SECAM D/PAL	SECAM K/PAL
ICELAND	PAL B	PAL G
INDIA	PAL B	
INDONESIA	PAL B	PAL G
IRAN	SECAM B	SECAM G
IRAQ	SECAM B	
IRELAND	PAL I	PAL I
ISRAEL	PAL B	PAL G
ITALY	PAL B	PAL G
IVORY COAST	SECAM K1	
JAMAICA	NTSC M	
JAPAN	NTSC M	NTSC M
JORDAN	PAL B	PAL G
KENYA	PAL B	PAL G
KOREA NORTH	SECAM D	
KOREA SOUTH	NTSC M	NTSC M
KUWAIT	PAL B	
LEBANON	SECAM B	SECAM G
LIBERIA	PAL B	PAL H
LIBYA	SECAM B	SECAM G
LUXEMBOURG	PAL B	PAL G/SECAM L
MADAGASCAR	SECAM K1	
MADEIRA	PAL B	
MALAGASY	SECAM K1	
MALAWI	PAL B	PAL G
MALAYSIA	PAL B	
MALI	SECAM K1	
MALTA	PAL B	PAL H
MARTINIQUE	SECAM K1	
MAURITANIA	SECAM B	
MAURITIUS	SECAM B	
MEXICO	NTSC M	NTSC M
MONACO	SECAM L	
MONGOLIA	SECAM D	
MOROCCO	SECAM B	
MOZAMBIQUE	PAL B	
NAMIBIA	PAL I	
NEPAL	PAL B	
NETHERLANDS	PAL B	PAL G
NETH. ANTILLES	NTSC M	NTSC M
NEW CALEDONIA	SECAM K1	
NEW GUINEA	PAL B	PAL G
NEW ZEALAND	PAL B	PAL G
NICARAGUA	NTSC M	NTSC M
NIGER	SECAM K1	
NIGERIA	PAL B	PAL G
NORWAY	PAL B	PAL G
OMAN	PAL B	PAL G
PAKISTAN	PAL B	
PANAMA	NTSC M	NTSC M

PARAGUAY	PAL N	
PERU	NTSC M	NTSC M
PHILIPPINES	NTSC M	NTSC M
POLAND	SECAM D/PAL	SECAM K/PAL
PORTUGAL	PAL B	PAL G
PUERTO RICO	NTSC M	NTSC M
QATAR	PAL B	
REUNION	SECAM K1	
RUMANIA	PAL D	PAL K
RUSSIA	SECAM D	SECAM K
RWANDA	SECAM K1	
SABAH/SARAWAK	PAL B	
ST. KITTS	NTSC M	NTSC M
SAMOA	NTSC M	
SAUDI ARABIA	SECAM B/PAL B	SECAM G
SENEGAL	SECAM K1	
SEYCHELLES	PAL B	PAL G
SIERRA LEONE	PAL B	PAL G
SINGAPORE	PAL B	PAL G
SOMALIA	PAL B	PAL G
SOUTH AFRICA	PAL I	PAL I
SPAIN	PAL B	PAL G
SRI LANkA	PAL B	
SUDAN	PAL B	PAL G
SURINAM	NTSC M	NTSC M
SWAZILAND	PAL B	PAL G
SWEDEN	PAL B	PAL G
SWITZERLAND	PAL B	PAL G
SYRIA	SECAM B	
TAHITI	SECAM K1	
TAIWAN	NTSC M	NTSC M
TANZANIA	PAL B	PAL B
THAILAND	PAL B	
TOGO	SECAM K	
TRINIDAD Y TOBAGO	NTSC M	NTSC M
TUNISIA	SECAM B	
TURKEY	PAL B	PAL G
UGANDA	PAL B	PAL G
UNITED ARAB EMIRATES	PAL B	PAL G
UNITED KINGDOM		PAL I
UPPER VOLTA	SECAM K1	
URUGUAY	PAL N	PAL N
USA	NTSC M	NTSC M
VENEZUELA	NTSC M	NTSC M
VIETNAM	PAL B	PAL G
YEMEN	PAL B	
YUGOSLAVIA	PAL B	PAL G
ZAIRE	SECAM K1	
ZAMBIA	PAL B	PAL G
ZIMBABWE	PAL B	PAL G

Cable channel allocation

(The following is from: (kruskal@watson.ibm.com (Vincent Kruskal).)

The following table gives the definitions of the numeric cable channels defined in the EIA (Electronic Industries Association) Interim Standards, IS-6 (CP), May 1983 and associated information that has been gathered. Definitions appear at the end.

Channel	HRC Picture Carrier	Cable Band		Other Names
1	72 MHz	Low	(VAR)	A-8, C54, J54, G64, 4+, 5A
2	54	Low		
3	60	Low		
4	66	Low		
5	78	Low		A-7, C55, J55, G65
6	84	Low		A-6, C56, J56, G66
7	174	High		
8	180	High		
9	186	High		
10	192	High		
11	198	High		
12	204	High		
13	210	High		
14	120	Mid		A
15	126	Mid	(ATC)	B
16	132	Mid	(ATC)	C
17	138	Mid	(VAR)	D
18	144	Mid	(VAR)	E
19	150	Mid	(VAR)	F
20	156	Mid	(VAR)	G
21	162	Mid	(VAR)	H
22	168	Mid	(VAR)	I
23	216	Super	(VAR)	J
24	222	Super	(VAR)	K
25	228	Super		L
26	234	Super		M
27	240	Super		N
28	246	Super		O
29	252	Super		P
30	258	Super		Q
31	264	Super		R
32	270	Super		S
33	276	Super		T
34	282	Super		U
35	288	Super		V
36	294	Super		W
37	300	Hyper		AA, W+1

38	306	Hyper	BB, W+2
39	312	Hyper	CC, W+3
40	318	Hyper	DD, W+4
41	324	Hyper	EE, W+5
42	330	Hyper	FF, W+6
43	336	Hyper	GG, W+7
44	342	Hyper	HH, W+8
45	348	Hyper	II, W+9
46	354	Hyper	JJ, W+10
47	360	Hyper	KK, W+11
48	366	Hyper	LL, W+12
49	372	Hyper	MM, W+13
50	378	Hyper	NN, W+14
51	384	Hyper	OO, W+15
52	390	Hyper	PP, W+16
53	396	Hyper	QQ, W+17
54	402	Hyper	RR, W+18, C62
55	408	Hyper	SS, W+19, C63
56	414	Hyper	TT, W+20, C64
57	420	Hyper (HAM)	UU, W+21, C65
58	426	Hyper (HAM)	VV, W+22, C66
59	432	Hyper (HAM)	WW, W+23, C67
60	438	Hyper (HAM)	AAA, W+24, C68
61	444	Hyper (HAM)	BBB, W+25, C69
62	450	Hyper (HAM)	CCC, W+26, C70
63	456	Hyper	DDD, W+27, C71
64	462	Hyper	EEE, W+28
65	468	Ultra	U14, FFF, W+29
66	474	Ultra	U15, GGG, W+30
67	480	Ultra	U16, HHH, W+31
68	486	Ultra	U17, III, W+32
69	492	Ultra	U18, JJJ, W+33
70	498	Ultra	U19, KKK, W+34
71	504	Ultra	U20, LLL, W+35
72	510	Ultra	U21, MMM, W+36
73	516	Ultra	U22, NNN, W+37
74	522	Ultra	U23, OOO, W+38
75	528	Ultra	U24, PPP, W+39
76	534	Ultra	U25, QQQ, W+40
77	540	Ultra	U26, RRR, W+41
78	546	Ultra	U27, SSS, W+42
79	552	Ultra	U28, TTT, W+43
80	558	Ultra	U29, UUU, W+44
81	564	Ultra	U30, VVV, W+45
82	570	Ultra	U31, WWW, W+46
83	576	Ultra	U32, AAAA, W+47
84	582	Ultra	U33, BBBB, W+48
85	588	Ultra	U34, CCCC, W+49
86	594	Ultra	U35, DDDD, W+50
87	600	Ultra	U36, EEEE, W+51
88	606	Ultra (RA)	U37, FFFF, W+52
89	612	Ultra	U38, GGGG, W+53
90	618	Ultra	U39, HHHH, W+54
91	624	Ultra	U40, IIII, W+55

92	630	Ultra		U41, JJJJ, W+56
93	636	Ultra		U42, KKKK, W+57
94	642	Ultra		U43, LLLL, W+58
95	90	Low	(FM)	A-5, C57, J57
96	96	Low	(FM)	A-4, C58, J58
97	102	Low	(FM)	A-3, C59, J59
98	108	Low		A-2, C60, J60, G60
99	114	Low		A-1, C61, J61, G61
100	648	Ultra		U44, MMMM, W+59
101	654	Ultra		U45, NNNN, W+60
102	660	Ultra		U46, OOOO, W+61
103	666	Ultra		U47, PPPP, W+62
104	672	Ultra		U48, QQQQ, W+63
105	678	Ultra		U49, RRRR, W+64
106	684	Ultra		U50, SSSS, W+65
107	690	Ultra		U51, TTTT, W+66
108	696	Ultra		U52, UUUU, W+67
109	702	Ultra		U53, VVVV, W+68
110	708	Ultra		U54, WWWW, W+69
111	714	Ultra		U55, AAAAA, W+70
112	720	Ultra		U56, BBBBB, W+71
113	726	Ultra		U57, CCCCC, W+72
114	732	Ultra		U58, DDDDD, W+73
115	738	Ultra		U59, EEEEE, W+74
116	744	Ultra		U60, FFFFF, W+75
117	750	Ultra		U61, GGGGG, W+76
118	756	Ultra		U62, HHHHH, W+77
119	762	Ultra		U63, IIIII, W+78
120	768	Ultra		U64, JJJJJ, W+79
121	774	Ultra		U65, KKKKK, W+80
122	780	Ultra		U66, LLLLL, W+81
123	786	Ultra		U67, MMMMM, W+82
124	792	Ultra		U68, NNNNN, W+83
125	798	Ultra		U69, OOOOO, W+84

Notes on cable and broadcast frequencies

(The following is from: (kruskal@watson.ibm.com (Vincent Kruskal).)

RF band: To get the band, subtract 1.25 from picture carrier (low end) and add 4.75 (high end).

Color subcarrier: Add 3.58... to picture carrier.

Sound carrier: Add 4.5 to picture carrier.

HRC: Harmonically Related Carrier. Makes both second- and third-order beats invisible by making them fall directly on the picture carrier of other channels. That is, multiplying the picture carrier by two or three will yield exactly another picture carrier.

IRC: Incrementally Related Carrier, add 1.25 to HRC frequency. A General Instruments (Jerrold) catalog said that IRC makes third-order (more important than second-order) beats invisible by making them fall directly on the picture carrier of other channels. But it is not true that multiplying an IRC picture carrier by two or three yields another IRC picture carrier. This contradiction has not been resolved. The reason third-order harmonics are more important is that oscillators and amplifiers tend to generate odd-order harmonics far more than even-order ones.

Broadcast frequency: Add 1.25 to HRC frequency except for channels 5 and 6. For them, subtract 0.75. But these are just nominal frequencies. The FCC actually has three channel designations for each number as in 5, 5- and 5+. The minus channels are 10 kHz below the nominal value and the plus channels are 10 kHz above. For example:

How did the (vertical) frame rate get chosen

Some people think that TVs are synchronized to the local power line since the vertical scan rate is around 60 Hz (or 50 Hz). This is not correct.

No TV (at least once the broadcast standards were defined - some experimental schemes did) ever used the power line for synchronization. However, older TVs had line frequency power transformers (no SMPSs) whose stray magnetic fields could affect the CRT deflection slightly. So it made sense (well, this is one justification at least) to make the vertical scan rate (field rate) equal to the power line frequency. Otherwise, there would be a jiggle or wiggle in the picture due to the stray magnetic field affecting the deflection of the beam inside the CRT. Since it was thought at the time (and for other reasons as well like cost) that 60 Hz was adequate to produce an acceptable amount of flicker, this all fit together nicely.

In the good old days before color TV, the frame/field rate was exactly 30/60 Hz (or 25/50) Hz. With color, it had to be changed slightly (see the section: Why is the NTSC color subcarrier such a weird frequency?) but since TVs no longer use line power transformers, there would not even be a slow position shift (period of several seconds) due to this so it didn't matter.

Why is the NTSC color subcarrier such a weird frequency?

(The following is from Bob Myers (myers@fc.hp.com).)

Actually, if we wanted to define the rates to the Nth degree, the important starting point is the field rate. The NTSC color frame rate was defined as (60 * 1000/1001) Hz, which is a bit more than 59.94 Hz. From this rate, all the others in the system are defined. The line rate is 262.5 times this, and the color subcarrier is defined as 455/2 times the line rate. This is often given as simply 3.579545 MHz, but the the color subcarrier was actually derived from the line/field rates rather than the other way around.

The whole thing was done so as to avoid (or at least minimize) interaction between the luminance, chrominance, and audio subcomponents in the standard color signal. This could have been achieved by moving either the audio subcarrier or adjusting the line and frame rates as described above. Unfortunately, the latter route was chosen, leaving us with this very strange looking set of rates.

The precise color burst frequency winds up being 3.579545.4545... under this definition, but giving it to the nearest Hz is within the tolerances of the system.

What is the maximal allowed deviation of the horizontal frequency?

(The following is from: Peter Bennett VE7CEI (bennett@triumf.ca))

In Canada and the US (525 line, 60 HZ, NTSC), the horizontal frequency is 15,734.264 Hz. The colour subcarrier is 455/2 times the horizontal frequency which should come to 3.579545 MHz. I believe the tolerance on the subcarrier frequency is +/- 10 Hz.

Informal comparison of TV standards

Q: I heard that TV in certain part of Europe has more quality in Europe then here in North America. I'd like to know the differences between the two systems. Is that why we cant use video tapes from there?

(Responses from: Mark Zenier (mzenier@netcom.com or mzenier@eskimo.com))

The first difference is that a lot of the world runs on 50 Hz power as opposed to North America's 60 Hz power. In the olden days, before active power supply regulators got cheap, it was decided that the vertical scan rate match the power supply frequency, so that ripple in the power supply wouldn't produce obnoxious visual effects.

So the PAL/SECAM signals have 50 vertical scans per second.

I don't know the exact reasoning, but the horizontal scan rate is close to the same. 15750 (now 15734) for 60 Hz, and 15625 for 50 Hz systems. My guess is the tradeoff between cost (50 years or so ago) and audibility for a large portion of the population.

So 50 Hz systems have more lines - 625 vs. 525 lines for 60 Hz systems.

The second difference is that European TV channels are wider. 7 or 8 MHz compared to the North American 6 MHz. Video bandwidth is limited to 4.2 MHz in a 6 MHz channel, but can be as much as 6 MHz in some of the 50 Hz systems. (Note: Systems is plural. There are many different European systems with incompatible color and sound transmission methods.)

As for the quality, if you move a little farther away, so that a pixel on each system subtends the same angle, NTSC doesn't have a poorer picture, just a smaller one.

PAL-plus

> "I wonder if you could tell me about PAL-Plus. The last time I was in Germany was in '84 so I've been out of touch with them."

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

Oh boy, here goes another long story:

PAL-plus is an attempt to extend the life-cycle of terrestrial PAL transmissions by including compatible wide-screen (16:9) transmissions. It is an advanced variant of the letterbox format, this means that when you receive a PAL-plus widescreen program on an older 4:3 receiver you will see black bars top and bottom. It was originally developed in Germany (university of Dortmund in cooperation with German terrestrial broadcasters and some setmakers). Later a large consortium of European and Japanese setmakers took over and finished the job. Strangely, the German broadcasters seem to use PAL-plus only very rarely.

The PAL-plus standard comprises three extensions to the PAL-standard:

1. Vertical helper. In order to compensate for the fact that 1/4 of the video lines are not used, which would deteriorate vertical resolution for the widescreen viewer, the missing vertical information has been coded into the black lines in a manner as to be nearly invisible on a 4:3 receiver (you see some dark blue). The 16:9 PAL-plus receiver combines 432 visible lines plus 144 helper lines into 576 new visible lines.

2. Colour-plus. The PAL colour carrier is modulated in a slightly different way (making use of correlation

between 2 fields) in order to give a cleaner Y/C separation in the PAL-plus receiver.

3. Signaling bits from which the receiver can conclude whether the transmission is 4:3/16:9/PAL-plus and adapt the display format accordingly. The bandwidth of these bits is low enough to survive recording on a VHS recorder.

In order to enable a poor-man's PAL-plus receiver, the standard permits using the mark "PAL-plus" if at least the vertical helper reconstruction is included. Colour-plus is optional, so you will find sets on the market with only half of the PAL-plus extension.

PAL-plus may also be combined with teletext, ghost cancellation reference, digital Nicam stereo, VPS, PDC and what-you-have more. Theoretically it can be broadcast over a satellite channel too, but it was not designed for that and some aspects of a satellite channel do indeed give interesting technical problems.

There are also sets marketed as "PAL-plus compatible". These are mostly widescreen sets without any PAL-plus processing at all, but they allow switching of the display format between 4:3 and 16:9. They may well do that automatically, based on the signaling bits.

There are 2 methods for displaying a 4:3 letterboxed signal on a 16:9 display, without using the PAL-plus helper lines:

1. Increase of the vertical deflection amplitude to display only the centre 432 lines.

2. Vertical interpolation without using the helper, to convert 432 lines into 576 lines and display on a 576 lines display.

Both modes may be called "movie expand". Only when you really convert to full-resolution widescreen will it be called "widescreen".

And there are 4 methods for displaying a regular 4:3 signal on a 16:9 display (regular PAL, has nothing to do with PAL-plus):

1. Decrease of the horizontal deflection amplitude, this gives black bars left and right.

2. Horizontal interpolation, to convert N pixels to 3/4*N pixels. Both modes may be called "4:3" or "normal".

3. Non-linear horizontal deflection waveform, called "Panorama mode" by JVC, works by increasing the S-capacitor value.

4. Non-linear horizontal interpolation, called "Superwide" by Philips, works with an advanced sample-rate converter.

With both modes, the left and right edges of the picture will be stretched to fill the left and right bars, but the aspect ratio of the centre part of the picture will hardly be affected.

Interesting, huh?

More information about watching NTSC video on PAL systems

(From: Aaron Smart (spectrum_kid@hotmail.com).)

Most VCRs of remote quality sold in the British Isles (UK & Ireland) and probably other PAL regions (and definitely in the Middle East) in the past few years say something along the lines of "NTSC playback on PAL TV". It's usually automatic (it often takes the VCR about a second to adjust to NTSC speed), but some older VCRs have a switch. They don't usually go into much detail about how it's done in the manuals, but I'm pretty sure they usually just convert the signal to NTSC 4.43. Many decent TVs made in the last decade or so can handle this well enough, but some (most noted are Philips sets) will only display it in a kind of 'meshed' black and white. However, use of an RGB connection (e.g. SCART) removes this problem.

All DVD players sold in PAL regions (I think) are equipped to play NTSC video (too bad that most of them only play Region 2 discs, which means the only NTSC discs they can play are Japanese or region-free titles). I don't know exactly how every player works of course, but with ones I have used, they either just play NTSC discs in NTSC 4.43 or have the option to do that or play them in 'PAL' which I assume is PAL 4.43 at 60Hz which seems to be the same, except it won't turn out in blank and white with a composite connection as it does on some sets.

Also, certain newer videogame consoles (Sega Dreamcast and Nintendo Gamecube mostly) have many games that are allowed to be played in either 60 or 50Hz modes (since most games originate from NTSC regions, and 50Hz versions are usually slowed down and contain sometimes MASSIVE 'letterbox' borders). I don't know about other consoles, but the Dreamcast displayed the 60Hz video modes in PAL.

Panasonic TV manuals call this system "PAL 60/525", and I've heard it called "PAL 60" before, so it must be standardised to some extent.

I've tried a few PAL TVs with displaying 60Hz (PAL or NTSC), and here's some vague results of what happened: (O = yes, X = No. 'M' under NTSC only means black and white with composite or RF connection - not tested with RGB. Sorry I don't know the model numbers for all the tested sets. All models are Irish models unless stated)

TV Make/Model (if known)	PAL 60	NTSC 4.43
Panasonic TX-21S4TL (1998)	O RGB only	
Panasonic TC-14JR1L (2000)	O	?
Hitachi C1405R (UK, 1994)	O	?
Philips 21"(mid 90s)	?	M
BPL 14" (early 90s)	X	X
Panasonic 21" (early 90s?)	O	?
Mitsubishi 21" (late 80s?)	X	X
Ferguson 14" (late 90s)	O	O
Akura 14"(Daewoo tube, early 90s)	X	X
Salora 21" (circa 1990)	O	?
Philips 28" (circa 2000)	O*	?

* The colour was screwy at the top of the screen and was kind of unstable.

I've noticed that on a lot of sets that 60Hz pictures go off the screen a bit (vertically), and the OSD is stretched with it.

As for multi-region TV sets, most sets sold in the British Isles only receive PAL I RF transmissions, but I've seen some cheaper TVs sold in Ireland with PAL G as well. However, I have seen a widescreen Philips set (circa 2000, 32"?) that actually had a country selection menu - and it was definitely changing to the different PAL systems and to SECAM when I put it on France. I personally haven't seen other TVs like this, but there probably are others.

In the Middle East, though, it's a totally different story. In Saudi Arabia, anyway, all TV sets and VCRs had at least PAL (dunno which one) and MESECAM support. Most VHS VCRs had NTSC 4.43 playback, you could get multi-region TVs which had support for PAL, SECAM, NTSC 4.43 and NTSC 3.58. I had a multi-region Daewoo TV which had 4 LEDs below the screen to tell you which system you were watching - how nice!

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8. Back to TV Repair FAQ Table of Contents.

Service Information

Advanced TV troubleshooting

If the solutions to your problems have not been covered in this document, you still have some options other than surrendering your TV to the local service center or the dumpster.

Also see the related document: Troubleshooting and Repair of Consumer Electronic Equipment.

Manufacturer's service literature: Service manuals are available for a great deal of consumer electronics. Once you have exhausted the obvious possibilities, the cost may be well worth it. Depending on the type of equipment, these can range in price from $10-50 or more. Some are more useful than others. However, not all include the schematics so if you are hoping to repair an electronic problem try to check before buying.

Inside cover of the equipment: TVs often have some kind of circuit diagram pasted inside the back cover. In the old days, this was a complete schematic. Now, if one exists at all, it just shows part numbers and location for key components - still very useful. Some TVs - as late as 10 years ago, maybe even now - included a complete schematic with the product information and owner's manual. I have a 1984 Mitsubishi which has this. It is, however, the exception rather than the rule anymore.

Sams' Photofacts (http://www.samswebsite.com/): These have been published for over 45 years (I don't know for how long but I have Sams' for a 1949 portable (3 inch) Pilot TV - about as portable as an office typewriter (if you remember what one of those was like) and are generally the best most consistent source of service info for TVs (nearly every model that has ever been sold), radios, some VCRs and other consumer electronics. For TV servicing, they are indispensable.

There are some Computerfacts but the number of these is very limited. The VCRfacts are also somewhat limited and the newer ones tend to have strictly (obvious) mechanical information.

Even if they don't list your model, they may have a folder for one using the same chassis so search by chassis number as well. Even if this doesn't help, there still may be a folder for models that are similar enough to be of value (though you really have to be in the library to be able to determine this by looking at the circuit diagrams or photos) so check out folders for other model numbers that are close to the one you really want.

You can search this site to determine if they have a folder for your model. Service info (EFacts) for most models manufactured after 1992 is available in electronic form (currently) about $11. These are similar to the print PhotoFacts but may be ordered on-line and will arrive via email within 1 business day. The hard copy versions are also available from major electronics distributors but may be more expensive than the EFacts. However, I don't know how quickly the Photofact is created after a new model is introduced. So, if your set is just out of warranty, it's possible that none is available.

Sams' Photofacts are also often available (for photocopy costs) from your local large public library which may subscribe to the complete series.

One advantage of the Sams' info is that it is compiled in a very consistent format so that once you are familiar with one model TV, it is easy to transfer that knowledge to any other. They provide waveforms at key locations and DC voltage measurements almost everywhere. Additional info such as IC pin to ground and coil resistances are often provided as well. The manufacturer's service manuals are generally not nearly as complete.

Note that I have no connection with Sams Technical Publishing (formerly Howard Sams).

Elsewhere around the world, libraries may also have Sams' or other service information:

(From: Chris Laudan (chris.laudan@zetnet.co.uk).)

This is true here in UK too, though not Sams photofacts, just schematics issued by manufacturers. Go to the reference library and ask for Video and TV service manuals, most main libraries carry a good selection.

(From: Michael Covington (mcovingt@ai.uga.edu).)

Concerning Sams' Photofacts, here is a bit of history that seems to be very little known:

The name "Sams" is not an acronym, nor is it "Sam." It's the last name of Howard W. Sams, who founded the Howard Sams publishing company (now Sams Technical Publishing). Accordingly, they are "Sams' Photofacts" rather than any of various other spellings that we often see on the net.

And they're a great product. Apparently "Howard W. Sams & Co., Indianapolis, Indiana" is a sufficient address to reach them. So is 1-800-GAT-SAMS.

Service manuals for really old TVs

Try your large public library for Sams' photofacts. I found a 3" TV of from around 1948 at a yard sale. There was no problem finding a complete set of Sams' service information including full schematics, parts list (of course, finding suitable parts like tubes in the 1990s may be a bit more difficult than when this set was new!), troubleshooting procedures, etc. Someday, I may even get around to fixing it. All the paper capacitors are leaky (for starters).

BTW, the case for this 3" TV is about 18" x 10" x 15" and it includes a handy option: a 6 inch semispherical water filled magnifier. The CRT is an oscilloscope tube. Not your modern portable!

How to locate service info when all the little stickers have fallen off

On newer TVs, the chassis number may be printed on the mainboard.

(From: "Clifton T. Sharp, Jr."

Somewhere on the chassis there may be an inked chassis number; an example for one color set was TS-914. A chassis number will at least get you some service information, and should be all you need unless you plan to try to get cabinet parts for it (chortle guffaw titter). Number should be findable on the back of the chassis (i.e. where the pots are mounted through the chassis).

Techical assistance help numbers

Here are contact numbers for some TV manufacturers:

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Curtis Mathis                  1-800-949-4999  Steve Long
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Mitsubishi                 1-800-552-8324

NAP                        1-900-896-8324

Zenith                     1-800-874-1930  ext 1065 or 1066
                           1-800-856-0981
                           1-312-745-5154

Sanyo                      1-800-877-5032

Panasonic                  1-201-348-7957
                           1-201-348-7958
                           1-201-392-6961
                           1-201-392-6992
```

Web resources

Many manufacturers are now providing extensive information via the World Wide Web. The answer to you question may be a mouse click away. Perform a net search or just try to guess the manufacturer's home page address. The most obvious is often correct. It will usually be of the form "http://www.xxx.com" where xxx is the manufacturers' name, abbreviation, or acronym. For example, Hewlett Packard is hp, Sun Microsystems is sun, Motorola is, you guessed it, motorola. Electronic parts manufacturers often have detailed datasheets for their product offerings.

Radio Shack (Tandy) has a nice web resource and fax-back service. This is mostly for their equipment but some of it applies to other brands and there are diagrams which may be useful for other manufacturers' VCRs, TVs, CD players, camcorders, remote controls, and other devices:

- Hitachi Service Manauls (Requires registration but should be free)
- Radio Shack Product Support

In addition to Tandy products, there is at least one Sony model. Furthermore, since Tandy does not manufacture its own TV sets - they are other brands with Realistic, Optimus, or other Radio Shack logos - your model may actually be covered. It may just take a little searching to find it.

Parts information

I have found one of the most useful single sources for general information on semiconductors to be the ECG Semiconductors Master Replacement Guide, about $6 from your local Philips distributor. STK, NTE, and others have similar manuals. The ECG manual will enable you to look up U.S., foreign, and manufacturer 'house' numbers and identify device type, pinout, and other information. Note that I am not necessarily recommending using ECG (or other generic) replacements if the original replacements are (1) readily available and (2) reasonably priced. However, the cross reference can save countless hours searching through databooks or contacting the manufacturers. Even if you have a wall of databooks, this source is invaluable. A couple of caveats: (1) ECG crosses have been known to be incorrect - the specifications of the ECG replacement part were inferior to the original. (2) Don't assume that the specifications provided for the ECG part are identical to the original - they may be better in some ways. Thus, using the ECG to determine the specifications of the parts in your junk bin can be risky.

Other cross reference guides are available from the parts source listed in the section: Repair parts sources.

Suggested references

Some good sources for technology information:

- Basic Theory of Colour Television
  Philips

  Ask for this book from your local technical bookstore.

- Basic Television & Video Systems, 5th ed.
  Bernard Grob
  McGraw Hill

For a technical reference on the various flavours of NTSC, PAL, and SECAM used around the world, I suggest:

- Recommendations and reports of the CCIR
  volume XI, Part 1

  Available from Omnicom, 115 Park St. S.E. Vienna, VA 22180 (703)281-1135

The following book is for PAL TV-standard specifications:

- Colour Television (With particular refererence to PAL)
  G.N. Patchett
  Norman Price (Publishers) Ltd.

  It has three heavyweight chapters describing NTSC/PAL/SECAM and has a decent amount of math content.

The following is more directed toward digital video but may still contain some information useful for understanding analog TV technology:

- Video demystified: A handbook for the digital engineer
  Keith Jack
  Brooktree Corporation, 1993
  ISBN 1-878707-09-4

There don't seem to be nearly as many TV repair books for modern solid state TVs as I recall for old tube sets. Here are a couple which you may find (or its predecessor) at your local public library (621.384 if you library is numbered that way) or a technical book store. MCM Electronics has the Davidson as well.

- Troubleshooting and Repairing Solid State TVs
  Homer L. Davidson
  2nd Edition, 1992 (The 1st edition is also useful)
  TAB Books, Inc.
  Blue Ridge Summit, PA 17214

- Lenk's Television Handbook: Troubleshooting and Repair
  John D. Lenk
  McGraw Hill, 1994
  ISBN 0-07-037517-8

  (Recommended by: Larry Sabo (sabo@storm.ca).)

- Color and Black & White Television Theory and Servicing
  Alvin A. Liff and Sam Wilson.

  (Recommended by: Michael Caplan (cy173@freenet.carleton.ca) who has the following comments.)

  There are three editions, the first going back to 1979. I've used both the second (1985) and third (1993) editions (ISBN 0-13-150012-0). The latter incorporates more digital circuitry and virtually no tube systems. The second has somewhat more tube-based information, but still focuses on semiconductor circuits. The first edition, I understand, had far more tube system detail.

- Basic Television Principles & Servicing
  Bernard Grob

- Complete TV Servicing Handbook
  Walter H. Buchsbaum
  Prentice-Hall, Inc., 1985

The following is a recent publication:

- Troubleshooting and Repair Guide to TV
  PROMPT Publications (Howard W. Sams), 1-800-428-7267
  ISBN #0-7906-1077-9, $29.95.

  From the advertising blurb for this book:

  "This book, 300 pages of detailed photos, schematic diagrams, and text explains in easy to understand language how TV works, how to troubleshoot problems, and advice on how to fix them. The Howard W. Sams Troubleshooting and Repair Guide to TV is the perfect reference book for technicians, instructional guide for students and hobbyists."

FCC ID Numbers of TVs

Only a few manufacturers actually produce the vast majority of TVs. For example, Radio Shack, Magnavox, and Emerson do not make their own TVs (I can tell you are not really surprised!).

How do you determine the actual manufacturer? For most types of consumer electronic equipment, there is something called an 'FCC ID' or 'FCC number'. Any type of equipment that may produce RF interference or be affected by this is required to be registered with the FCC. This number can be used to identify the actual manufacturer of the equipment.

A cross reference and other links can be found at:

- S.E.R FCC ID FAQ

Interchangeability of components

The question often arises: If I cannot obtain an exact replacement or if I have a monitor, TV, or other equipment carcass gathering dust, can I substitute a part that is not a precise match? Sometimes, this is simply desired to confirm a diagnosis and avoid the risk of ordering an expensive replacement and/or having to wait until it arrives.

For safety related items, the answer is generally NO - an exact replacement part is needed to maintain the specifications within acceptable limits with respect to line isolation, X-ray protection and to minimize fire hazards. Typical parts of this type include flameproof resistors, some types of capacitors, and specific parts dealing with CRT high voltage regulation. However, during testing, it is usually acceptable to substitute electrically equivalent parts on a temporary basis. For example, an ordinary 1 ohm resistor can be substituted for an open 1 ohm flameproof resistor to determine if there are other problems in the horizontal deflection circuits before placing an order - as long as you don't get lazy and neglect to install the proper type before buttoning up the monitor or TV.

For other components, whether a not quite identical substitute will work reliably or at all depends on many factors. Some deflection circuits are so carefully matched to a specific horizontal output transistor that no substitute will be reliable.

Here are some guidelines:

1. Fuses - exact same current rating and at least equal voltage rating. I have often soldered a normal 3AG size fuse onto a smaller blown 20 mm long fuse as a substitute.

2. Resistors, capacitors, inductors, diodes, switches, potentiometers, LEDs, and other common parts - except for those specifically marked as safety-critical - substitution as long as the replacement part fits and specifications should be fine. It is best to use the same type - metal film resistor, for example. But for testing, even this is not a hard and fast rule and a carbon resistor should work just fine.

3. Rectifiers - many are of these are high efficiency and/or fast recovery types. Replacements should have at equal or better PRV, Imax, and Tr specifications.

4. Posistors - many of these are similar. Unfortunately, the markings on the devices are generally pretty useless in determining their ratings. Note, however, that the prices for replacement posistors may be quite reasonable from the original manufacturer so it may not make sense to take the risk of using an unknown part.

   (From: Stefan Huebner (Stefan.Huebner@rookie.antar.com).)

   In most cases you can use a standard 3-terminal-device, the resistance of the temperature dependent resistors in it are nearly identical. Here is a list of possible replacement devices:

   380000-01, 24340521, 2199-603-1201, 163-024A, 163-035A, CO2200-N66, C8ROH, QX265P05503, 32112026, 4822-A1-11240148, 02199-003-120, 15-08-001A, 5391560067, F400001.

5. Transistors and thyristors (except HOTs and SMPS choppers) - substitutes will generally work as long as their specifications meet or exceed those of the original. For testing, it is usually OK to use types that do not quite meet all of these as long as the breakdown voltage and maximum current specifications are not exceeded. However, performance may not be quite as good. For power types, make sure to use a heatsink.

   Also see the section: Replacement power transistors while testing.

6. Horizontal output (or SMPS) transistors - exact replacement is generally best but except for very high performance monitors, generic HOTs that have specifications that are at least as good will work in many cases. Make sure the replacement transistor has an internal damper diode if the original had one. For testing with a series light bulb, even a transistor that doesn't quite meet specifications should work well enough (and not blow up) to enable you to determine what else may be faulty. The most critical parameters are Vceo/Vcbo, IC, and Hfe which should all be at least equal to the original transistor. I have often used by favorite BU208D as a temporary substitute for other HOTs and SMPS (chopper) transistors. Make sure you use a heatsink and thermal grease in any case - even if you have to hang the assembly by a cable tie to make it fit.

For that matter, you can usually substitute a similar HOT with the D suffix instead of the A (or no) suffix. These have a built-in damper diode and two in parallel (the external one) will not hurt (or remove it). Naturally, the reverse is not true since a damper diode IS essential and the HOT will probably not last beyond the click of the power relay without one!

On SVGA monitors, there will likely be additional circuitry between the HOT and the damper so this trick doesn't work for them.

However, using a HOT with much better specs may actually result in early failure due to excessive heating from insufficient and/or suboptimal base drive. See the document: "TV and Monitor Deflections Systems" for more info.

For more information, see the document: TV and Monitor Deflection Systems.

7. Deflection yokes - in the old days, particularly for B/W TVs, all of these were quite similar. It was common to just swap with one that fit physically and at most need to adjust or change a width coil. With color TVs and high performance multiscan monitors, this is no longer the case. Sometimes it will work but other times the power supply won't even be able to come up as a result of the impedance mismatch due to different coils and pole piece configurations. In addition, there may be other geometry correction coils associated with the yoke that could differ substantially.

   However, if you are really determined, see the section: Swapping of deflection yokes.

   Also see the section: Replacement power transistors while testing.

8. Standby power transformer - this most likely only has a single secondary so locating a standard UL approved (for safety reasons) power transformer with the same output voltage should not be difficult.

   Check the service manual or the Sams' Photofact for the set to determine the required output voltage and if a centertap is needed. Current should be quite low.

9. CRTs - aside from the issues of physical size and mounting, many factors need to be considered. These include deflection angle, neck diameter, base pinout, focus and screen voltage requirements, purity and convergence magnets, etc. Color CRT replacement is rarely worth the effort in any case but trying to substitute a different CRT is asking for frustration. For monochrome CRTs, there is less variation and this may be worth a try.

10. The following are usually custom parts and substitution of something from your junk box is unlikely to be successful even for testing: flyback (LOPT) and SMPS transformers, interstage coils or transformers, microcontrollers, and other custom programmed chips.

Horizontal output transistor pinouts

You will nearly always find one of two types of horizontal output transistors in TVs and monitors:

9. Metal can - TO3 package:

```
          _
        / O \         View from bottom (pin side)
      / o   o \
```

```
        (  B   E  )      B = Base, E = Emitter, C = Collector
         \       /
           \ O / C       The metal case is the Collector.
```

10. Plastic tab - TO3Pn (n = several suffixes) package:

```
           _____
          /     \
         |   O   |      View from front (label side)
         |       |
         |       |      B = Base, E = Emitter, C = Collector
         |_______|
           | | |        If there is an exposed metal tab, this is the
           | | |         Collector as well.
           B C E
```

Some other transistor types use the same pinout (TO66 for metal can, TO218 and TO220 for plastic tab) but not all. However, for horizontal output transistors, these pinouts shouuld be valid.

Note that those with a built in damper diode may read around 50 ohms between B and E (near 0 on the diode test range) - this is normal as long as the resistance is not really low like under 10 ohms.

How do you locate the HOT

Well, it is usually the LARGEST transistor in the set near the LARGEST transformer in the set (flyback - the thing with the FAT red wire connecting to the picture tube) on the LARGEST heat sink in the set.

Got that? :-)

Or, in the good old days....

(From: Don Wall (d.wall@nunet.neu.edu).)

Sure, it's usually the largest tube in the set, has a top cap, runs very hot, and is often a 6BQ6G or some such. (tongue firmly in cheek) Actually, back in the days of yore, the Horizontal Output Tube was frequently referred to as the HOT; guess some things don't change!

Replacement power transistors while testing

During testing of horizontal deflection circuits or switchmode power supplies, particularly where the original failure resulted in the death of the HOT or chopper, overstress on replacement transistors is always a possibility if all defective components have not be identified.

Therefore, using a part with better specifications may save you in the long run by reducing the number of expensive blown parts. Once all other problems have been located and repaired, the proper part can be installed.

However, this is not always going to work. In a TV and especially a high performance monitor, the HOT may be closely matched to the drive and output components of the deflection circuits. Putting in one with higher Vce, I, or P specifications may result in overheating and failure due to lower Hfe.

Where possible, a series load like a light bulb can be used limit the maximum current to the device and will allow you to power the equipment while checking for other faults. Some designs, unfortunately, will not start up under these conditions. In such cases, substituting a 'better' device may be the best choice for testing.

(From: Glenn Allen (glenn@manawatu.gen.nz).)

I been repairing SMPS of all types but when I started on those using MOSFETs I was blowning a few of them when replaced because something else was faulty.

Ever since I have been using a BUZ355 on a heat sink I haven't blown it. It is rated at 800 V, 6 A, and 220 W. it is a TO218 case bigger than a T0220. It seems the higher ratings allows you to do repair where as a something like a 2SK1117 or MTP6N60 will just blow.

Testing of replacement HOTs

The following is useful both to confirm that a substitute replacement HOT is suitable and that no other circuit problems are still present. However, single scan line anomalies (particularly when changing channels and/or where reception is poor with a TV or when switching scan rates and/or when no or incorrect sync is present with a monitor) resulting in excessive voltage across the HOT and instant failure are still possible and will not result in an HOT running excessively hot.

(From: Raymond Carlsen (rrcc@u.washington.edu).)

After installing a replacement HOT in a TV set or monitor, I like to check the temperature for awhile to make sure the substitute is a good match and that there are no other problems such as a weak H drive signal. The input current is just not a good enough indicator. I have been using a WCF (well calibrated finger) for years. For me, the rule of thumb, quite literally, is: if you can not hold your finger on it, it's running too hot, and will probably fail prematurely. Touching the case of the transistor or heat sink is tricky....

Metal case transistors will be connected to the collector and have a healthy pulse (>1,200 V peak!) and even with plastic case tab transistors, the tab will be at this potential. It is best to do this only after the power is off and the B+ has discharged. In addition, the HOT may be hot enough to burn you.

A better method is the use of an indoor/outdoor thermometer. I bought one recently from Radio Shack for about $15 (63-1009). It has a plastic 'probe' on the end of a 10' cable as the outdoor sensor. With a large alligator clip, I just clamp the sensor to the heat sink near the transistor and set up the digital display near the TV set to monitor the temperature. The last TV I used it on was a 27" Sanyo that had a shorted H. output and an open B+ resistor. Replacement parts brought the set back to life and the flyback pulse looked OK, but the transistor was getting hot within 5 minutes... up to 130 degrees before I shut it down and started looking for the cause. I found a 1 uF 160 volt cap in the driver circuit that was open. After replacing the cap, I fired up the set again and monitored the heat sink as before. This time, the temperature slowly rose to about 115 degrees and stayed there. I ran the set all day and noticed little variation in the measurement. Test equipment doesn't have to cost a fortune.

Removing and replacing the deflection yoke

Should you need to remove the deflection yoke on a color CRT, some basic considerations are advised both to minimize the needed purity and convergence adjustments after replacement as well as to prevent an unfortunate accident.

The position and orientation of the yoke (including pitch and yaw) and magnet assembly (purity and static convergence rings, if used) are critical. Use paint or White-Out(tm) to put a stripe across all of the magnet rings so you will know their exact positions should they accidentally shift later. If there are rubber wedges between the yoke and the funnel of the tube, assure that they are secure. Tape them to be doubly sure as adhesive on old tape dries up with age and heat and becomes useless. This will avoid the need for unecessary dynamic convergence adjustments after reassembly.

The neck is the most fragile part of the CRT so do not apply any serious side-ways force and take care not to bend any of the pins when removing and replacing the CRT socket.

The yoke and purity/static convergence assemblies will be clamped and possibly glued as well. However, the adhesive will probably be easily accessible - big globs of stuff like hot melt glue and/or RTV silicone. Carefully free the adhesive from the glass neck of the CRT. Loosen the clamps and gently wiggle the magnets and yoke off the neck. They may appear stuck from age and heat but should yield with gently persuasion.

Once the yoke is replaced, some fine adjustments of the picture rotation, purity, and static and dynamic convergence may be needed but hopefully with your most excellent diagrams, these will be minimal.

Similar comments apply for monochrome CRTs but there are far fewer issues as the yoke is positioned firmly against the funnel of the CRT and rotation and centering are usually the only adjustments. However, there may be magnets located on swivels or glued to strategic locations on the CRT envelope to correct for geometric distortion.

Swapping of deflection yokes

This should work with identical TVs or monitors. Your mileage will vary if you are attempting a swap between monitors with similar specifications. Chances of success for monitors with widely different screen sizes or scan rate specifications is close to zero.

One indication of compatibility problems would be major differences in resistance readings for the corresponding yoke windings, CRT HV and other bias levels, etc.

Before you do the transplant, see the section: Swapping of deflection yokes for procedures and precautions to minimize problems in realignment.

Make a precise diagram of everything you do.

Keep the purity/static convergence magnet assembly with the original CRT if possible and install it in the same or as nearly the same position as possible when you replace it.

Once you are sure of the connections, power it up carefully - there is no assurance that your yokes are compatible. A yoke with a much lower resistance or inductance than the original may overstress components in the power supply.

You will then need to go through all the adjustments starting with purity and convergence.

Swapping of CRTs

Given the problems of just replacing a CRT with an identical new one, it isn't surprising that attempting to substitute a CRT which is not the same type will result in difficulties - to say the least. Obviously, the closer in size, scan rate (for monitors), and deflection angle, the more likely the chances of success. Where the alternative is to junk the TV or monitor, it may be worth a shot - and you may get lucky!

It may be best to transfer as much as possible with the CRT - yoke and purity and convergence magnets. The connectors to the yoke may need to be changed but this may be the least of your problems. Difference in yoke impedance and other characteristics may result in anything from incorrect size to a truly spectacular melt-down! The latter is much more likely with SVGA monitors compared to similar size/deflection angle TVs.

Where the neck size is the same, the yoke can be moved from one CRT to the other but you will have to do a complete purity and convergence set up and even then you may have uncorrectable convergence errors. See the section: Swapping of deflection yokes.

(From: J. G. Simpson (ccjgs@cse.bris.ac.uk).)

Monitors are generally designed by choosing a CRT, then the EHT, then designing a yoke to scan the CRT, then designing a driver circuit to drive the yoke.

In a CRT test lab it's common to have variable supplies for EHT and other voltages, a small selection of yokes, and variable amplitude drive circuits.

EHT affects scan sensitivity, brightness, spot size. You can't get high brightness and small spot size on a large monitor with 3 kV of EHT. Virtually every variable has some effect on convergence. Spot size is important, in as much as you want most of it on the phosphor and not the shadow mask.

Provided the neck size is the same you can swap tubes in yokes but don't expect it to work very well. Different tube manufacturers may use radically different gun structures. A given yoke and its driver may give underscan or overscan and it's pretty well certain that convergence will be way off.

The military spends a small fortune on trying to get the drop into the yoke and it flies with no adjustment or convergence CRT. For the rest of us swapping a CRT is a pain in the butt.

Decayed glue in electronic equipment

Larger components like electrolytic capacitors are often secured to the circuit board with some sort of adhesive. Originally, it is white and inert. However, with heat and age, some types decay to a brown, conductive and/or corrosive material which can cause all sorts of problems including the creation of high leakage paths or dead shorts and eating away at nearby wiring traces.

The bottom line: Most of the time, this stuff serves no essential purpose anyhow and should be removed. A non-corrosive RTV or hot-melt glue can be used in its place if structural support is needed.

Repair parts sources

For general electronic components like resistors and capacitors, most electronics distributors will have a sufficient variety at reasonable cost. Even Radio Shack can be considered in a pinch.

However, for consumer electronic equipment repairs, places like Digikey, Allied, and Newark do not have the a variety of Japanese semiconductors like ICs and transistors or any components like flyback transformers or degauss Posistors.

See the document: Major Service Parts Suppliers for some companies that I have used in the past and others that have been recommended.

For those hard-to-find or overpriced TV replacement boards, modules, or other parts, try:

- PTS Electronics Corporation

- Bloomington, Indiana (National Headquarters): 1-800-844-7871
- Arvada, Colorado: 1-800-331-3219
- Tustin, California: 1-800-380-2521

Email: pts@ptscorp.com
Web: http://www.ptscorp.com/

Also see the documents: Troubleshooting of Consumer Electronic Equipment and Electronics Mail Order List (this one is quite dated though) for additional parts sources.

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-- end V3.12 --

TV and Monitor CRT (Picture Tube) Information

Version 1.94

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

Acknowledgements

Special thanks to Bob Myers (myers@fc.hp.com) and Jeroen Stessen (Jeroen.Stessen@philips.com) for their contributions to this document through their newsgroup postings and private email.

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Introduction

Scope of This Document

This document contains a collection of information relating to CRT (picture tube) construction, characteristics, problems, maintenance, troubleshooting, and repair. This was originally from the TV and monitor repair guides of the Sci.Electronics.Repair FAQ but has been moved here due to its being of general interest.

Most new CRT related information originating on the sci.electronics.repair, comp.sys.ibm.pc.hardware.video, or other USENET newsgroups will be included here rather than in those other documents.

Related Documents

The following may be of interest and cover many relavent topics related to CRT based equipment:

- Safety Guidelines for High Voltage and/or Line Powered Equipment.
- Notes on the Troubleshooting and Repair of Computer and Video Monitors.
- Notes on the Troubleshooting and Repair of Television Sets.
- Performance Testing of Computer and Video Monitors.
- Notes on Approaches to using Fixed Frequency Monitors on PCs.
- Notes on Video Conversion.

Additional Information on CRTs

The PC Technology Guide has some information with nice diagrams on both CRT and flat panel displays. This site is well worth visiting to get an idea of the construction, operation, and problems for a variety of display technologies.

(From: David Moisan (dmoisan@shore.net).)

I've seen a few such pictures and I was fortunate enough to find a book on color CRTs that explained quite a few things:

> Color Television Picture Tubes
> Morell, Law, Ramberg, Harold
> ISBN 0-12-022151-0.

I'm not sure if its still in print but you might check out your local university library.)

If you are lucky enough to see "The Secret Life of Machines" on The Learning Channel (or was, last time I saw it), there's an episode on the secret life of the TV. It's excellent! The creator and presenter, Tim Hunkin, has a weird sense of humor but he's very well informed and quite gifted in the way he demonstrates difficult-to-explain concepts. In the opening scene, he showed off a TV that he sawed in half, showing the CRT construction very clearly. (He must have let the air into the tube, then used a diamond saw to cut it; that's the only way it could be done without glass everywhere!)

(Of course, he may not *actually* have cut a TV in half - manufacturers no doubt maintain props of this sort!)

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CRT Safety Issues

Electrical Safety

TVs and computer or video monitors are among the more dangerous of consumer electronic equipment when it comes to servicing. (Microwave ovens are probably the most hazardous due to high voltage at flesh frying and cardiac arresting high power.)

There are two areas which have particularly nasty electrical dangers: the non-isolated line power supply and the CRT high voltage.

Major parts of nearly all modern TVs and many computer monitors are directly connected to the AC line - there is no power transformer to provide the essential barrier for safety and to minimize the risk of equipment damage. In the majority of designs, the live parts of the TV or monitor are limited to the AC input and line filter, degauss circuit, bridge rectifier and main filter capacitor(s), low voltage (B+) regulator (if any), horizontal output transistor and primary side of the flyback (LOPT) transformer, and parts of the startup circuit and standby power supply. The flyback generates most of the other voltages used in the unit and provides an isolation barrier so that the signal circuits are not line connected and safer.

Since a bridge rectifier is generally used in the power supply, both directions of the polarized plug result in dangerous conditions and an isolation transformer really should be used - to protect you, your test equipment, and the TV, from serious damage. Some TVs do not have any isolation barrier whatsoever - the entire chassis is live. These are particularly nasty.

The high voltage to the CRT, while 200 times greater than the line input, is not nearly as dangerous for several reasons. First, it is present in a very limited area of the TV or monitor - from the output of the flyback to the CRT anode via the fat red wire and suction cup connector. If you don't need to remove the mainboard or replace the flyback or CRT, then leave it alone and it should not bite. Furthermore, while the shock from the HV can be quite painful due to the capacitance of the CRT envelope, it is not nearly as likely to be lethal since the current available from the line connected power supply is much greater.

Safe Discharging of Capacitors in TVs and Video Monitors

It is essential - for your safety and to prevent damage to the device under test as well as your test equipment - that large or high voltage capacitors be fully discharged before measurements are made, soldering is attempted, or the circuitry is touched in any way. Some of the large filter capacitors commonly found in line operated equipment store a potentially lethal charge.

This doesn't mean that every one of the 250 capacitors in your TV need to be discharged every time you power off and want to make a measurement. However, the large main filter capacitors and other capacitors in the power supplies should be checked and discharged if any significant voltage is found after powering off (or before any testing - some capacitors (like the high voltage of the CRT in a TV or video monitor) will retain a dangerous or at least painful charge for days or longer!)

The technique I recommend is to use a high wattage resistor of about 100 ohms/V of the working voltage of the capacitor. This will prevent the arc-welding associated with screwdriver discharge but will have a short enough time constant so that the capacitor will drop to a low voltage in at most a few seconds (dependent of course on the RC time constant and its original voltage).

Then check with a voltmeter to be double sure. Better yet, monitor while discharging (not needed for the CRT - discharge is nearly instantaneous even with multi-M ohm resistor).

Obviously, make sure that you are well insulated!

- For the main capacitors in a switching power supply which might be 100 uF at 350 V this would mean a

5K 10W resistor. RC=.5 second. 5RC=2.5 seconds. A lower wattage resistor can be used since the total energy in not that great. If you want to be more high tech, you can build the capacitor discharge circuit outlined in the companion document: Capacitor Testing, Safe Discharging, and Other Related Information. This provides a visible indication of remaining charge and polarity.

- For the CRT, use a high wattage (not for power but to hold off the high voltage which could jump across a tiny 1/4 watt job) resistor of a few M ohms discharged to the chassis ground connected to the outside of the CRT - NOT SIGNAL GROUND ON THE MAIN BOARD as you may damage sensitive circuitry. The time constant is very short - a ms or so. However, repeat a few times to be sure. (Using a shorting clip lead may not be a bad idea as well while working on the equipment - there have been too many stories of painful experiences from charge developing for whatever reasons ready to bite when the HV lead is reconnected.) Note that if you are touching the little board on the neck of the CRT, you may want to discharge the HV even if you are not disconnecting the fat red wire - the focus and screen (G2) voltages on that board are derived from the CRT HV.

  WARNING: Most common resistors - even 5 W jobs - are rated for only a few hundred volts and are not suitable for the 25kV or more found in modern TVs and monitors. Alternatives to a long string of regular resistors are a high voltage probe or a known good focus/screen divider network. However, note that the discharge time constant with these may be a few seconds. Also see the section: Additional Information on Discharging CRTs.

  If you are not going to be removing the CRT anode connection, replacing the flyback, or going near the components on the little board on the neck of the CRT, I would just stay away from the fat red wire and what it is connected to including the focus and screen wires. Repeatedly shoving a screwdriver under the anode cap risks scratching the CRT envelope which is something you really do not want to do.

Again, always double check with a reliable voltmeter!T

Reasons to use a resistor and not a screwdriver to discharge capacitors:

1. It will not destroy screwdrivers and capacitor terminals.

2. It will not damage the capacitor (due to the current pulse).

3. It will reduce your spouse's stress level in not having to hear those scary snaps and crackles.

Additional Information on Discharging CRTs

You may hear that it is only safe to discharge from the Ultor to the Dag. So, what the @#$% are they talking about? :-).

BTW, don't wash your CRTs even if the Maid complains about the filth until you have confirmed that your 'Dag isn't water soluble (maybe that's why it has 'aqua' in the name!). It may all come off! Wipe off the dirt and dust with a cloth (and stay away from the HV connector or make sure it is discharged first!).

(From: Asimov (mike.ross@juxta.mnet.pubnix.ten).)

'Dag' is short for Aquadag. It is a type of paint made of a graphite pigment which is conductive. It is painted onto the inside and outside of picture tubes to form the 2 plates of a high voltage filter capacitor using the glass in between as dielectric. This capacitor is between .005uF and .01uF in value. This seems like very little capacity but it can store a substantial charge with 25,000 volts applied.

The outside "dag" is always connected to the circuit chassis ground via a series of springs, clips, and wires around the picture tube. The high voltage or "Ultor" terminal must be discharged to chassis ground before working on the circuit especially with older TV's which didn't use a voltage divider to derive the focus potential or newer TV's with a defective open divider.

Warning about disconnecting CRT neck board

Some manufacturers warn against powering a TV or monitor CRT without the CRT neck board connected. Apparently, without something - anything - to drain the charge resulting from the current flow due to residual gas ions inside the CRT, the shortest path may be through the glass neck of the tube to the yoke or from the pins outside the CRT to whatever is nearby. There aren't many ions in a modern CRT but I suppose a few here, a few there, and eventually they add up to enough to cause a major disaster at least on some CRTs.

This is probably not a problem on small CRTs but for large ones with high high voltages and high deflection angles where the glass of the neck is very thin to allow for maximum deflection sensitivity, the potential does exist for arcing through the glass to the yoke to occur, destroying the CRT.

There is really no way to know which models will self destruct but it should be possible to avoid such a disaster by providing a temporary return path to the DAG ground of the CRT (NOT SIGNAL GROUND!!) via the focus or G2 pins preferably through a high value high voltage rated resistor just in case one of these is shorted.

This probably applies mostly to large direct-view TVs since they use high deflection angle CRTs but it won't hurt to take appropriate precautions with video and computer monitors as well.

CRT Implosion Risk?

Also see the section: [Disposing of Dead TVs or Monitors (CRTs and Charged HV Capacitors)].

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

I have checked with our CRT expert and he thinks that any 'normal' type of scratch does not pose any danger. Usual disclaimer applies ... (what is 'normal'?)

The front of the tube is much thicker and stronger than the rear. It has to be, to withstand the air pressure, because the curvature radius is so much larger. You won't break it by throwing a slipper at it. The neck is in fact very easy to break, usually without causing injuries to anyone.

Normally, if the tube should implode, the rimband (the tensioned steel band around the rim of all modern CRTs of any size) prevents the glass from flying outward too far. Every tube type has to pass tests in which it is deliberately imploded and it is checked whether any large shrapnel flies too far out.

What *is* very dangerous is a CRT with its rimband missing, or a CRT which never had a decent rimband in the first place (like some dubious Russian-made samples we once saw). Such a tube should not be handled at all. NEVER ever attempt to remove the rimband for and reason!

I just saw a picture tube that was broken due to dropping the (entire) TV on one corner. In the cone (the backside) there are open cracks of some 3 feet length in total. Nevertheless all the glass is still in its original place and it looks as if no glass has flown outward. The faceplate is still intact. So in this case nobody would have got hurt. I remember reading about Americans (who else?) who tried to shoot CRT's with smaller rifles, with little or no success.

Does this comfort you? Get out the shotgun and have a go at it!

Or, perhaps, the following:

(From: Ren Tescher (ren@rap.ucar.edu).)

Our 6 month old 20" SGI color monitor (model GDM-20D11) lost a fight with a fork lift. The case is intact, the CRT probably still has a vacuum, but the outer layer of glass on the screen is shattered.

Picture Tube Implosion IS Possible - But You Really Need To Work at It!

As noted elsewhere in this document, picture tube implosion is a hazard but under normal conditions, quite unlikely. Someone wrote:

> "I heard somewhere that in the early days of TV, the tubes had a tendency to implode at the drop of a hat. (Due to poor design?) In order to prevent flying glass, the sets had a plastic sheet in front of the screen. Obviously, modern sets no longer have this. How safe are modern CRT screens in terms of impact damage etc?"

Well, it isn't quite as simple as that..... However, even if CRT implosion is one of those highly unlikely events, the downside is that should it occur in just the wrong way, the consequences can be disastrous. So, I wouldn't depend on the experiences below to guide you! Treat a CRT about the same way you would an armed nuclear bomb. OK, well maybe just 10 sticks of dynamite. :-)

(From: Dan Evens (dan.evens@hydro.on.ca).)

In high school, our electronics teacher did a demo for each class. He saved out an old black-and-white tube for each class and set up a place to break it. Put the tube on the ground by a brick wall, with a hammer suspended on a wire from the top of the wall. Did it on the driveway so that the glass would be easier to pick up. The tube was placed image-side down.

First he pulled the hammer back about 20 feet and just let it go. It bounced off the tube. This was to show that such tubes are pretty tough. Then he pulled the hammer back and gave it a pretty good shove, turning his back to the tube and moving quickly away from it. (Let's face it, the guy could probably have found a safer way to do this.)

Palm sized chunks of glass flew 50 feet. The noise was quite impressive. The thickness of the image plate of the tube was also quite impressive. Kind of looked like a porthole on a submarine. This was from the tube of a small black-and-white TV, about 14 inches or so. One of the larger colour models might be a LOT more violent.

If I was handling these things in such a way as to have the possibility of dropping one, I'd insist on body armor and face protection. And if it involves a picture tube, I insist on competent trained professionals for service.

(From: Matthias Meerwein (Matthias.Meerwein@rt.bosch.de).)

They ARE quite safe. I've got several TVs and computer monitors in for repair that had been dropped. None of them had an imploded CRT. The damage encountered ranged from:

- Broken circuit boards, often around the flyback transformer (the most heavy weight part on the board) - This is quite easily repairable.

- Shadow mask inside the tube knocked out of position (mostly in trinitron tubes due to their heavy aperture grille construction) - this renders the tube (and thus usually the set) a dumpster candidate.

- Neck of tube broken of (usually when the set hit the floor back end first) - obviously junk.

Furthermore, I did some experimentation with junk sets:

- 26 inch color TV with back panel removed placed face-down under a bridge. Dropped a ~10 pound brick from top of the bride (about 10 ft high) into the glass funnel of the tube. Result: Funnel of tube shattered, faceplate intact. All glass shards (most of them rather large) were lying inside the set's cabinet - no flying glass.

- 14 inch B/W computer monitor tube dropped from the second story onto concrete floor, hitting the ground faceplate-first. Result: tube shattered into thousands of small glass particles (the largest ones were about one inch in size), but all debris was located on one heap - none of them traveled farther than about three feet.

Conclusion: According to my experience, spectacular picture tube implosions are something like cars in movies that explode upon roll-over, hitting a tree or driving down the cliffs: an urban legend.

(From: Clifton T. Sharp Jr. (agent150@spambusters.ml.org).)

With today's tubes, that's more or less true (although walking through a picture tube plant can be instructive as you hear the exploding tubes). With older tubes it was a hazard. With pre-1960 tubes it was a big one. My old boss in the TV service, who I trusted not to exaggerate about such things, told me stories of setting a picture tube near a second-floor window, having them fall to the sidewalk and literally blow a hole in the sidewalk. I can tell you factually and first-person that although he took few precautions with other things, when he had to "pop" a picture tube in the dumpster he never ever ever did it without safety glasses, a shield and a six-foot piece of heavy pipe. (I stopped working there around 1973.)

Risks from CRT Scratches?

A really deep long scratch or gouge on the CRT face should be considered a serious safety hazard as it may reduce the structural integrity and increase the risk of implosion. However, you would likely need a hammer and chissel or diamond tipped tool to make scratches that deep. It is very unlikely that such scratches could come from any reasonable normal use. Dropping it from a cliff, deliberate use of a glass cutter, the use of a really really BIG hammer, or 12 gauge shotgun, might perhaps be sufficient.

This is more of a concern for modern CRTs that usually have 'integral implosion protection' - that steel rimband around the outside near the front. Older CRTs used either (1) a separate safety shield - that laminated glass plate in front of your grandmom's TV - or (2) a second contoured glass panel bonded to the actual tube face. In both of these cases, the second panel is protective and cosmetic but is not part of the structure of the CRT. Therefore, any damage to it does not significantly compromise the tube. In the case of modern CRTs, the steel band in conjunction with the basic tube envelope is used to maintain the integrity of the overall CRT. In addition should implosion occur as a result of catastrophic damage, the rimband will reduce the range and velocity of flying debris.

Also see the section: CRT Implosion Risk?.

BTW, scratches in the CRT have absolutely no effect on X-ray emission. X-rays are blocked long before they come anywhere near the surface and glass has very little effect on their direction. Any scratch deep enough to have any detectable effect on X-ray emission (actually, it would need to be an inch deep gouge) would have caused the tube to implode.

Disposing of Dead TVs or Monitors (CRTs and Charged HV Capacitors)

I don't know what the law says, but for safety, here is my recommendation:

Treat the CRT with respect - the implosion hazard should not be minimized. A large CRT will have over 10 tons of air pressure attempting to crush it. Wear eye protection whenever dealing with the CRT. Handle the CRT by the front - not the neck or thin funnel shaped envelope. Don't just toss it in the garbage - it is a significant hazard. The vacuum can be safely released (Let out? Sucked in? What does one do with an unwanted vacuum?) without spectacular effects by breaking the glass seal in the center of the CRT socket (may be hidden by the indexing plastic of the socket). Cover the entire CRT with a heavy blanket when doing this for additional protection. Once the vacuum is gone, it is just a big glass bottle though there may be some moderately hazardous materials in the phosphor coatings and of course, the glass and shadow mask will have many sharp edges if it is broken.

In addition, there could be a nice surprise awaiting anyone disconnecting the high voltage wire - that CRT capacitance can hold a charge for quite a while. Since it is being scrapped, a screwdriver under the suction cap HV connector should suffice.

The main power supply filter caps should have discharged on their own after any reasonable length of time (measured in terms of minutes, not days or years).

Of course around here, TVs and monitors (well, wishful thinking as I have yet to see a decent monitor on the curb) are just tossed intact which is fortunate for scavengers like me who would not be happy at all with pre-safed equipment of this type!

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

We have a procedure for disposing of used CRT's. The vacuum must be broken to avoid future implosion, like when it will be crushed by the dumpster truck press. That's NOT funny! One method is to punch or drill a small hole in the anode contact, which is made of a soft metal. But take care of the electrical discharge of the aquadag capacitance first!!!

The other method is to break the stem in the centre of the socket pins. This is the stem through which the tube was pumped empty during manufacturing. It breaks off easily (after you have removed the plastic part around the pins).

You want to avoid making too large holes, like for example from chopping off the entire neck in one blow with a hammer.

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General CRT Construction and Characteristics

Why is the CRT Still Dominant?

Currently, most TVs and computer monitors are still based on the Cathode Ray Tube (CRT) as the display device. However, many hand-held TVs, portable equipment, laptop computers, and the screens inside video projectors now use flat panel technology, mostly Liquid Crystal Displays - LCDs. These are a lot less bulky than CRTs, use less power, and have better geometry - but suffer from certain flaws.

First, the picture quality in terms of gray scale, color, and brightness is generally inferior to a decent analog monitor. The number of distinct shades of gray or distinct colors is a lot more limited. They are generally not as responsive as CRTs when it comes to real-time video which is becoming increasingly important with multimedia computers. Brightness is generally not as good as a decent CRT display. And last but not least, the cost is still much much higher due both to the increased complexity of flat panel technology and lower production volumes (though this is certainly increasing dramatically). It is really hard to beat the simplicity of the shadow mask CRT. For example, a decent quality active matrix color LCD panel may add $1000 to the cost of a notebook computer compared to $200 for a VGA monitor. More of these panels go into the dumpster than make it to product do to manufacturing imperfections.

A variety of technologies are currently competing for use in the flat panel displays of the future. Among these are advanced LCD, plasma discharge, and field emission displays. Only time will tell which, if any survives to become **the** picture-on-the-wall or notepad display - at reasonable cost.

At least one company is about to introduce a 42 inch diagonal HDTV format flat plasma panel multisystem color TV/monitor which will accept input from almost any video or computer source. Its price at introduction will be more than that of a typical new automobile - about $15,000! :-) Thus, at first, such sets will find their way into business conference rooms and mansions rather than your home theater but prices will drop over time.

Projection - large screen - TVs and monitors, on the other hand, may be able to take advantage of a novel development in integrated micromachining - the Texas Instruments Inc. Digital Micromirror Device (DMD). This is basically an integrated circuit with a tiltable micromirror for each pixel fabricated on top of a static memory - RAM - cell. This technology would permit nearly any size projection display to be produced and would therefore be applicable to high resolution computer monitors as well as HDTV. Since a reflective medium is used in this device, the light source can be as bright as needed. Commercial products based on the DMD are beginning to appear.

Comparison of CRT Types

> "Could someone please help to elucidate the comparative advantages of each technology? I know how they work but do not know which is advantageous and why."

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

Trinitron is Sony technology. The shadow mask (called the aperture grille) consists of vertical wires under tension. The mask is always straight in the vertical direction and curved in the horizontal direction, thus the shape is a cylinder. The tube surface is also cylindrical, which causes some strange effects, particularly funny mirror reflections of yourself. Because the wires are under a lot of tension, the internal tube structure must be very strong and thus relatively heavy. Because the glass surface is cylindrical instead of spherical, the glass must be thicker and heavier too, to withstand atmospheric pressure.

Heavier always equates to more expensive!

The electron gun construction is also different: there are still 3 guns (not one as some may thing but the 3 guns share one main lens. (The assembly of focusing grids is called a lens, in analogy to the optical principle.) There are still 3 cathodes and 3 G1s, as usual. The large diameter lens has the advantage of less spherical aberration (and thus a sharper spot) but the disadvantage of large physical length which means a deeper cabinet.

In the deflection coil design another compromise is found between spot quality, purity and convergence. As a result horizontal convergence must be helped by an auxiliary dynamic convergence waveform (on an extra convergence coil?). This adds to cost and can occasionally give an interesting failure of the horizontal convergence.

The best non-Trinitron (or clone) CRTs use a conventional shadow mask made of Invar - originally Matsushita technology; Philips uses it too. The shadow mask is of the standard shape (spherical metal plate with holes in it) but it is made of a special alloy with a 7 times lower coefficient of thermal expansion than regular iron. This allows a brighter picture with less purity errors.

The problem with regular shadow masks is 'doming'. Due to the inherent principle of shadow masks, 2/3 or more of all beam energy is dissipated in the mask. Where static bright objects are displayed, it heats up several hundred degrees. This causes thermal expansion, with local warping of the mask. The holes in the mask move to a different place and the projections of the electron beams will land on the wrong colours: purity errors. The use of invar allows about 3 times more beam current for the same purity errors. See the section: What is Doming?.

Combating purity errors is a necessity due to 2 trends:

- Flatter picture tubes: flatter shadow masks are more sensitive to doming
- Darker (glass) picture tubes: this gives more contrast but more beam current is needed for enough brightness

The trinitron aperture grill shadow mask is inherently insensitive to doming as long as the tension in the wires remains positive. If the wires become too long then they become more sensitive to microphony (try tap the cabinet...). The vertical wires are connected in several places by thin horizontal wires. Some people complain about seeing faint shadows of these wires.

To summarize: Trinitron monitors are probably heavier, larger, more expensive, maybe better on purity, and maybe better on focus than other monitors, with or without invar shadow masks. There are excellent monitors other than Trinitron too... I suppose the Coke-Pepsi comparison is true.

Color CRT Construction

For a couple introductory on-line articles about (mostly) CRTs, see:

- High Tech Tubes, Popular Mechanics, April 1997.
- Display.

All the color CRTs found in TVs and computer and video monitors utilize a shadow mask or aperture grill a fraction of an inch (1/2" typical) behind the phosphor screen to direct the electron beams for the red, green, and blue video signals to the proper phosphor dots. Since the electron beams for the R, G, and B phosphors originate from slightly different positions (individual electron guns for each) and thus arrive at slightly different angles, only the proper phosphors are excited when the purity is properly adjusted and the necessary magnetic field free region is maintained inside the CRT. Note that purity determines that the correct video signal excites the proper color while convergence determines the geometric alignment of the 3 colors. Both are affected by magnetic fields. Bad purity results in mottled or incorrect colors. Bad convergence results in color fringing at edges of characters or graphics.

The shadow mask consists of a thin steel or InVar (a ferrous alloy) with a fine array of holes - one for each trio of phosphor dots - positioned about 1/2 inch behind the surface of the phosphor screen. With some CRTs, the phosphors are arranged in triangular formations called triads with each of the color dots at the apex of the triangle. With many TVs and some monitors, they are arranged as vertical slots with the phosphors for the 3 colors next to one another.

An aperture grille, used exclusively in Sony Trinitrons (and now their clones as well), replaces the shadow mask with an array of finely tensioned vertical wires. Along with other characteristics of the aperture grille approach, this permits a somewhat higher possible brightness to be achieved and is more immune to other problems like line induced moire and purity changes due to local heating causing distortion (doming) of the shadow mask.

However, there are some disadvantages of the aperture grille design:

- Weight - a heavy support structure must be provided for the tensioned wires (like a piano frame).

- Price (proportional to weight).

- Always a cylindrical screen (this may be considered an advantage depending on your preference.

- Visible stabilizing wires which may be objectionable or unacceptable for certain applications.

Apparently, there is no known way around the need to keep the fine wires from vibrating or changing position due to mechanical shock in high resolution tubes and thus all Trinitron monitors require 1, 2, or 3 stabilizing wires (depending on tube size) across the screen which can be see as very fine lines on bright images. Some people find these wires to be objectionable and for some critical applications, they may be unacceptable (e.g., medical diagnosis).

Assembly of Color CRTs

(Portions from: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The following is a greatly simplified description of the general process of color (shadow or slot mask) CRT construction. Trinitrons should be basically similar.

The screen and envelope glass pieces are molded separately and then glued (Epoxied?) together as one of the last steps of assembly prior the baking and evacuation. (You will note this seam if you examine the envelope of a color CRT near the front.)

The shadow mask is manufactured through a photo etching process. No, there are no workers responsible for punching all those holes! Since a position error of even a tiny fraction of a mm would result in purity errors, each shadow mask is unique for its faceplate. They are not interchangeable. To facilitate the following steps, it can easily be mounted and removed (essentially clicked in place) during tube production. Registration pins assure precise alignment.

- For each of the phosphor colours (and optional black matrix) one phosphor layer is deposited followed by one photoresist layer.

  At least one manufacturer adds some steps for the Superbright tubes. They put 3 different colour filters between the glass and the phosphor. In terms of contrast that tube is a definite killer.

- The shadow mask for that CRT (unique) is then mounted - clicked in place.

- An intense point source of light is mounted at the location of the effective center of deflection for the electron gun associated with that phosphor.

- The photoresist is exposed to light.
- The shadow mask is removed and the excess resist (not exposed to light) and phosphor is washed away.

These steps are repeated for the red, green, and blue phosphors, and the optional (but very common) black matrix surround.

Using the shadow mask repeatedly in this manner guarantees close registration. How else would you lay down a million individual dots in exactly the right place - paint by numbers? :-).

Then, an aluminum overcoat is deposited over the phosphor/black matrix. This has several functions:

- Provide the return path for the electron beam - connected to the EHT 2nd anode.

- Reduces backscattering or secondary emission. Electrons that bounce back from either the shadow mask or the screen may hit a phosphor elsewhere and thus cause unwanted white light. That reduces contrast and colour purity.

- A side benefit is that it blocks negative ions from residual air molecules from hitting the phosphors. These might result in an unsightly blemish in the center of the screen since they are much heavier (many thousands of times the mass) than electrons and are not deflected very much. (This was a problem in the early days of CRT production but apparently not with present high vacuums and getters to clean up whatever is left.)

The shadow mask is then mounted for a final time and the faceplate, envelope (with its electron gun assembly already fused to it) are mated. At this point, it is ready for the final baking and evacuation.

The tube is evacuated through the thin stem that is located in the middle of the socket. That takes several hours at the vacuum pumps. The stem is then sealed by heating and melting.

The getter - part of the electron gun assembly - is then 'activated' via induction heating from a coil external to the next of the CRT. This vaporizes and deposits a highly active metal on the interior of the glass of the neck. The getter material adsorbs much of any remaining gas molecules left over from the evacuation of the tube. The getter material is normally silvery - if it changes to red or milky white, the tube is probably gassy or up to air.

When the tube is ready it is matched with a deflection coil that provides optimum purity. It takes some ingenuity to get a good match between using a light for exposure which matches the behaviour of the future electron optical system, in order to get good purity.

Amazingly, this basic process has not changed in any fundamental way since the invention of the shadow mask CRT!

However, Computer Aided Design (CAD) has had a major impact on the design of the electron optics. The working of the electron gun and deflection system is now much more predictable thanks to advanced computer simulation. This has reduced the number of active correction circuits for focus, geometry and convergence to almost zero.

CRT Fine Tuning

Once the CRT is sealed, baked, evacuated, etc., the job is not yet done!

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

They still need to match the finished tube with a deflection coil that will give adequate purity performance and then they need to fiddle with magnets (multipole rings around the neck and sometimes other magnets all over the cone) to improve it further. And even then many tubes need active correction for convergence and/or geometry.

Only after all that correction can you call the yield high. (But you should see their scrap yard, good thing that glass recycles well...)

Northern/Southern Hemisphere Corrections and Adjustments

The vertical component of the earth's magnetic field varies in intensity and polarity (N/S) as one moves from the North pole over the equator and to the South pole. It is maximum at the poles and decreases to zero at the equator. The total strength is not large - after all it is less than the total magnitude of the earth's magnetic field of about .5 Gauss (.00005 Tesla). However, it is enough to affect the trajectory of the electron beam(s) slightly.

For monochrome monitors and B/W TVs, this will result only in a slight shift in position or rotation of the picture depending on the orientation of the CRT with respect to the earth's magnetic field. For the most part such effects will not be significant enough to be objectionable.

However, for high resolution color monitors and even some color TVs, the result of transporting the unit from the hemisphere from which it was manufactured or set up to a location in the opposite hemisphere may be uncorrectable purity problems or excessive sensitivity to local magnetic fields.

Note that is it quite possible that you will never encounter any of these problems. The extent to which your particular monitor or TV is affected depends on many factors - many of which you have no control over.

(From: Bob Myers (myers@fc.hp.com).)

For many monitors - especially the larger sizes, such as 21" - there is a subtle difference in the CRT itself which may mean that a unit with the wrong tube could NOT be adjusted to be within specifications when used in the 'wrong' hemisphere.

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

There are two types of adjustments:

- The passive ones that are done in the picture tube factory and
- The active ones that are done by the setmaker a/o the customer.

In the factory inside the neck of every (Philips) tube a metal ring is permanently magnetized to create a multipole correction field. Then each tube is matched with a deflection yoke to achieve optimum colour purity. It is possible that a couple of yokes must be tried in succession. This matching is done under specific ambient magnetic field conditions. On oriental tubes you will often see little permanent magnets added to achieve further fine correction of landing and/or convergence. When the tube is within landing specification it is shipped to the setmaker.

Depending on the sophistication of the circuitry in the (television or monitor) set, the setmaker can adjust geometry and sometimes convergence (if there is a set of convergence coils present). If there is a rotation coil present then this may also improve the landing a bit.

In the 'digital monitors' there are flexible waveform generators to adjust the corrections. There may be further adjustments possible for the uniformity of the colour point and brightness. This gives a place-dependent modulation of the 3 beam currents, it does nothing to improve the landing.

The most expensive monitors (large screen, fine phosphor pitch, very critical on landing) may have active magnetic field compensation in all 3 directions with electronic magnetic field sensors for automatic adjustment. These monitors should be mostly insensitive to the earth magnetic field. (This technology was originally invented for the use of CRT displays on board of jet fighter planes, which tend to turn relative to the earth...)

All other monitors will degrade picture quality when the degaussing is not able to completely compensate for the earth magnetic field. With a tube built for the wrong hemisphere it is possible that the effect of the vertical component of the earth magnetic field will give a residual landing error. This can not be corrected by turning any of the available adjustments, digital or not. Re-alignment might become a very costly job.

Tubes for All Nations

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

CRT Manufacturers actually make different versions of their tubes for TV's for the northern and southern hemisphere, and sometimes a 3rd neutral type. These are so-to-say precorrected for the uncompensated field. (Note that the term 'tube' here includes much of the convergence hardware as well - not just what is inside the glass.)

I remember when we exported projection televisions from Belgium to Australia, a couple of years ago. They all had to be opened on arrival to re-adjust the rotation settings on the convergence panel, due to the different magnetic field in Australia. Projection TV's don't have degaussing (there is nothing to degauss), and the customer can only adjust red and blue shift, not rotation.

Our CRT application group has a "magnetic cage". This is a wooden cube (approx. 2 meter long sides) with copper coils around each of the 6 surfaces. With this they can simulate the earth magnetic field for every place on earth (as indicated on a map on the wall).

During production and adjustment of the tube, the beam landing is optimized for the field condition in which it will be used later. There may be different tube specifications for north, south and equator ("neutral"). If you choose to use it in different conditions then the landing reserve will be diminished and you will suffer sooner from colour purity errors. I'm not so sure if the convergence would be a primary problem, maybe yes.

With a dotted shadow mask, also the horizontal component of the field matters, which is bad because it also depends on which direction you orient the display. This too will eat away from your landing reserve. How critical it all is depends on tube size (bigger is worse) and on dot pitch (smaller is worse). Workstation monitors are most critical.

Using a Helmholtz cage you can test or optimize for a particular place on earth. The most expensive monitors come with their own built-in Helmholtz cage and magnetic sensors to always create a field-free space.

Another interesting bit of trivia:

B&O (Bang & Olufsen of Danmark) use Philips picture tubes in their beautifully designed cabinets. In order to facilitate a more narrow styling they decided to mount the tube upside-down, so they don't need safety clearance for the EHT on top. As a consequence they needed a southern-hemisphere tube for the northern hemisphere! So here is a hint for a solution to you all...

(From the editor).

In light of the above discussion, the following makes perfect sense:

(From: Nigel Morgan (nigel@wycombe.demon.co.uk).

When I was in the TV trade some 20 years ago, I was introduced to a model with a PYE badge on which differed in one significant detail: on all TV sets I'd seen to that date the tube had the blue gun uppermost and the EHT connector at the top of the tube. Thorn TV sets mounted the tube upside-down for some reason so that the EHT connector was at the bottom along with the blue gun, but these PYE sets had the blue gun at the bottom, but the EHT connector was at the top! When I asked about this, I was told that the tubes used in the PYE sets were 'Southern Hemisphere tubes. I never could decide whether this was genuine or BS!

(From: Terry DeWick (dewickt@esper.com).)

The magnetic field for South America is about 0 to -100 mG while the U.S. runs 400 to 500 mG (milli Gauss). For a CRT to set up correctly the gun is offset 1 to 1.5 mm left of center for the 500mG field and 1 mm to the right for 0 mG this way the purity will be centered and the yoke tilt will be centered making setup easy during production. A North American CRT can be set up in South America but there is a chance that it will not set up well with excessive purity correction and or wedging set to the extremes.

So What Does It Mean to Have a Trinitron CRT?

Trinitron is a CRT technology developed by Sony. The patent has recently expired and therefore other manufacturers are free to offer similar CRTs. The CRT uses a set of fine vertical wires called an aperture grill instead of a steel shadow mask to separate the R, G, and B electron beams and force them to strike only the appropriate colored phosphors. This in conjunction with an in-line set of electron guns is supposed to provide a brighter image with simpler convergence and purity adjustments. It should be brighter because the percentage of open space of the aperture grill is higher then that of a shadow mask. Other adjustments should be less critical in the vertical direction. In addition, since there is no imposed structure in the vertical direction, undesirable moire patterns caused by scan line pitch compared with the shadow mask dot pitch should be eliminated.

You can recognize a Trinitron tube by the fact that the picture is made up of fine vertical stripes of red, green, and blue rather than dots or slots. The shadow mask in all other kinds of common CRTs are made up of either dots (nearly all good non-Trinitron computer monitors) or slots (many television sets). The Trinitron equivalent is called an aperture grill and is made of around a thousand vertical wires under tension a fraction of an inch behind the glass faceplate with its phosphor stripes.

Several photos of a disemboweled Trinitron aperture grille can be found at James Sweet's Sony/Trinitron Directory along with some screen shots showing the symptoms resulting from a monitor falling on its face. :(

Since the aperture grill wires run the full height of the tube, there are 1 or 2 stabilizing wires to minimize vibration and distortion of the aperture grill. These may be seen by looking closely 1/3 and/or 2/3 of the way down the tube. The larger size tubes will have 2 while those under 17 inch (I think) will only have a single wire. Many have complained about these or asked if they are defects - no they are apparently needed. You can be sure that Sony would have eliminated them if it were possible.

Another noticeable characteristic of Trinitrons is the nearly cylindrical faceplate. The radius in the vertical direction is very large compared to the horizontal. This is both a requirement and a feature. Since the aperture grill wires are under tension, they cannot follow the curve of the glass as a normal shadow mask may. Therefore, the glass must be flat or nearly flat in the vertical direction. As a selling point, this is also an attractive shape.

In the final analysis, the ultimate image quality on a monitor depends as much on other factors as on the CRT. There are many fine monitors that do not use Trinitrons as well as many not-so-great monitors which do use Trinitron tubes.

Why are There Fine Lines Across My Trinitron Monitor or TV?

These are not a defect - they are a 'feature'. :-)

All Trinitron (or clone) CRTs - tubes that use an aperture grille - require 1, 2, or 3 very fine wires across the screen to stabilize the array of vertical wires in the aperture grille. Without these, the display would be very sensitive to any shock or vibration and result in visible shimmering or rippling. (In fact, even with these stabilizing wires, you can usually see this shimmering if you whack a Trinitron monitor.) The lines you see are the shadows cast by these fine wires.

The number of wires depends on the size of the screen. Below 15" there is usually a single wire; between 15" and 21" there are usually 2 wires; above 21" there may be 3 wires.

Only you can decide if this deficiency is serious enough to avoid the use of a Trinitron based monitor. Some people never get used to the fine lines but many really like the generally high quality of Trinitron based displays and eventually totally ignore them.

Differences between Trinitron and Diamondtron CRTs

(From: Bill Nott (BNott@Bangate.compaq.com).)

Mitsubishi makes the Diamondtron under license from Sony - the subtle differences (according to Mitsubishi) are improvements in the electron gun design for spot uniformity over the CRT face. Also, for the time being, Mitsubishi has tried to introduce Diamondtron tubes in sizes which are not available as Trinitrons - to keep from directly competing, and (ostensibly) to address niches which other sizes can't address.

In order to properly evaluate a monitor, one must consider more than the tube alone - as many readers know, Trinitrons are finding their way into various manufacturer's sets, but they don't all perform the same. In todays market, it's quite possible to find a dot mask design which performs as well as (or better in some cases) the aperture grill design - IMHO every critical monitor purchase should be made by personally examining the monitor to be bought, under the intended application(s).

(BTW, all color tubes use 3 guns, including the Trinitron. Sony used to talk about a "unitized gun", but that only refers to the cathode structure. It's classical use of a misleading term to gain market awareness (looks like it works).)

(From: Someone who wishes to remain anonymous.)

I have found other differences between the Trinitron and Diamondtron tubes. Most noticeable is the grill pitch. The 21" Sony GDM-F520 is 0.22 mm. The 22" Mitsubishi (Cornerstone P1750) is 0.25 mm. For high resolution screens, this makes a difference.

I have also noticed that in a room full of Dell Trinitron monitors, no two monitors have the same color. This is not just a setup issue, the actual tubes have different colors when they are off. The darkness of the black changes.

My gut feeling is that the Dells use a Mitsubishi tube, and that the quality control is not up to Sony's. It is just a feeling, I have not done any research on this.

From what little I know, if you want the very best, you will have to pay for it, (or you get what you pay for).

Some History of In-Line Gun CRTs

(From: Thomas Maggio (staccato@gate.net).)

GE's first set was a 10 or 11 inch " "PortaColor" TV which, to the best of my memory, was introduced in the mid-60s. It was a tube chassis that made use of space saving Compactron multifunction tubes. A solid state version followed some years later I believe. If I remember correctly, the color circuit used a novel method to generate the local 3.58 MHz color signal: it used the recovered color burst to 'ring' a series crystal to produce a continuous carrier. I remember reading about all this in one of the late great "Radio-Electronics" Annual Color TV issues that I looked forward to each year back then as color TVs were dynamically evolving from many US companies.

The GE CRT did indeed use 3 in-line guns aimed at a conventional shadow mask triad phosphor screen. This simplified convergence and the CRT neck components needed. Sony uses one gun with a large common cathode to emit 3 electron beams which focus through a single large electrostatic 'lens' instead of 3 smaller ones like the GE and others used.

One last stroll down memory lane: Does anyone remember the forerunner of the Sony Trinitron? It began as the "Lawrence Tube" (named after its U.S. inventor Dr. Lawrence) then was demonstrated as the "Chromatron" (I think Paramount had some stake in it then). I don't know how the concept became Sony's property so if anyone can corroborate or correct any of my recollections, I would enjoy hearing about it. Thanks.

(From: Andy Cuffe (baltimora@psu.edu).)

I read about Sony's development of the Trinitron. Apparently Sony actually manufactured a 17" TV with a Chromatron CRT in the early 60's. It was only sold in Japan and used a very unreliable tube chassis. According to the book they all ended up being returned and Sony lost a lot of money on it. Later Sony took ideas from the GE in-line tube and the Cromatron to invent the Trinitron. They used the 3 in-line cathodes of the GE tube with the vertical phosphor stripe screen of the chromatron. The common focusing lens was a way to stay as close as possible to the single electron gun design of the chromatron. The tone of the book suggested that Sony bet the whole company on the success of the Trinitron. Apparently they were very close to licensing the shadow mask design from RCA because of the amount of money they were losing by developing their own color CRT. If anyone is interested I think the title of the book was "Sony Vision". It also had chapters on the Betamax and the development of the first solid state TV.

How Far is the Shadow Mask from the Phosphor Screen?

(Portions from: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

This is simple geometry - similar triangles (at least for a good approximation).

It is easy to do the calculations based on the distance between the electron guns and the horizontal stripe pitch of the CRT (assuming slot mask or Trinitron - just a little more trouble for dot mask to convert the dot pitch).

```
    Dot pitch: 0.3 mm
      | |
 ___________________________________ Phosphor screen
  G B R G B R G B R G B R G B    ^
       \|/                     15 mm
 - ----- ----- ----- ----- --------- Shadow mask
       /|\                       ^
      / | \                      |
     /  |  \                   350 mm
    /   |   \                    |
   /    |    \                   v
  B-gun G-gun R-gun ---------------- Electron guns (center of deflection)
        |     |
        |     |
       Gun pitch: 7 mm
```

(Cool diagram based on efforts of Jeroem Stessen.)

Be aware that both face-plate and shadow-mask are curved and that the radius of curvature is much larger than the distance to the guns. The screen is relatively flat. This too has consequences for the calculation. Oh, heck.

At the center of the screen, we have:

```
          Distance between E-guns (R-G)           Slot pitch (R-G)
     -----------------------------------------  = -----------------
      Distance from deflection center to mask      Mask to screen
```

For a typical 25 inch TV CRT with a .9 mm slot pitch (.3 mm between adjacent stripes) and 7 mm between adjacent guns we have a ratio of about 23:1.

For a distance of 350 mm between the center of deflection and mask, this gives us about 15 mm (~.6 inches) between the mask and the screen.

How is the Shadow Mask Mounted Inside the CRT?

(Portions from: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The shadow mask is mounted in a diaphragm. The diaphragm is mounted to the inside of the tube with 4 metal springs. In the old days these were bimetal springs. They have an important role for colour purity: they allow the mask to move forward as it expands due to self-heating.

Remember: it must dissipate a lot of power and there is no cool air in there...

During production the mask is mounted and removed many times to allow for etching of the phosphors. A point light source is precisely positioned at the deflection center of each gun in-turn to expose the photoresist used in laying down the phosphor dots. (I know, you thought they were painted on one spot at a time! :-)

The mask is never fastened permanently, only clicked in to place just prior to having the envelope glued to the front assembly.

As no two masks are identical, each tube is always paired with its own mask.

(From: David Moisan (dmoisan@shore.net).)

From pictures I've seen, the best way to describe the shadow mask is that it is like a picture inside its frame: The glass face is the frame and the mask is the picture it holds, so to speak. The mask is carefully designed in a frame of its own, with spring clips around the edges, so that it won't distort under the heating it gets from the electron beams (not to mention during manufacturing). There's also a magnetic shield around the inside of the bell in some tubes.

Why is the Shadow Mask or Aperture Grill Made of a Magnetic Material?

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

The question often arises: Well, if magnetization and the need for degauss is a problem, why not make the shadow mask or aperture grille from something that is non-magnetic?

The shadow mask *must* be made of magnetic material! This may seem to be undesirable or counterintuitive but read on:

Together with the internal shielding hood it forms sort of a closed space in which it is attempted to achieve a field-free space. The purpose of degaussing is *not* to demagnetize the metal, but to create a magnetization that compensates for the earth's magnetic field. The *sum* of the two fields must be near zero! Degaussing coils create a strong alternating magnetic field that gradually decays to zero. The effect is that the present earth magnetic field is "frozen" into the magnetic shielding and the field inside the shielding will be (almost) zero. Non-zero field will cause colour purity errors.

Now you will understand why a CRT must be degaussed again after it has been moved relative to the earth's magnetic field. This will also explain why expensive computer monitors on a swivel pedestal have a manual degaussing button, you must press it every time after you have rotated the monitor.

The axial component of the magnetic field is harder to compensate by means of degaussing. Better compensation may be achieved by means of a "rotation coil" (around the neck or around the screen), this requires an adjustment that depends on local magnetic field. CRT's for moving vehicles (like military airplanes) may be equipped with 6 coils to achieve zero magnetic field in all directions. They use magnetic field sensors and active compensation, thus they don't need any degaussing function. This is too expensive for consumer equipment.

Why do CRTs Use Red, Green, and Blue rather than Red, Yellow, Blue?

So you were taught in grade school that any color could be made up of red, yellow, and blue paint. Why are these not used in CRTs?

Nearly any color that we can perceive can be made from some combination of primary colors. There are two types - additive and subtractive.

RGB are primary additive colors - anything that emits light will use these.

The three types of cone (color) recepters in the retina of the human eye have peaks (roughly) sensitive to these primary colors.

Those red, yellow, and blue primaries you used to create your works of art should actually not have been red, yellow, blue but rather magenta, yellow, cyan - close but no cigar. Red, yellow, and blue are approximations good enough for basic painting or printing but are not capable of reproducing the widest range of colors.

CMY (cyan, magenta, yellow) are subtractive colors. Printing processes and color photography use these because layers of ink or dye absorb light. Basically, each of CMY removes a single color from (RGB).

- Cyan = (green+blue) and is the complement of red.
- Magenta = (red+blue) and is the complement of green.
- Yellow = (red+green) and is the complement of blue.

The phosphors used in CRTs are not necessarily optimal - that is why some monitors or TVs may appear to have better color rendition than others.

Purpose of a Separate CRT Faceplate

The surface of the screen you see is most often part of the CRT envelope. In this case, there should be a tensioned steel band - a rimband - around the edge of the CRT near the front. The rimband is essential to assure the structural integrety of the CRT envelope against the emmense forces due to the air pressure attempting to crush it. In the event of a catastrophic event, the rimband will also reduce the range and velocity of any debrie. This is called 'integral implosion protection' by some manufacturers.

Warning: A CRT that is supposed to have a rimband but where it is missing or damaged is a serious hazard since the possibility of implosion is greatly increased and the effects of such an implosion will be more severe. However, such a situation is virtually impossible to occur on its own since the rimband is part of the mounting bracket assembly. Don't be tempted to remove the rimband for any reason unless the vacuum has been let out (in, whatever one does with a vacuum) of the CRT! Spontaneous implosion is even possible. See below for an example.

In some cases, there will be a separate faceplate. Older TVs usually had either a totally separate laminated glass plate in front of the CRT or a contoured glass panel bonded (glued) to the CRT itself. Part of its purpose is protective. It would prevent damage to the CRT in the event of a blow from a thrown object like an ashtray or shoe! In addition, it would contain the debrie in the unlikely event of an implosion resulting from some really catastrophic event.

However, the separate or bonded glass plate can also be used for cosmetic purposes to:

- Improve contrast in a bright light by using a tinted glass.
- Reduce reflection by using an anti-reflection coating.
- Iron out the bumps by using a glass plate smoother than the CRT.
- Give the impression of a flatter display by using a glass plate with a larger radius of curvature than the CRT itself.
- Give the impression of a Sony Trinitron by using a cylindrical (plastic) plate in front of a real-flat rear-projection screen.

(From: Joe (rimband@megsinet.net).)

I got my User ID from the metal band. :) Anyway, a friend of mine decided to cut the rimband off a picture tube. I wasn't there, he told me about it. This was a 25" RCA tube he wanted to fit into a Zenith TV (don't ask me why). What happened in the next few seconds after he cut the rimband, the picture tube imploded in his face, embedding the neck and yoke assembly in the ceiling, he came out with a cut about half an inch above his right eye that needed 6 stitches to close. Had that shard of glass been half an inch lower, he would be wearing an eye patch or have a glass eye for the rest of his life.

I told him what an idiot he was, he's lucky he didn't kill himself or blind himself, and also told him NEVER cut the rimband off a picture tube that has vacuum. I just wanted to add that!:)

Leaded Glass and CRT Coatings

> "Is it really true that they put lead in the CRT glass for X-ray shielding? What is the transparent conductive coating on the front of the CRT made of?"

(From: Bob Myers (myers@fc.hp.com).)

First - yes, the glass is leaded (or contains other "impurities") to reduce emissions. In short, it's not just straight sand. :-)

There are various proprietary formulas used to make the faceplate coating, which often acts both as a conductive layer to reduce low-frequency electric fields and as a glare-reduction layer, but one of the most popular materials for making a transparent conductive layer is indium-tin oxide, a.k.a. "ITO". Such transparent conductors are also used in LCDs and other flat-panel technologies - at least the top layer of electrodes (row or column lines) has to be transparent! As conductors go, these things aren't THAT conductive - the age of see-through power lines or Star Trek's "transparent aluminum" is not upon us (and for certain theoretical reasons CAN'T be) - but they get the job done.

Flat Versus Non-Flat CRTs

The long and the short of it is that people would like absolutely flat tubes but there are several electronics and manufacturing problems which make the production of a totally flat (or even almost totally flat) CRT a challenge:

- **Geometry correction:** As the electron beam scans across a flat faceplate, its velocity increased near the edges and corners. Without compensation, the pixels will be stretched significantly in these areas.

- **Brightness uniformity:** Likewise, this means less time on each phosphor dot and lower brightness. In addition, the electron beam hits the screen at an increasingly steep angle which further decreases the brightness for a fixed dot size.

- **Structural integrity:** A totally flat faceplate would have to be much thicker to withstand the force due to the atmosphere with respect to the vacuum inside. So, most "flat" CRTs will still have a slight spherical shape.

Compensation for the geometry and brightness problems becomes much more challenging and it's never perfect. Even a well adjusted CRT will often have a very detectable, if not obvious, variation in brightness from center to edges and corners. Scan linearity and pincushion correction require most complex and carefully adjusted circuits. The thicker faceplate means a heavier CRT and monitor.

The net effect is that for a given screen size, cost will be greater. At a normal viewing distance, the perceived advantages may be minimal. Some people may find (after having gotten used to a moderately spherical CRT) that they actually like a flat one *less* especially if the deficiencies are easily seen. Note that Sony Trinitron (and clone) CRTs are nearly flat in the vertical direction and curved in the horizontal direction. To get used to this geometry may take some time as well.

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Resolution, Dot Pitche, and Other CRT Specifications

Color CRT Resolution - Focus and Dot/Slot/Line Pitch

The ability to display fine detail involves many factors including the resolution of the video source, video bandwidth, sharpness of the electron beam(s), and the dot/slot/line pitch (color only) of the CRT.

The CRT is primarily responsible for the latter two.

The focus or sharpness of the spot or spots that scan across the screen is a function of the design of the electron gun(s) in the CRT and the values of the various voltages which drive them. Focus may be adjustmented but excellent focus everywhere on the screen is generally not possible.

Sharp focus is a difficult objective - the negatively charged electrons repel each other and provide an inherent defocusing action. However, increasingly sharp focus would not be of value beyond a certain point as the ultimate resolution of a color CRT is limited by the spacing - the pitch - of the color phosphor elements. (For monochrome displays and black-and-white TVs, CRT resolution is limited primarily by the electron beam focus.)

One of three approaches are used to ensure that only the proper electron beam strikes each color phosphor. All perform the same function:

1. Dot mask - the phosphor screen consists of triads of R, G, and B, circular dots in a triangular arrangement. The shadow mask is a steel or InVar sheet filled with holes - one for triad. The dot mask has been used since the early days of color TV and is still popular today. The electron guns are also arrange in a triangular configuration.

2. Slot mask - the phosphor screen consists of triples of vertically elongated R, G, and B, stripes (actually, these are usually full vertical stripes interrupted by narrow gaps). The shadow mask is a steel or InVar sheet filled with slots - one for each triple. Ideally, the metal between the slots vertically is as thin as possible to maintain the structural stability of the slot mask sheet. This type of tube seems to be very popular in TVs but also shows up in some computer monitors. The electron guns are in line which makes some of the setup adjustments less critical compared to the dot mask CRT.

3. Aperture grille - the phosphor screen consists of triples of vertical R, G, and B, lines running the full height of the screen. The aperture grille is a series of tensioned steel wires running vertically behind the phosphor stripes - one for each triple. The aperture grille - until recently under patent protection and therefore only available in the Trinitron from Sony - is found in both TVs and monitors. The electron guns are also in line.

The pitch of a color CRT refers to the spacing of phosphor triads or triples. For dot mask CRTs, this parameter is relevant in both the horizontal and vertical direction. For slot mask and aperture grille CRTs, the pitch is only relevant in the horizontal direction.

Dot pitches as small as .22 mm are found in high resolution CRTs. Very inexpensive 14" monitors - often bundled with a 'low ball' PC system - may have a dot pitch as poor as .39 mm. This is useless for any resolution greater than VGA. Common SVGA monitors use a typical dot pitch of .28 mm. TVs due to their lower resolution have pitches (depending on screen size) as high as .75 mm - or more.

Obviously, with smaller screens and higher desired video source resolutions, CRT pitch becomes increasingly important. However, it isn't a simple relationship like the size of a pixel should be larger than the size of a dot triad or triple, for example. Focus is important. All other factors being equal, a smaller pitch is generally preferred and you will likely be disappointed if the pitch is larger than a pixel. As the pixel size approaches the phosphor triad or triple size, Moire becomes more likely. However, the only truly reliable way to determine whether Moire will be a problem with your monitor is to test it at the resolutions you intend to use.

A Discussion of Issues Relating to Monitor and CRT Resolution

Many factors influence the effective resolution of a monitor but the CRT dot or slot mask or aperture grill is the ultimate limit (though it may still be possible to use a monitor at a resolution which exceeds the that of the CRT). However, as the pixel spacing approaches that of the CRT, moire effects are likely to be more of a problem.

(From: Bob Niland (rjn@csn.net).)

Dot pitch is the major component in the actual resolution of the monitor. Most monitor vendors quote the highest resolution signal their monitor will sync to irrespective of whether or not the tube can resolve it. Indeed, it often cannot resolve the highest (and even second highest) claimed display resolution.

(From: Bob Myers (myers@fc.hp.com).)

Very true. On the other hand, things may not be quite as bad as what the numbers appear to say, sometimes.

(From: Bob Niland (rjn@csn.net).)

It's no accident that monitor size is specified in inches, and dot pitch in mm. The vendors don't want to make it easy for you to know what the geometry of their phosphor triads actually is, i.e. how many RGB dot triplets there are across and down the screen."

(From: Bob Myers (myers@fc.hp.com).)

Well, I wouldn't want to accuse the tube industry of deception. Expressing diagonal sizes in inches comes from long-standing tradition. Expressing pitch in millimeters is actually a relatively new practice in comparison, and isn't too unusual when you realize that most tube manufacturers - esp. those in the Far East - actually spec their tube diagonals in metric terms. For instance, Matsushita (Panasonic) has listed their "15 inch visual" color CRTs as "420xxxx" models, 420 being the overall diagonal in mm (16.54")

(From: Bob Niland (rjn@csn.net).)

Here's how to figure it out. You need first to know:

- The diagonal 'active picture" area (APD). If the vendor fails to specify this, subtract 1 inch from the advertised monitor size. I.e. a '21 inch' monitor will usually have about a 20-inch usable diagonal picture area. ('PC Inches' versus 'real inches' is a topic for another time. :-)

- You need the horizontal dot pitch (HDP). The vertical and horizontal are often different (with the vertical being a smaller number). If you have been given only one number, it's probably the diagonal, and is misleading, but it is all we have to work with.

(From: Bob Myers (myers@fc.hp.com).)

Trinitron (aperture grille) tubes will never have the pitch specified as a diagonal measurement, since they have vertical stripes of phosphor. Conventional (flat-square) models will, and probably the safest conversion between diagonal and horizontal for these is to mlutiply by the cosine of 30 degrees (0.866), unless you know for sure the angle to horizontal at which the diagonal measurement was made. (It varies for different tube designs.) See the section: How to Compute Effective Dot Pitch.

(From: Bob Niland (rjn@csn.net).)

- The monitor aspect ratio (AR). This is 4:3 (or 1.33:1) for any CRT you are likely to be using.

To calculate useful horizontal resolution:

- Multiply the APD by .80 (4:3 tube).

  This is the Active Picture Horizontal size (APH) in inches.

- Multiply APH by 25.4.

  This is the APH in mm (APHmm).

- Divide the APHmm by the HDP.

  This is the useful horizontal resolution of the monitor.

  Notice that this number probably does not precisely match any common (640, 800, 1024, 1152, 1280 or 1600) resolution in use, and that it is probably *less* than what the vendor claimed.

I use a Hitachi AccuVue UX4921D (aka HM-4921-D/A-HT01) 21-inch monitor. It is a claimed 1600x1200 monitor, and having a .22 horizontal dot pitch, actually has over 1800 phosphor triads across the screen. This is rare. Most large monitors usually have 1280 or fewer triads across the screen.

(From: Bob Myers (myers@fc.hp.com).)

Here is where some words of explanation are in order.

What many people fail to realize is that the phosphor triads of the screen *do not* correspond to pixels in the image; they are not kept in alignment with the image pixels/lines/whatever, nor is there are reason for them to be. The phosphor dot pitch IS a limiting factor in resolution, but we need to look a little further to determine whether or not a given tube will be usable for a given format (what most people mistakenly call a "resolution".)

The true resolution capabilities of a CRT are limited primarily by the dot pitch AND the spot size. For practically all CRTs and monitors in the PC market, the spot size is considerably larger than the dot pitch - up to 2X or so at the corners, if the tube is at or near its specification limits. This doesn't necessarily cause a problem with the image quality, however, since you aren't really resolving individual "pixels" in any case - what you need to resolve are the *differences* between adjacent pixels, or pixel/line pairs. And, oddly enough, it doesn't take a dot pitch of equal or greater size than a logical pixel to do this to most people's satisfaction. In fact, display types sometimes talk about a 'Resolution/Addressibility Ratio', or RAR, which is in effect the ratio of the actual size of a spot on the display to the size of a "logical" pixel in the image. And for best perceived appearance, this is generally going to be GREATER than 1:1 - say, 1.5:1 or even 2:1. (Too high, and the image is blurred; but too low, and the image takes on a grainy appearance that most people find objectionable.)

Bob is absolutely correct in stating that most displays, when run at the highest support addressibility or format (or, if you insist, "resolution") wind up with the "pixel size" being smaller than the dot pitch. But what is also correct, if somewhat counterintuitive, is that this is OK, and can still result in an image that will be acceptable (and even perceived as 'sharp') to the user.

You can certainly exceed the resolution capabilities of a tube and/or monitor (monitors differ from simple tubes by also having a video amp to worry about!). For instance, you probably won't be really happy with 1600 x 1200 on a 17" 0.28 mm CRT. But 1280 x 1024 on an 0.31 mm 20-21" tube can look very good, even though the numbers don't appear to work out.

(From: Bob Niland (rjn@csn.net).)

While not stated above, I would speculate that this is due to various human visual system factors, particularly that humans have more visual acuity in luminance (B&W) than in chrominance (color). If a CRT can actually illuminate less than a full phosphor triad, its luminance resolution can exceed the dot pitch. There will be some color fringing, but the eye may not notice.

(From: Bob Myers (myers@fc.hp.com).)

That's a good bit of it. Whether or not you're going to be satisfied with a given dot pitch versus addressibility ("resolution") basically has to do with what you think "resolve" means.

The fact that we don't generally have the same spatial acuity for color - in other words, you won't really see small details based on differences in color alone, there has to be a difference in brightness - is a big part of this. And you will be able to see such variations acceptably even when the size of the logical pixel is somewhat under the dot pitch size. When this occurs, you don't get constant color pixels - you don't even get constant *luminance* pixels - but you do perceive acceptable levels of detail to call the image 'sharp'.

About the Quality of Monitor Focus

> "I have 2 identical monitors. One is razor sharp from edge to edge. The other is blurred at the corners- not from convergence problems, but just plain out of focus. In this monitor, the focus adjustment on the flyback can improve the focus at the edges, but then the center of the screen becomes worse..My question is : Is this a problem in the electronics and presumably a fixable flaw or is it caused by variance in the picture tube itself and not correctable ? Or is it some other issue?"

(From: Bob Myers (myers@fc.hp.com).)

The adjustment on the flyback sets the "static" focus voltage, which is a DC voltage applied to the focus electrode in the CRT. However, a single fixed focus voltage will not give you the best focus across the whole CRT screen, for the simple reason that the distance from the gun to the screen is different at the screen center than it is in the corners. (The beam SHAPE is basically different in the corners, too, since the beam strikes the screen at an angle there, but that's another story.) To compensate for this, most monitors include at least some form of "dynamic" focus, which varies the focus voltage as the image is scanned. The controls for the dynamic focus adjustment will be located elsewhere in the monitor, and will probably have at LEAST three adjustments which may to some degree interact with one another. Your best bet, short of having a service tech adjust it for you, would be to get the service manual for the unit in question.

It is also possible that the dynamic focus circuitry has failed, leaving only the static focus adjust.

As always, DO NOT attempt any servicing of a CRT display unless you are familiar with the correct procedures for SAFELY working on high-voltage equipment. The voltages in even the smallest CRT monitor can be lethal.

How to Compute Effective Dot Pitch

We always see CRTs specififed in terms of dot pitch but what does this mean with respect to actual useful horizontal and vertical dot pitch?

The usual arrangement of phoshpor dots on the screen of a dot mask type CRT is shown below:

```
      B R G B R G B R G B R G B R                         R --- G --- B --- R
     R G B R G B R G B R G B R G B   Magnified ->             / |
      B R G B R G B R G B R G B R                         /     |
     R G B R G B R G B R G B R G B                     G --- B -+- R --- G --- B
```

(Portions from: Jac Jamar (jamar@comp.snads.philips.nl).)

For a dot mask type CRT, normally the nominal pitch (also called the Hexagonal Pitch or HexP) is defined as the distance between one phosphor dot to the next same colored one in the 'hexagonal' direction (i.e. in the direction 30 degrees above the horizontal).

The calculations below follow from simple geometry:

- The Vertical Dot Pitch (VDP) will be equal to: HexP * 1/2.

- The Same Color Horizontal Dot Pitch (SCHDP) will be:

  ```
          SCHDP = HexP * sqrt(3) (sqrt(3) = 1.732 or 2 * cos(30 degrees))
  ```

  This is the distance between one phosphor dot and the next dot of the same color on the same horizontal line.

- The Horizontal Dot Pitch (HDP) is the distance between adjacent columns of same color dots. This is equal to: SCHDP * 1/2.

- The distance between adjacent dots of different colors or Closest Dot Spacing (CDS) is equal to: SCHDP * 1/3. A landing error of this magnitude (due to improper manufacture, adjustment, inadequate degauss, external fields, or doming) may completely shift the color from what it is supposed to be to one of the other primary colors.

So, for a 0.28 mm dot pitch CRT, VDP = .14 mm, SCHDP = .485 mm, HDP = .242 mm, and CDS = .16 mm.

Dot Pitch of TV CRTs

Computer monitor specifications always include the dot pitch of the CRT. However, this information is rarely available for TVs. Why? The quick answer is that since TVs are always used at the same scan rate (except for multisystem international TVs), this information is not nearly as important for TVs as for high resolution multiscan computer monitors.

In general, the dot/slot/line pitch of TV CRTs is very large compared to even mediocre computer monitors. Here are some typical values which I measured very precisely (!!) by putting a machinest's scale against the screen. These are all slot mask type CRTs:

- 13 inch GE - .60 mm.
- 19 inch Samsung - .75 mm.
- 25 inch RCA - .9 mm.

Therefore, you can forget about trying to use one of these CRTs for your 1280x1024 high resolution PC or workstation. The dot/stripe pitch needed for 1280 pixels on a 25" tube would be about .3-.4 mm maximum. The pixels are about .35 mm. Typical high resolution CRTs for high resolution computer monitors have a dot/stripe pitch of .25 to .28 mm (I have heard of numbers as low as .22 mm in commercially available monitors).

CRT Aspect Ratio

Nearly all modern CRTs have a 4:3 aspect ratio (H:V). Of course, with HDTV, 16:9 will probably become standard but CRTs may be obsolete by then!

(From: Bob Myers (myers@fc.hp.com).)

The physical shape of the tubes themselves came through this evolution, but the aspect ratio assumed for the original transmission format specs WAS 4:3, as driven by Hollywood. Where did you think the shape of the masks came from?

The desired 4:3 aspect ratio standard was known right from the start, and the early TV designers DID realize that the use of round tubes to display this was a literal case of a "square peg in a round hole". Rectangular CRTs for TV use had been developed as early as 1939, with the first American rectangular tube to enter production in late 1949.

(See Peter Keller's very excellent "The Cathode Ray Tube: Technology, History, and Applications" for all the details.)

CRT Deflection Angle

What does this mean? What is the difference between a 110 degree tube and a 90 degree tube?

This is the maximum angle the beam makes with respect to the gun axis to fill the screen.

- All other factors being equal, a 110 degree tube is shorter than a 90 degree tube. This is the principle advantage of higher deflection angle CRTs.

- High deflection angles means higher deflection power for a given accelerating (2nd anode) voltage.

- Higher deflection angle CRTs are more difficult to converge and maintain focus, purity, and uniform brightness across the screen. Reducing geometric errors is more challenging. Yoke design is also trickier.

In the early days, 60 degrees was considered high tech. 110 degrees is about the practical limit for TV CRTs now. Give me a 90 degree CRT any day. Monitor tubes are usually 90 degrees.

CRT Contrast Ratio

(From: Don Stauffer (stauffer@htc.honeywell.com).)

Apparently CRTs have made quite an increase lately. Years ago when I looked into it, CRTs were not much better than about 20:1. Now, folks are claiming well over 40:1.

One thing to watch, though. The phosphor has two decay curves, a rapid one followed by a slow one. A change in scene can lower contrast ratio of a bar chart that appears in a region that was a large white area.

(From: Steve Eckhardt (skeckhardt@mmm.com).)

This comment makes me curious about the claims made by manufacturers of video projectors. Visually, their images have lots of resolution but mediocre contrast at large scale. A video monitor looks a lot better in contrast. The manufacturers, however, claim contrast ratios of 100:1 or better.

Are the numbers simply marketing hyperbole or have I missed something interesting?

There are several methods for arriving at the advertised numbers for contrast. One is to simply advertise the number for the imager and ignore the degradation due to the rest of the system. Another is to measure the illuminance of a white screen compared to a black screen. The best way is to use the ANSI method and advertise ANSI contrast, which is the practice at 3M. We really do sell projectors that achieve 100:1 contrast when measured by the ANSI standard. This is, however, a relatively recent achievement. LCD projectors are improving at a rapid rate.

CRT projectors are an alternate technology that I know little about, but they have characteristics that allow them to produce very high localized contrast. This can make displays and projectors based on CRT's look superior to anything an LCD can produce.

(From: Don Stauffer (stauffer@htc.honeywell.com).)

One big problem with LCD displays, projection or otherwise, is view angle. In order to cut off the light completely, polarization needs to be controlled to a couple of degrees. The LCD works by affecting the rotation, so many degrees per unit distance through the crystal. But the total path through the crystal depends on view angle. So max contrast may be only over a small field angle. Now, games can be played with this in projection optics, but it is hard.

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Effects of External Magnetic Fields on CRTs

Magnetic Interference and Shielding

When color CRTs must be operated in areas where the magnetic field causes unacceptable purity errors or distortion (either static or dynamic depending on whether the source is constant (as with the magnet in an MRI scanner or MegaBase(tm) loudspeaker) or changing (as with nearby motors, transformers, or even other monitors), there are several options (besides relocating):

- Passive shielding - soft magnetic materials (those that are easily magnetized and don't retain their magnetism) can effectively block modest strength magnetic fields. The best known of these for shielding purposes is called 'Mu-metal', an alloy of 76% nickel, 17% iron, 5% copper, and 2% chromium. (from Nelson and Parker, A.L.Physics).

  Advantages: simple (at least in priniple), doesn't care if conditions change (within specified field strength limits). Mu-metal can be very effective if used properly - but see below.

  Disadvantages: expensive and often ugly. The cost of a complete functional but not aesthetic enclosure for use of a color monitor near an MRI scanner was about $2,000 a couple of years ago when we needed to provide this for one of our customers. Check out MuShield specifically under "Monitor Enclosures" if you're curious. Less EMF, Inc. sells Mu-metal foil by the foot but what they have listed is rather thin - I don't know how well it would work for CRT shielding.

- Active compensation - a set of coils is energized with exactly the correct currents to cancel the effects of the interfering fields.

  Advantages: can be built inside the monitor using small coils in some cases.

  Disadvantages: must be engineered for each situation. Change almsot anything and it will no longer be effective even if feedback is used. Complex in practice since interfering field geometry is often not well behaved.

- Shielding can also sometimes be introduced at the source. See the section: Comments on Speaker Shielding.

  Advantages: will reduce interference for all monitors in the vicinity.

  Disadvantages: shielding location may not be readily accessible. Geometry offending device may not lend itself to a reasonable size or shape shield.

(From: Tony Williams (tonyw@ledelec.demon.co.uk).)

You can buy commercial Mu-metal screening cans and yes they are a complete enclosure, with small holes for the I/O wires.

Mu-metal is very expensive and not easy to work but will solder, especially with acid flux.

I suggest you try a dummy run first with some mild steel to get the design sorted and to test if it looks worth it.

You never know your luck, mild steel may do the job anyway and you may not want to deal with mu-metal (--- sam):

> "Just got my 10' sheet of mu-metal delivered today. It came very well packaged sandwiched between two pieces of wood so that it would not bend during shipment."

(From: James P. Meyer (jimbob@acpub.duke.edu).)

One of the reasons it came so well packaged was the fact that the magnetic properties are degraded if the material is bent or stressed in any way. Once you fabricate anything out of the mu-metal, you have to go through a high temperature annealing process to remove the stress and restore its full magnetic properties. If you don't do that, you are no better off with Mu-metal than you would be with tin-can stock.

Comments on Speaker Shielding

When loudspeakers - even those little speakers that came with your PC - are near TVs or monitors, there may be problems with the fringe fields of the powerful magnets affecting color purity, convergence, or geometry. Speakers designed to be used with PCs in close proximity to their monitor will likely include some internal shielding. This may even be effective. However, the large powerful loudspeakers used with high performance stereo systems will likely not have such shielding. The best solution where display problems have been traced to the loudspeakers is to move them further away from the TV or monitor (and then degauss the CRT to remove the residual magnetism). Where this is not possible, consider the special speakers designed to be used in closer proximity to CRTs. These have (or should have) specially shielded magnet structures or an additional magnet with its field set up to cancel the main magnet's fringe field which will minimize these effects.

Shielding of conventional speakers may also be possible:

(From: Lionel Wagner (ck508@freenet.carleton.ca).)

Put a Tin can over the magnet. This will reduce the external field by about 50%. If more shielding is desired, put additional cans over the first, in layers, like Russian dolls. (Note: a Tin can is actually made nearly entirely of steel - the term 'Tin' is historical. --- sam)

(From: Nicholas Bodley (nbodley@tiac.net).)

While both electrostatic and electromagnetic (E/M) fields can affect the paths of the electron beams in a CRT, only E/M fields are likely to be strong enough to be a problem.

Magnetic shields have existed for about a century at least. Some decades ago, a tradenamed alloy called Mu-Metal became famous, but it lost its effectiveness when bent or otherwise stressed. Restoring it to usefulness required hydrogen annealing, something rarely done in a home shop (maybe one or two in the USA).

More-recent alloys are much less fussy; tradenames are Netic and Co-Netic.

Magnetic shields don't block lines of force; they have high permeability, vastly more than air, and they guide the magnetism around what they are shielding; they make it bypass the protected items.

I have been around some shielded speakers recently, but never saw any disassembled. They looked conventional, must have had the "giant thick washer" (my term) magnet, and seemed to have a larger front polepiece than usual.

They had a shielding can around the magnet; there was a gap between the front edge of the can and the polepiece. I suspect that a second internal magnet was placed between the rear of the main magnet and the rear (bottom) of the can, so there would be minimal flux at the gap between the can and the front polepiece. Holding pieces of steel close to the gap between the can and the polepiece showed very little flux there.

Modern magnets are not easy to demagnetize, in general.

(From: Dave Roberts (dave@aasl.demon.co.uk).)

The *good* so-called magnetically screened speakers rely on two means of controlling stray flux. The static field from the magnet on the speaker (which would cause colour purity problems) is minimized by the design of the magnet. This is often at the expense of gap field linearity, leading to greater distortion - not that most users seem to worry about that...

The mains varying field is minimized by use of a toroidal mains transformer, but the more recent mains powered speakers seem to be coming with *plug top* PSUs, which take the problem further away.

Why Magnetic Fields May Cause the Picture to Rotate

One might think that the result of the Earth's or stray magnetic fields would only be for the picture to shift position slightly. Why isn't this the case?

Magnetic fields don't really 'pull' on charged particles, they result in a force at right angles to the field lines with a direction dependent on the charge (negative for electrons, positive for protons) and field (North or South). The magnitude of the effect also depends on the energy/speed of the particles and their mass. For the case of a CRT:

- If the field is horizontal with respect to the screen, the picture will mostly shift up or down.

- If the field is vertical with respect to the screen, the picture will mostly shift left or right.

- If the field is in the direction of the tube axis, electrons going toward the right will experience a shift in the opposite direction as those going toward the left (as the beam is deflected). Presto: The picture will rotate.

The actual direction of the Earth's magnetic field experienced by the CRT depends on the latitude and includes both horizontal and vertical components - horizontal at the equator and becoming progressively angled toward the poles (with opposite polarities - N or S - depending on which hemisphere it is in). This is the main reason that TVs and monitors really need to be set up slightly differently depending on location (hemisphere and latitude). And, of course, local magnetic conditions also affect this including geologic formations and other equipment and wiring which produce magnetic fields.

The rotation knob or setting ion some TVs and monitors varies the current in a coil wrapped around the CRT bell just beyond the neck which has its axis parallel to the CRT's axis and adds a magnetic field to counteract the component of the ambient field along that direction.

Best Direction to Face a Monitor?

One would think that the magnetic field of the earth is inconsequential compared to what is used to drive a CRT. While the reasons this is not true should be obvious from other sections of this document, some would still call worrying about such issues as the direction of the monitor nonsense.

(From: Bob Myers (myers@fc.hp.com).)

No, it's not nonsense. The fields generated by the deflection coils, etc., ARE much greater in magnitude than the Earth's field, but they're AC fields. The DC offset of these fields is relatively small, and the Earth's field (also DC) IS sufficient to cause a visible shift in the position of the raster and affect the beam landing, etc.. This is why, for instance, there ARE often problems when trying to use a "Northern hemisphere" monitor in the Southern hemisphere.

Having said that, however, this isn't really something the average user needs to worry about. In the detailed specs for any monitor, there generally ARE a set of specific ambient conditions under which certain performance specs are intended to be checked. These usually include the ambient magnetic fields (which also tells you what magnetic environment was used at the factory for adjustment), and the orientation of the monitor within those fields. For the vast majority of monitors, the specified ambient conditions simulate average magnetic fields in the U.S. or Europe (which are very similar), and the monitor is specified as facing east or west within those fields. Strictly speaking, one has to establish those conditions (and so match the factory adjustment environment) in order to evaluate the monitor for compliance with these specifications.

Monitors are aligned in whatever field the manufacturer (or large OEM customer) SPECIFIES. This USUALLY involves an east or west alignment, as this results in no field component in the CRT's Z-axis (the axis "down the throat" of the CRT, perpendicular to the center of the screen).

However, this doesn't necessarily mean that optimum performance at YOUR location will be obtained with the unit facing east or west, as local fields can vary considerably from the specified nominal field. The field identified in the specs is just that - it is part of the conditions under which those specifications are to be checked.

But the *specific* conditions for a given installation can vary considerably from the nominal, and so the only advice I can give the individual user is that if you're happy with the performance, don't worry about it. If you DO think that a local DC field (the Earth's field or any other) is causing a problem, THEN try to move or rotate the unit to see if you can find a better orientation or location. Of course, *AC* fields, such as those from a nearby power line or electrical equipment, are something else entirely.

Ways Around North/South or Other Sensitivity to Magnetic Fields?

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

They use magnetic field compensation for the professional types. This is too expensive for us mortals, so we get a CRT that has been optimized for one field condition only: North, South or Neutral. Not all displays are CRTs. LCDs for instance are not sensitive to the earth magnetic field. And not all CRTs use a shadow mask for colour selection. For instance, in Tektronix colour oscilloscope they use a white CRT with a colour LCD shutter in front of it. That too would not be affected too much by the earth magnetic field.

You see, plenty of ways out for aircraft, ships, and the Space Shuttle.

Additional Comments/Summary on Northern/Southern Hemisphere Issues

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

- The vertical component of the earth magnetic field varies as a function of latitude, particularly between hemispheres a vertical magnetic field will influence the color purity of a CRT.
- The magnetic shielding of a CRT will, after degaussing, not provide complete compensation for the vertical field, especially for the space between shadow mask and screen.
- That's why manufacturers produce different displays for different hemispheres: northern, southern and neutral. They do this by adjusting for optimum purity in a simulated magnetic field.

Where you have a TV or monitor that was manufactured for a different location, your options (apart from tossing it) are:

- Re-adjust the purity, this involves moving the deflection coil, adjustment magnets, adding more magnets, etcetera. This is a big job and success would not be guaranteed.
- Simulate a southern hemisphere location by creating a vertical magnetic field around the TV, put two big multi-turn wire loops (Helmholtz coils) above and below the TV and run a DC current through them. Might be expensive and certainly would provide a 'different' look!
- Replace the picture tube with a northern hemishpere type, this is very expensive.
- Mount the picture tube upside-down inside the TV cabinet. Then reverse the wires for the line (H) and field (V) deflection to put the picture correct side up again.

  For this case, you might have some problems with:

  - The mounting nuts for the tube are hard to reach and may have left thread (look carefully before turning!
  - The wires to the inverted picture tube panel being too short, they can probably be easily extended.
  - The distance between high-voltage anode connection and the chassis (circuits) being too short (safety!)
  - Condensation dripping into the anode contact.

  Bang & Olufsen once made a compact style television where they wanted the anode contact to be away from the top of the cabinet, so the back cover could fit tighter. So they mounted the tube upside-down.

> Consequently they had to order southern hemisphere tubes for a northern hemisphere TV set. That works, of course.

Orientation Considerations for Projection TVs

Projection TVs do have have CRTs with shadow masks or aperture grills but nonetheless can be affected by magnetic fields. In fact, it is possible that degaussing could even be needed if a strong magnet were somehow placed near the set - but how would THAT happen? :-)

> "Any truth to the rumor that how you position a projection TV in a room (N,E,S,W) can affect the image quality? Does the Earth's magnetic field truly have that much of an effect."

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

Yes, it is true.

It makes a difference whether you talk about a front or rear projector. Front projectors are expensive and critical enough that they will be converged after installation, so that takes care of any convergence errors. Purity errors are of course no issue with 3 separate CRTs...

Rear projectors are converged in the factory, the customer does only the static convergence (4 pots) after he has decided which direction the set will face. This takes care of problems due to the horizontal component of the earth agnetic field.

In a rear projector the CRTs are mounted almost vertically. The vertical component of the earth magnetic field causes a rotation error. Normally this is not an issue because that component does not depend on the orientation of the set and it is more or less constant over the entire continent.

It makes a biiiig difference though if you manufacture PTVs in Belgium and then export them to Australia... That means opening the cabinet and re-adjusting for rotation.

A front projector has its tubes mounted horizontally. The rotation error will depend on the direction the set is facing. This is easily adjusted through the convergence.

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Picture Quality and Appearance Issues

Why Does the Intensity Appear So Non-Uniform in Bright Areas?

Actually, the intensity variation is likely to be even worse than you might think - possibly as much as 2:1 from the center to the corners. In most cases you do not notice it. With large deflection angle tubes, fewer electrons make it to phosphor dots near the edge of the screen. It is simple geometry.

(From: Bob Myers (myers@fc.hp.com).)

It is extremely difficult for any CRT display to maintain perfect brightness and color uniformity across the entire image. Just the geometry of the thing - the change distance from the gun to the screen as the beam is scanned, the changing spot size and shape, etc. - makes this nearly impossible, and there can also be variations in the phosphor screen, the thickness of the faceplate, etc.. Typical brightness-uniformity specs are that the brightness won't drop to less than 70% or so of the center value (usually the brightest spot on the screen).

On color tubes, the lack of perfect brightness uniformity is aggravated by the lack of perfect *color* uniformity and purity. What appear to be "dark spots" on a solid gray image may actually be beam mislanding (color purity) problems, which may to some degree be remedied by degaussing the monitor.

Again, *some* variation is normal; if you think you're seeing too much, you can try degaussing the thing and seeing if that helps. If it doesn't, then the question is whether or not the product meets its published specs, and that is something you'll have to discuss with the manufacturer or distributor.

Comments On Color Purity, Set Orientation, and Doming

> "The problem with my TV is that bright parts of the picture change color. For example, white areas may shift towards yellow or blue depending on the orientation of the set.
>
> What are the possible causes of doming? I have noticed that the magnitude of the doming effect varies with TV orientation even after degaussing several times at the new orientation. Does this help identify the cause of the doming in my case?"

(Portions from: Jeroen Stessen (Jeroen.Stessen@philips.com).)

The problem with regular shadow masks is 'doming'. Due to the inherent principle of shadow masks, 2/3 or more of all beam energy is dissipated in the mask. Where static bright objects are displayed, it heats up several hundred degrees. This causes thermal expansion, with local warping of the mask. The holes in the mask move to a different place and the projections of the electron beams will land on the wrong colours: purity errors. The use of invar allows about 3 times more beam current for the same purity errors.

Both local doming and magnetic fields compete for the remaining landing reserve. Due to improper degaussing, the doming problem may be more visible. And applying a tube designed for the wrong hemisphere may very well increase the doming complaints. It is possible to deliberately offset the nominal landing in order to get more doming reserve (the shift due to doming is always to the outside of the tube). You would do this using spoiler magnets put in the right places.

Permanently setting the contrast lower is not a real cure because the customer might not like such a dark picture. A better picture tube (Invar shadow mask) *is* a good cure (in most cases) but there is the cost price increase. (This is mainly due to the fact that Invar metal is harder to etch.)

Also see the section: What is Doming?.

Difference in Color Rendition Between CRTs

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

There can be several reasons why primary colours (especially red) may look different between picture tube brands:

1. Different phosphor composition. In the beginning everybody was looking for the phosphors with the highest luminous efficiency. Nowadays with the trend to avoid heavy metals, particularly cadmium, in consumer products the composition had to be changed. This shifts the colour point.

2. Back scattering. Not all electrons that hit the shadow mask are absorbed. In fact, a quite high percentage is scattered back into the empty space between gun and mask. If they bounce back again from internal metal parts, then they may find their way to the screen and activate an arbitrary phosphor element. This increases the black level and reduces saturation of the primary colours. Red turns a bit towards orange. Even with good phosphors, large area colours will be less than perfect. Triple-CRT projection TVs do not have this problem, fantastic red!

3. Colour filters. Toshiba has developed a process where they put individual colour filters between glass and phosphor. This makes the black much better and also improves the colour points when unwanted spectral lines are suppressed.

4. There can also be differences with respect to the NTSC system, like wrong matrix from YUV to RGB. The definition in the Japanese NTSC system differs from the USA NTSC system and the signal processing should take that into account.

Contour Lines on High Resolution Monitors - Moire

These fall into the category of wavey lines, contour lines, or light and dark bands even in areas of constant brightness. (Some people may refer to this phenomenon as "focus or Newton's rings".) These may be almost as fine as the dot pitch on the CRT or 1 or 2 cm or larger and changing across the screen. If they are more or less fixed on the screen and stable, then they are not likely to be outside interference or internal power supply problems. (However, if the patterns are locked to the image, then there could be a problem with the video board.)

One cause of these lines is moire (interference patterns) between the raster and the dot structure of the CRT. Ironically, the better the focus on the tube, the worse this is likely to be. Trinitrons, which do not have a vertical dot structure should be immune to interference of this sort from the raster lines (but not from the horizontal pixel structure).

You can test for moire by slowly adjusting the vertical size. If it is moire, you should see the pattern change in location and spatial frequency as slight changes are made to size. Changes to vertical position will move the patterns without altering their structure - but they will not remain locked to the moving image.

If they are due to the raster line structure - your focus is too good - the patterns will remain essentially fixed in position on the face of the CRT for horizontal size and position adjustments - the patterns will remain fixed under the changing image.

How to eliminate it? If moire is your problem, then there may be no easy answer. For a given resolution and size, it will either be a problem or not. You can try changing size and resolution - moire is a function of geometry.

Ironically, I have a monitor which is nicer in this respect at 1024x768 interlaced than at 800x600 non-interlaced.

Some monitors have a 'Moire Reduction Mode' switch, control, or mode. This may or may not be of help. One way to do this is - you guessed it - reduce the sharpness of the beam spot and make the picture fuzzier! You might find the cure worse than the disease.

Another cause of similar problems is bad video cable termination creating reflections and ghosting which under certain conditions can be so severe as to mimic Moire effects. This is unlikely to occur in all colors with a VGA display since the termination is internal to the monitor and individual resistors are used for each color (RGB).

I think it is ironic that some people will end up returning otherwise superb monitors because of moire - when in many cases this is an indication of most excellent focus - something many people strive for! You can always get rid of it - the converse is not necessarily true!

Moire and Shadow Mask Dot Pitch

(From: myers@fc.hp.com (Bob Myers).)

The density of the holes in the shadow mask set an upper limit on the resolution supported by that monitor. Lower resolutions work just fine; there is no need to have the logical pixels in the image line up with the physical holes in the mask (nor is there any mechanism to make this happen), and so you can think of this as the "larger pixels" of the lower-res image simply covering more than one hole or slot in the mask.

As the effective size of the pixels in the image approach the spacing of the mask holes, individual pixels are no longer guaranteed to cover enough phosphor dots on the screen to ensure that they are constant color or constant luminance, but an image will still be displayed which ON AVERAGE (over a reasonably large area) looks OK. Actually, the specified "top end" format ("resolution") for most monitors usually is at or slightly beyond this point - the effective pixel size is somewhat UNDER the dot pitch.

Isolated Spots on Display

These could be a problem with the video source - bad pixels in the video card's frame buffer or bad spots on a camcorder's CCD, for example. Or, they could be dirt or dead phosphor areas in the CRT. Except for problems with the on-screen character generator, it is unlikely that the monitor's circuitry would be generating isolated spots.

You can easily distinguish between video problems and CRT problems - missing pixels due to the video source will move on the screen as you change raster position. CRT defects will remain stationary relative to the screen and will generally be much more sharply delineated as well.

There is a specification for the number and size of acceptable CRT blemishes so you may have to whine a bit to convince the vendor to provide a replacement monitor under warranty.

Purple Blob - or Worse

Have you tried demagnetizing it? Try powering it off for a half hour, then on. Repeat a couple of times. This should activate the internal degausser. See the section: Degaussing (Demagnetizing) a CRT.

Is there any chance that someone waved a magnet hear the tube? Remove it and/or move any items like monster speakers away from the set.

Was your kid experimenting with nuclear explosives - an EMP would magnetize the CRT. Nearby lightning strikes may have a similar effect.

If demagnetizing does not help, then it is possible that something shifted on the CRT - there are a variety of little magnets that are stuck on at the time of manufacture to adjust purity. There are also service adjustments but it is unlikely (though not impossible) that these would have shifted suddenly. This may be a task for a service shop but you can try your hand at it if you get the Sams' Photofact or service manual - don't attempt purity adjustments without one.

If the monitor or TV was dropped, then the internal shadow mask of the CRT may have become distorted or popped loose and you now have a hundred pound paper weight. If the discoloration is slight, some carefully placed 'refrigerator' magnets around the periphery of the tube might help. See the section: Magnet Fix for Purity Problems - If Duct Tape Works, Use It!.

It is even possible that this is a 'feature' complements of the manufacturer. If certain components like transformers and loudspeakers are of inferior design and/or are located too close to the CRT, they could have an effect on purity. Even if you did not notice the problem when the set was new, it might always have been marginal and now a discoloration is visible due to slight changes or movement of components over time.

Magnet Fix for Purity Problems - If Duct Tape Works, Use It!

The approach below will work for slight discoloration that cannot be eliminated through degaussing. However, performing the standard purity adjustments would be the preferred solution. On the other hand, the magnets may be quick and easy. And, where CRT has suffered internal distortion or dislocation of the shadow mask, adjustments may not be enough.

In any case, first, relocate those megablaster loudspeakers and that MRI scanner with the superconducting magnets.

The addition of some moderate strength magnets carefully placed to reduce or eliminate purity problems due to a distorted or dislocated shadow mask may be enough to make the TV usable - if not perfect. The type of magnets you want are sold as 'refrigerator magnets' and the like for sticking up notes on steel surfaces. These will be made of ferrite material (without any steel) and will be disks or rectangles. Experiment with placement using masking tape to hold them in place temporarily. Degauss periodically to evaluate the status of your efforts. Then, make the 'repair' permanent using duct tape or silicone sealer or other household adhesive.

Depending on the severity of the purity problem, you may need quite a few magnets! However, don't get carried away and use BIG speaker or magnetron magnets - you will make the problems worse.

Also note that unless the magnets are placed near the front of the CRT, very significant geometric distortion of the picture will occur - which may be a cure worse than the disease.

WARNING: Don't get carried away while positioning the magnets - you will be near some pretty nasty voltages!

(From: Mr. Caldwell (jcaldwel@iquest.net).)

I ended up with the old 'stuck on a desert island trick':

I duck taped 2 Radio Shack magnets on the case, in such a way as to pull the beam back.!!!!

A $2 solution to a $200 problem. My friend is happy as heck.

RCA sells magnets to correct corner convergence, they are shaped like chevrons and you stick them in the 'right' spot on the rear of the CRT.

How Much Tilt is Acceptable?

This was in reply to a concern that a 1 degree tilt on a 27" TV was a problem. Yes, you may not like it, but unless there is a user tilt adjustment, the laws of physics prevail!

(From: David Kuhajda (dkuhajda@mail.locl.net).)

A 1 degree tilt given the effect of the earth's magnetic field is well within tolerance for a 27" TV set. The larger the picture tube, the more the tilt effect of the earth's magnetic field is noticeable. Even a shielded speaker may have just enough magnetic field to cause some slight tilt. 1 degree, however, is anything but a serious problem. Probably you would notice it you turned the TV 180 degrees on its axis that the tilt would then be going the other was. Factory standard is to have the picture straight when the back of the TV set is facing magnetic north. The actual measured tilt we have seen is as much as 3 degrees on a 36" tv set. This is why the higher-end larger TV sets have an adjustment for picture tilt.

What is Doming?

The shadow or slot mask inside the CRT is a thin sheet of steel or InVar positioned a half an inch or so behind the phosphor screen. The flatter the screen, the more susceptible it will be to thermal expansion effects: With individual phosphor dots spaced as as little as .13 mm apart (for a .22 mm dot pitch CRT), it doesn't take much inaccuracy in their position to result in a noticeable effect. (See the section: How to Compute Effective Dot Pitch.) As a result, high resolution CRTs tend to be more susceptible to doming problems.

(Portions from: Jac Jamar (jamar@comp.snads.philips.com).)

1. Doming is a deformation of the shadow mask or its support structure caused by heating and subsequent expansion in bright (high beam current) areas of the picture. This causes a shift in position of the finely spaced holes or slots in the mask. The result will be color purity problems - discoloration and brightness variations. For a .28 mm dot pitch CRT, a change of only .14 mm in the position of a hole or slot can totally shift the display from one of the primary colors to another.

2. InVar shadow masks can sustain a significantly higher current density than steel shadow masks (by as much as 3:1) without noticeable problems.

Trinitrons are more resistant to local doming effects as long as the wires are under enough tension. However, expansion of the suspension components can still result in doming with an overall bright picture.

3. The onset and disappearance of color purity problems will generally lag the cause due to the thermal mass of the affected components. For local heating resulting from picture highlights, this will be only a few seconds since the thermal mass of a small area of the mask is not that great. However, for effects having to do with expeansion of the suspension or support structure, it may take up to 30 minutes to reach equilibrium.

4. The orientation of the TV or monitor with respect to the earth's magnetic field and even whether the CRT was set up for the Northern or Southern hemispheres may affect the resulting color shift. Thus, the picture may tend toward yellow while the monitor is facing one way and blue when rotated 180 degrees on its base (even if degaussed at each position).

5. Reducing the brightness/contrast or setting the brightness limiter will prevent doming but may result in an unacceptably dark picture.

6. Shadow mask doming in itself is not something that becomes defective and has to be repaired. It is a characteristic of the CRT assembly. However, shifts in the position of purity adjustments can results in increased sensitivity to slight doming.

Purity problems resulting in discolouration and/or brightness variations are due to mislanding of the microscopic electron beams (the electron beams after the mask) on the red/green/blue phosphor stripes or dots. The mislanding is in general caused by:

- Influences of ambient magnetic fields (such as the earth magnetic field).
- Shadow mask doming.
- Tolerances occurring in the production of CRTs.
- Less than optimal setup of the purity adjustments (yoke position, rings on CRT neck, etc.

Only when the sum of these influences exceeds the 'guardband' provided in the CRT design, discolouration (or brightness variations) becomes visible.

If discolouration complaints arise, this will normally not be due to changes in doming behaviour, but to changes in shielding against magnetic fields.

The ambient magnetic fields are shielded by means of iron components inside (or sometimes outside) the tube, which have to be 'degaussed' to give good shielding. For this in a set degaussing coils and circuits are provided. A discolouration complaint will thus often be due to insufficient degaussing.

- TV sets and monitors which are kept in 'stand-by' mode for a long time may never be degaussed adequately because the degaussing circuit may only operate for a short time after the unit is switched on from cold - whether this is so with your unit depends on the design). In this case, they can pick up magnetic fields from magnets moved nearby or other equipment.

The solution in this case is to switch the TV or monitor completely off or pull the plug if in doubt, let it cool down for half an hour or longer and switch it on again. If necessary this procedure can be repeated a few times (I had to do this at home once when my children had been playing with magnets). For monitors with degauss buttons, you can usually hear a hum when the degauss is activated.

- Similarly, if the orientation of a unit with respect to the earth's magnetic field is changed, it requires degaussing. So if you put your TV in another corner of the room or rotate your computer monitor on its tilt-swivel base, you have to activate its degauss circuitry (by letting it cool down or in the case of a high-end monitor, using its degauss button) or degauss it manually (see the section: Degaussing (Demagnetizing) a CRT).

- The PTC resistor (thermistor or posistor) in the degaussing circuit can become defective. This prevents proper degaussing after switch-on.

Since lower resolution CRTs are used for most TVs compared to similar size computer monitors, doming would not be nearly as much of a problem if they were both run at similar brightness (energy density) levels. However, TVs are very often used at higher brightness levels resulting in more of a thermal load on the mask which offsets the lower resolution.

Afterglow - Phantom Patterns on CRT After Shutoff

Why is there a splotch of colored light at the center of the CRT after I kill power to my TV? Why does this not happen if the plug is pulled instead? It seems to last for hours (well maybe minutes at least).

(Portions of the following from a video engineer at Philips.)

A broad diffused glow (not a distinct spot in the middle of the screen) that lasts for a few seconds to minutes is called 'afterglow' and may be considered 'normal' for your model. The warm CRT cathodes continue to emit electrons due to the high voltage that is still present even though the signal circuits may have ceased to operate.

For more sharply defined spots there are two phenomena:

1. Thermal emission from a cathode that has not yet cooled off (and this could take several minutes) gives a more or less circular spot near the centre. It is actually 3 spots from the 3 cathodes, we at Philips call them 'Christmas balls'.
2. Field emission from sharp whiskers on any electron gun part gives a much sharper spot, sometimes with a moon-shaped halo around it. Even with the filament off, there may be some electron emission from these sharp points on the cold cathode(s) due to the strong high voltage (HV) electric fields in the electron gun. I do not know how likely this is or why this is so.

The shape of the spot is an inverted image of the shape of the emitting area(s) on the electron guns cathodes.

The visibility of both effects depends in the same way on the decay time of the high voltage (HV/EHT) on the anode.

When turned off with the remote or front panel button, you are not actually killing AC power but are probably switching off the deflection and signal circuits. This leaves the HV to decay over a few minutes or longer as it is drained by the current needed to feed the phantom spot or blob.

When you pull the plug, however, you are killing AC input and all the voltages decay together and in particular, the video signal may be present for long enough to keep the brightness (and beam current) up and drain the HV quickly. Whether this actually happens depends on many factors - often not dealt with by the designers of the set.

A proper design (who knows, yours may simply have been broken from day 1 or simply be typical of your model) would ensure that the HV is drained quickly or that the other bias voltages on the CRT are clamped to values that would blank the CRT once the set is off. If the problem developed suddenly, then this circuitry may have failed. On the other hand, if it has been gradually getting more pronounced, then the characteristics of the CRT or other circuitry may have changed with age.

In most sets it is left to chance whether the picture tube capacitance will be discharged by beam current at switch-off. It may simply be due to the behaviour of the video control IC when its supply voltage drops that causes the cathodes to be driven to white and this may not be formally specified by the manufacturer of the IC. Some of of the latest sets have an explicit circuit to discharge the EHT at shutdown.

As noted in the section: "Safety guidelines" the HV charge on the CRT capacitance can be present for a long time. A service technician should be very aware of that before touching HV parts!

Interestingly, most sets for the Asian Pacific market have a bleeder resistor built in that will discharge the EHT without the need for a white flash at switch-off. These will in fact drive the beam to black at switch-off via a negative voltage to the CRT G1 electrode. The AP market is very sensitive to proper set behaviour, they don't like a white flash.

In short, it all depends on the demands of the particular market, the chance of the picture tube producing a spot/blob, and the mood of the designer.

So, it may not be worth doing anything to 'fix' this unless the splotch is so bright (more so than normal video and for an extended time) that CRT phosphor damage could result. This is usually not a problem with direct view TVs but would definitely be a concern with high intensity projection tubes.

On the other hand, your phantom blob may provide for some interesting conversation at your next party!

Discussion on the causes of color flare

On the right side of high intensity colors, some CRTs will exhibit a flare - the color will appear to be stuck at its highest level. This often occurs with older CRTs even at modest drive but can usually be forced to happen with any CRT if the drive level is turned up very high.

(From: Andy Cuffe (baltimora@psu.edu).)

I think it's due to the electron gun clipping when it's overdriven. Even a new CRT will bleed if it's driven hard enough, but most TVs are designed so you can't turn up the contrast that much. Once the CRT goes into clipping, it must take a short time to start working normally again after the drive level falls below clipping. The same thing happens when certain problems develop in the video amp.

All CRTs do it when they get weak enough. Samsung seem to be worse than most. In general, all CRT manufacturers have been cutting costs. A larger percentage or 8 year old or newer TVs that I see have bad CRTs than ones that are more than about 16 years old. I just picked up a heavily used 1982 Zenith from the side of the road and it has a better looking CRT than most new TVs.

(From: Michael Shell (mikes1987@yahoo.com).)

I suspect that you may be right. I used to work a lot on older tube color televisions and I don't recall the bleeding problem. The first time I remember seeing it was on a 1978 Sampo. I have seen it EVERYWHERE since then. Has anybody seen the problem on a, say 1970, tube type set with good video drivers and correct CRT voltages (so you know it to be the CRT).

(From: Andy.)

My theory is that a weak CRT (or a good one with reduced G2) represents a higher impedance load to the video output transistor. The biasing of the video outputs would have to be designed for the load created by a good CRT. When the output load impedance goes high enough, the voltage can go high enough to saturate the transistor (the CRT isn't pulling enough current to keep the C-E voltage from going close to 0).

tubes, being like FETs (in that they are majority carrier devices) which are used in high speed digital circuits because don't have any delay in getting out of saturation.

(From: Michael.)

I think we may have a winner. A scope on the cathode should be able to confirm it.

(From: JURB6006 (jurb6006@aol.com).)

Hmm, that's one of most technical questions I've heard in a while.

First of all, realize that most sets do this with a lowered G2 voltage. While on the surface, lowering the G2 seems to mimic a weak CRT, this is not the case. Only in some ways it does, apparently.

Some sets have an unusual resistance, and others seem to have an unusual propensity to "bleed" (we call it flaring at my shop).

I was around before ICs, and have had an opportunity to study the design of the video output circuit(s) of TVs without ICs. I do understand circuit design, and have reached the following conclusion (this completely excludes sets with AKB):

It depends on how the video output transistors are driven. It seems that if there is a path for current feedback, the set will flare. This is the worst in sets that drive the emitters of the outputs.

Other sets, which could be designated as "voltage drive sets" either have such solid drive to the emitters that CRT load doesn't affect it or they just drive the base(s) of the outputs.

Engineering-wise, I think it basically boils down to the output impedance of the video output stage, and on a single ended stage, as most are and were, this impedance is different for negative and positive going slopes in the waveform.

There are other theories, this is only one. I speak of this because the flaring effect was almost always noticed on some chassis, back when all the CRTs were interchangeable. It followed the set, not the CRT.

(From: Michael.)

OK, I agree with what you are getting at here. Consider what happens when a transistor is overdriven. There are so many excess carriers in the device that it takes a long time for recombination to occur. This delay will result in the transistor taking a longer than normal time to switch off.

As noted above, often bad video driver circuitry/designs can cause bleeding (flaring) too. These cases could be caused by overdriven transistors (see above), feedback loops, or some type of ringing effect. I am interested in this as well, but my real fascination is when the CRT is the trouble maker.

Unlike a semiconductor, a CRT is a pure majority carrier device - no holes, just electrons flying around in there.

What bothers me is this: Say we have a test pattern consisting of a solid red square in the middle of an otherwise black screen. We turn up the saturation/contrast (and have a weak CRT), we will see bleeding to the right of the square. Instinctively, we FEEL we know what is going on. But think about it. The instant the electron beam leaves the square, the voltages on the CRT grid/cathodes are such (or should be) that the red gun should be shut off. (It is only like a nanosecond from the gun to the screen.) If the CRT cathode is weak, or the G2 voltage is too low, then I would expect the beam to cutoff even faster! Yet, the phosphors in the bleed DO see electrons exciting them! So, what is happening here? Did charge somehow build up somewhere in the tube? OR has the tube changed properties in such a way to cause trouble for the video output stages in a manner which would cause problems like Jurb6006 suggested? In the later case, it should be possible to design or modify the output stages to be resistant or immune to this problem. (I am not suggesting it would be worth it though).

The thing I really despise is that it seems to happen on CRTs that still have perfectly acceptable brightness.

(From: JURB6006.)

When they flare, yet the CRT isn't weak, it is usually due to a low collector Supply voltage to the vid outs. Unfortunately there is no way to tell on a normal scope whether the effect is being driven to the CRT or if the effect is IN the CRT.

Actually on what I call "voltage driven" units, you CAN see some type of clipping when either the CRT is weak or the G2 is low, but let's say on an older Sony, it seems like the clipping is omnidirectional.

Yet when this happens, the purity is not extremely affected.

On the sets that flare profusely, is it possible that the designers stumbled on a rudimentary form of AKB?

(From: Asimov (warpcastgate@dynip.com.)

It's analogous to how speakers and amps distort when the clip. When the clipping occurs in the CRT it's bandwidth falls to zero and you see then a type of ringing or smear. It's like the beam gets cutoff then saturates repeatedly very fast at a video rate. Also the electrostatic voltages which set the convergence get all thrown out of whack when this happens. This last is why a CRT with weak emission will also show poor purity, bad convergence, and a loss of tracking.

(From: Andy.)

I wonder if it would be possible to modify the video output circuit to eliminate the bleeding in a TV with a weak CRT that's not too far gone to be usable?

(From: Michael.)

I plan to try this in the next month or so. If I have any luck, I will post the results. In order to do this, voltages are gonna have to climb to keep that transistor out of saturation. This is going to result in more heat. Could it be possible that energy conservation mandates from the government resulted in flaring? If so, the same thing that causes my CRTs to flare also causes my toilet and shower to lose power.

From the point of view of the cathode, the CRT is a current controlled device like a BJT. From the point of view of the grid, it is a voltage controlled device, like a MOSFET. I can't remember why the video drive is applied to the cathodes rather than the grids, but I know there was/is a good reason.

So, barring a radical change, such as CRT grid drive, I think we want to use BJTs, but we need total control over Ik, regardless of how Mr. CRT feels. So, we would drive the CRT cathode with the NPN BJT collector, and have a fairly large Vce - which implies a bigger transistor with more heat sinking. I had thought of an alternative - using a transistor that comes out of saturation faster, but as you mentioned before, we lose detail in saturation and thus would still not like the resulting picture. Another simple solution would be to "tweak a few V's".

Instinctively, I feel we can do this. Then why haven't the OEMs?

I thought up some humorous explanations for flaring during the course of this discussion. Maybe somebody will get a laugh:

1. A crust spot on the cathode, which only emits at high drive levels, causes the electrons that pass through it to have a reduced velocity - by a factor of a 10000. These delayed electrons form the flare.

2. The front of the cathode starts to wear out. Under high drive levels, electrons are emitted from the BACK of the cathode. The G2 voltage then pulls them around, but the result is a corkscrew spiral path to the screen whose total linear length is on the order of a 1000 feet. Hence the delay. Purity is not affected due to "circular symmetry".

3. A crust forms on the cathode. Under high drive levels, electrons are trapped within the layers of this crust. Even when the video drive cuts off current to the cathode, the trapped electrons continue to leak to the surface resulting in a flare. This is known as the "cathode becomes a capacitor" theory.

4. The phosphor of old CRTs become "flaky". When hit by electrons, ionic radiation is emitted radially outward. This radiation makes other adjacent phosphors super sensitive to future electron exposure.

Hence, we are able to see a nearly zero electron beam which results in the flare.

And finally:

5. It's all in your head. Buying a new TV raises endorphens in the human brain, fixing the problem for a couple years. This also explains why more expensive, feature rich TVs have the problem less often. The CRT restorer should be applied to the USER not the TV. In skillful hands, it can also cure one of "color vision" allowing the use of much more inexpensive B/W sets.

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Magnetic Fields and Degaussing

Degaussing (Demagnetizing) a CRT

Degaussing may be required if there are color purity problems with the display. On rare occasions, there may be geometric distortion caused by magnetic fields as well without color problems. The CRT can get magnetized:

- if the TV or monitor is moved or even just rotated.
- if there has been a lightning strike nearby. A friend of mine had a lightning strike near his house which produced all of the effects of the EMP from a nuclear bomb.
- If a permanent magnet was brought near the screen (e.g., kid's magnet or megawatt stereo speakers).
- If some piece of electrical or electronic equipment with unshielded magnetic fields is in the vicinity of the TV or monitor.

Degaussing should be the first thing attempted whenever color purity problems are detected. As noted below, first try the internal degauss circuits of the TV or monitor by power cycling a few times (on for a minute, off for at least 20 minutes, on for a minute, etc.) If this does not help or does not completely cure the problem, then you can try manually degaussing.

Note: Some monitors have a degauss button, and monitors and TVs that are microprocessor controlled may degauss automatically upon power-on (but may require pulling the plug to do a hard reset) regardless of the amount of off time. However, repeated use of these 'features' in rapid succession may result in overheating of the degauss coil or other components. The 20 minutes off/1 minute on precedure is guaranteed to be safe. (Some others may degauss upon power-on as long as the previous degauss was not done within some predetermined amount of time - they keep track with an internal timer.)

Commercial CRT Degaussers are available from parts distributors like MCM Electronics and consist of a hundred or so turns of magnet wire in a 6-12 inch coil. They include a line cord and momentary switch. You flip on the switch, and bring the coil to within several inches of the screen face. Then you slowly draw the center of the coil toward one edge of the screen and trace the perimeter of the screen face. Then return to the original position of the coil being flat against the center of the screen. Next, slowly decrease the field to zero by backing straight up across the room as you hold the coil. When you are farther than 5 feet away you can release the line switch.

The key word here is ** slow **. Go too fast and you will freeze the instantaneous intensity of the 50/60 Hz AC magnetic field variation into the ferrous components of the CRT and may make the problem worse.

WARNING: Don't attempt to degauss inside or in the back of the set (near the CRT neck. This can demagnetize the relatively weak purity and convergence magnets which may turn a simple repair into a feature length extravaganza!

It looks really cool to do this while the CRT is powered. The kids will love the color effects.

Bulk tape erasers, tape head degaussers, open frame transformers, and the "butt-end" of a weller soldering gun can be used as CRT demagnetizers but it just takes a little longer. (Be careful not to scratch the screen face with anything sharp. For the Weller, the tip needs to be in place to get enough magnetic field.) It is imperative to have the CRT running when using these whimpier approaches, so that you can see where there are still impurities. Never release the power switch until you're 4 or 5 feet away from the screen or you'll have to start over.

I've never known of anything being damaged by excess manual degaussing as long as you don't attempt to degauss *inside* or the back of the TV or monitor - it is possible to demagnetize geometry correction, purity, and static converence magnets in the process! However, I would recommend keeping really powerful bulk tape erasers-turned-degaussers a couple of inches from the CRT.

If an AC degaussing coil or substitute is unavailable, I have even done degaussed with a permanent magnet but this is not recommended since it is more likely to make the problem worse than better. However, if the display is unusable as is, then using a small magnet can do no harm. (Don't use a 20 pound speaker or magnetron magnet as you may rip the shadow mask right out of the CRT - well at least distort it beyond repair. What I have in mind is something about as powerful as a refrigerator magnet.) Also see the juggler's technique, below. :-)

Keep degaussing fields away from magnetic media. It is a good idea to avoid degaussing in a room with floppies or back-up tapes. When removing media from a room remember to check desk drawers and manuals for stray floppies, too.

It is unlikely that you could actually affect magnetic media but better safe than sorry. Of the devices mentioned above, only a bulk eraser or strong permanent magnet are likely to have any effect - and then only when at extremely close range (direct contact with media container).

All color CRTs include a built-in degaussing coil wrapped around the perimeter of the CRT face. These are activated each time the CRT is powered up cold by a 3 terminal thermister device or other control circuitry. This is why it is often suggested that color purity problems may go away "in a few days". It isn't a matter of time; it's the number of cold power ups that causes it. It takes about 15 minutes of the power being off for each cool down cycle. These built-in coils with thermal control are never as effective as external coils.

Note that while the monochrome CRTs used in B/W and projection TVs and mono monitors don't have anything inside to get magnetized, the chassis or other cabinet parts of the equipment may still need degaussing. While this isn't likely from normal use or even after being moved or reoriented, a powerful magnet (like that from a large speaker) could leave iron, steel, or other ferrous parts with enough residual magnetism to cause a noticeable problem.

If you try the 'technique' below, make sure you don't smash the TV or your spouse!

(From: Mike Champion (mchampfl@gdi.net).)

I replaced the magnetron in my microwave and ripped apart the old one with my kids to 'see how it works'. Boy, there are some mother magnets in there! The kids and I had fun with them. You know - push me pull you; the paper clip boat; which Easter egg has the metal and which has the wood; etc. Dnough with this kid stuff - 'wanna see something really cool?', says I. Having been around monitors for a long time in the computer business, i showed them what what a REALLY powerful magnet will do to an electron beam in a cathode ray tube - my sharp 19" color TV. "Wow, dad!", "psychodelic!" "it looks like all the colors are flushing down the toilet!" Boy, was I DAD or what? The problem was that my experience with magnets and monitors were in the monochrome days! so the price I paid for such esteem in the eyes of my children were purple faces and green legs on my sharp 19" color TV! Uh-oh! well, maybe it will be allright by tomorrow. Well it wasn't. Now I'm getting worried! I used to do computer support at a television station so I called an old engineer friend there for help. He just hee-hawed! As he was drying his eyes, he suggested that I had probably just magnetized the mask and he'd loan me a degausser. I offered to buy him lunch for the favor. This was Friday and because of my friend's diagnosis T was able to relax about the problem enough to think about it. Hmmmm. degausser = alternating magnetic field... Strong magnetron magnet... Alternating... So I got this great idea! I took the ring magnet I used to mess it up, tied a string to it, suspended it on the string and spun it as fast as i could. I put it up to the CRT and brought it away slowly! Eureka! On Monday I called my smart-alek friend and cancelled the lunch!

How Often to Degauss

Some monitor manufacturers specifically warn about excessive use of degauss, most likely as a result of overstressing components in the degauss circuitry which are designed (cheaply) for only infrequent use. In particular, there is often a thermister that dissipates significant power for the second or two that the degauss is active. Also, the large coil around the CRT is not rated for continuous operation and may overheat.

If one or two activations of the degauss button do not clear up the color problems, manual degaussing using an external coil may be needed or the monitor may need internal purity/color adjustments. Or, you may have just installed your megawatt stereo speakers next to the monitor!

You should only need to degauss if you see color purity problems on your CRT. Otherwise it is unnecessary. The reasons it only works the first time is that the degauss timing is controlled by a termister which heats up and cuts off the current. If you push the button twice in a row, that thermister is still hot and so little happens.

One word of clarification: In order for the degauss operation to be effective, the AC current in the coil must approach zero before the circuit cuts out. The circuit to accomplish this often involves a thermister to gradually decrease the current (over a matter of several seconds), and in better monitors, a relay to totally cut off the current after a certain delay. If the current was turned off suddenly, you would likely be left with a more magnetized CRT. There are time delay elements involved which prevent multiple degauss operations in succession. Whether this is by design or accident, it does prevent the degauss coil - which is usually grossly undersized for continuous operation - to cool.

Ultra Cheap Degaussing Coil

Pack Rat Trick #457384:

Next time you scrap a computer monitor (or tv), save the degaussing coil (coil of wire, usually wrapped in black tap or plastic) mounted around the front of the tube. To adapt it for degaussing sets, wrap it into a smaller coil, maybe 4"-6". To limit the current to something reasonable, put it in series with a light bulb (60 to 100 W, maybe as high as 200 W but keep a finger on the temperature of the coil!). You need AC current to degauss, so just put the bulb in series with the coil and use the your local 120 VAC outlet. BE VERY CAREFUL that you actually wired it in series, and that everything is properly insulated before you plug it in (A fuse would be a real good idea too!!)

A few circles over the affected area will usually do it. Note that it will also make your screen go crazy for a little bit, but this will fade out within a minute or so.

Just a couple of points for emphasis:

1. The coil as removed from the TV is not designed for continuous operation across the line as indicated above. In fact, it will go up in a mass of smoke without the light bulb to limit the current. The poor TV from which this organ was salvaged included additional circuitry to ramp the current to 0 in a few seconds after power is turned on.

2. Reducing the coil size by a factor of 2 or 3 will increase the intensity of the magnetic field which is important since we are limiting the current with the light bulb to a value lower than the TV used. You don't need to unwind all the magnet wire, just bend the entire assembly into a smaller coil. Just make sure that the current is always flowing in the same direction (clockwise or counterclockwise) around the coil.

3. Insulate everything very thoroughly with electrical tape. A pushbutton momentary switch rated for 2 amps at 115 volts AC would be useful so that you do not need to depend on the wall plug to turn it on and off.

(From: Larry Sabo (sabo@storm.ca).)

I've been using a couple of degaussing coils from "parts" monitors, connected n series. The combined resistance is about 27 ohms, for a current of around 4 to 5 amps. Sorry, I don't know the wire size, but it's very substantial, not like some of the thin, flimsy stuff I see. Works great!

Bob Myers' Notes on Degaussing

A couple of comments: first of all, it makes no difference whatsoever if the display is on while it's being degaussed. (Oh, some people DO like to watch the psychodelic light show, but it really doesn't help anything for it to be on.) Actually, there is a very minor case to be made for degaussing while OFF, at least for the Trinitron and similar tubes. (The field of an external degauss coil CAN cause the grille wires to move slightly, and they're a bit more flexible when hot - so it is conceivable, although certainly unlikely, that you're running a higher risk of causing the grille wires to touch or cross and become damaged.)

Secondly, a good practice for degaussing is to slowly back away from the monitor after giving the screen a good going over. Once you're about 5-6' away, turn the coil so it's a right angles to the CRT faceplate (which minimizes the field the monitor is seeing), and THEN turn to coil off. This is to reduce the possibility of the field transient caused by switching the coil off from leaving you once again with a magnetized monitor.

The last point is to make sure that you DON'T leave the coil on too long. These things are basically just big coils of wire with a line cord attached, and are not designed to be left on for extended periods of time - they can overheat. (I like the kind with the pushbutton "on" switch, which turns off as soon as I release the button. That way, I can never go off and leave the coil energized.)

Oh, one more thing - make sure your wallet is in a safe place. You know all those credit cards and things with the nice magnetic stripe on them? :-)

(Actually, I've got a good story about that last. I was teaching a group of field service engineers how to do this once, and being the "Big Deal Out of Town Expert", made VERY sure to place my wallet on a shelf far away from the action. Unfortunately, Mr. Big Deal Out of Town Expert was staying in a hotel which used those neat little magnetic-card gadgets instead of a "real" key. Ever try to explain to a desk clerk how it was that, not only would your keycard NOT let you into your room, it was no longer anything that their system would even recognize as a key? :-))

Degaussing after lightning strike

Sometimes a nearby lightning strike may produce effects which mimic those of a nuclear explosion, at least in terms of EMP induced magnetization. This may be take the form rainbow patterns or purity blotches that the internal degaussing coil or even an typical external degauss won't cure.

(From: JURB6006 (jurb6006@aol.com).)

A lightning strike produces a VERY high magnetic field, something the degausser can't handle. Somehow connect a good, like 10 amp Variac straight to the degaussing coil(s) and turn it all the way up and down, fairly quickly. You might do better to get ready, flip the switch on and turn it down from the top, but DON'T blow the fuse, that might make things worse. Turn it down quick, but it is the top end that gets the job done. Thing is those coils can only stand it for a second or two, but that is way longer than it takes. You can also do this with it running, but you risk damaging the vertical circuit. However you can try different levels and see if less than max is enough to do it. At extremely high levels you risk damaging the shadow mask, that is if it is not already damaged.

I almost scrapped a 36" Sony for this, same thing, near a lightning strike. The colors were seriously FUBARed. The coil to the variac trick did it. What happens is I think the purity shield itself gets magnetized, despite it's low coercivity. It takes a bit more than the standard degausser in the set to do the trick.

Degaussing Humor - If it Works, Use It!

Note: If you are forced to use this stunt, sorry, approach, make sure you don't end up smashing something important! :)

(From: Mike Champion (mchampfl@gdi.net).)

I replaced the magnetron in my microwave and ripped apart the old one with my kids to 'see how it works'. Boy, there are some mother magnets in there! me and the kids had fun with them. you know - push me pull you; the paper clip boat; which easter egg has the metal and which has the wood; etc. enough with this kid stuff - 'wanna see something really cool?' Says I. Having been around monitors for a long time in the computer business, I showed them what what a REALLY powerful magnet will do to an electron beam in a cathode ray tube - my sharp 19" color TV. "Wow, dad! psychodelic! It looks like all the colors are flushing down the toilet!" Boy, was I DAD or what? The problem was that my experience with magnets and monitors were in the monochrome days! So the price I paid for such esteem in the eyes of my children were purple faces and green legs on my sharp 19" color TV! Uh-oh! Well, maybe it will be all right by tomorrow. Well it wasn't.

Now I'm getting worried! I used to do computer support at a television station so I called an old engineer friend there for help. He just hee- hawed! As he was drying his eyes, he suggested that I had probably just magnetized the mask and he'd loan me a degausser. I offered to buy him lunch for the favor. This was Friday and because of my friend's diagnosis I was able to relax about the problem enough to think about it. Hmmmm... Degausser = alternating magnetic field. Strong magnetron magnet. Hmmmm... Alternating... So I got this great idea! I took the ring magnet I used to mess it up, tied a string to it, suspended it on the string and spun it as fast as I could. I put it up to the CRT and brought it away slowly! Eureka! On Monday, I called my smart-aleck friend and cancelled the lunch! :)

Can a Really Strong Magnet Permanently Damage the CRT?

Even a magnet that can suspend your weight may still not have much range as they usually have metal pole pieces that concentrate the flux and work well only with a matching flat steel plate.

The only thing in the guts of a TV or monitor (that is accessible from outside the cabinet) that can be damaged permanently is the shadow or slot mask of the CRT. If the magnet is strong enough to distort it, the CRT will be ruined. Even manual degaussing with a similarly powerful degaussing coil will then not totally clear up color purity problems. The shadow or slot mask is a very thin perforated steel or InVar sheet about 1/2 inch behind the glass of the CRT screen - which is itself about 1 inch thick or more. So, even up against the screen, your magnet is still at least 1-1/2 inches from the shadow mask. It would take a mighty powerful magnet to distort it.

For Trinitron (or clone) CRTs with aperture grilles - tensioned fine wires in place of a shadow or slot mask, the force required would be even greater.

No way to know without trying it :-(.

(From: Jeff Mangas (jeff@edldisplays.com).)

I work in a small monitor factory and some time ago we were using some very strong degaussing wands to remove magnetism from some of our chassis. We found that this caused a weakening of the shadow mask and it would take only a small shock/vibration to break the mask loose. We are not 100% sure that it was the degaussing that caused the problem but we only used these strong wands for a short time (lost several tubes while using them) and have not had any problems before or since.

WARNING about degaussing late model Sony Trinitron CRTs

The following has been confirmed by others.

(From: David Kuhajda (dkuhajda@locl.net).)

You should NEVER use a big degauss coil on ANY SONY WEGA tube, or ANY SONY 27" or larger CRT made after 1997. Sony deliberately put a small amount of magnetic field into the strapping and aperture grill to compensate and improve the convergence. A BIG degauss will remove this and make the tube look very bad.

A BIG manual degauss coil from about 3 feet away should have a low enough field to be safe. (Note: should) I NEVER use the large degauss coils on the Sony tubes after seeing the Sony video of how CRTs have been damaged. I USE a smaller degauss coil and work it on a Variac at a lowered AC voltage, and bring the voltage up each successive pass to degauss the CRT until it is cleared up.

If the internal degauss is not taking care of the problem, you have other things to look at. Has the yoke or yoke purity rings been moved? Have the TV or monitor been dropped? Are all the connections good on the degauss thermister? If it is a three leg thermister it still may be bad as those leave a small current flowing on the older Sony coils. Have any of the extra purity magnets fallen off the yoke or CRT?

Note that Sony tubes do NOT have shadow masks, but they have aperture grills which are an array of incredibly fine wires under tension. A BIG degauss coil can also rip the aperture grill away from the stabilization wires.

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CRT Related Adjustments

Principles of Purity and Convergence Adjustment

Purity involves bending all 3 of the beams so that they cross the space between shadow mask and screen at the proper angle and will land at a different place on the phosphors. Convergence involves adjusting the aim of 1 or 2 of the beams at a different angle so that they all land at the same place on the screen.

Dynamic convergence circuitry is now virtually non-existent, except in high resolution monitor tubes and in Sony Trinitron tubes (they require a very basic horizontal convergence). All other tubes have the convergence correction built into the design of the tube and the coil. Sony has chosen a different trade-off between price and performance (which includes also sharpness).

Most CRTs have a series - usually 3 pairs - of ring magnets mounted on the neck near the socket end. These are used for part of the purity adjustment and static convergence. (Coarse purity is set by the position of the yoke and dynamic convergence is set by the tilt of the yoke.) These rings consist of multi-pole magnets which due to their field configuration are able to affect the electron beams from the 3 guns in different ways.

(Some CRTs employ internal structures that are premagnetized at the factory and cannot be adjusted in the field - though perhaps auxiliary magnet rings could be added if the original magnetization were lost for reasons we won't go into :-). This type of CRT will be obvious as there will be no adjustable rings to mess screw up!)

The relative orientation of the rings in a pair affect the strength of the effect.

In a nutshell, the electron guns in most modern CRTs are arranged in-line. For example: GRB. Some of the ring adjustments are designed to affect them all while others pretty much leave the center gun's beam alone and only affect the outer ones. Various options then exist depending on the magnetic field configuration.

The three sets of ring magnets are shown below along with the position of the red (R), green (G), and blue (B) electron beams passing through them. Each is actually a pair of rings which may be moved relative to one-another to control the strength of the magnetic field. When the tabs are adjacent, the fields from the two rings nearly cancel and the rings then have no effect. Two typical orientations are shown (N and S are the poles of the ring magnets):

Orientation 1:

```
                          S             S   N

  N  R G B  S       N  R G B  N     N  R G B  S

                          S             S   N

    2-pole            4-pole            6-pole
   (purity)         (red-blue)    (red/blue-green)
   0 Degrees        0 Degrees         0 Degrees
```

Orientation 2:

```
       N             N       S            S
                                      N       N
     R G B             R G B            R G B
                                      S       S
       S             S       N            N

    2-pole            4-pole            6-pole
   (purity)         (red-blue)    (red/blue-green)
  90 Degrees        45 Degrees        30 Degrees
```

(My apologies if I have the direction of deflection reversed - I can never remember the right hand rule for electrons moving in magnetic fields!)

- The 2-pole purity rings move the set of RGB beams more or less together to fine tune the position of the center of deflection.

  The field lines go generally across (at the orientation shown) between the N and S poles.

  Orientation 1, the RGB beams will be raised.

  Orientation 2, the RGB beams will be moved to the right.

- The 4-pole red-blue rings move the R and B beams relative to the G beam but leave the G beam alone.

  The field lines go generally between adjacent N and S poles. On opposite sides of the rings, the polarity/direction of the lines oppose and thus tend to move the R and B beams in opposite directions. The G beam in the center does not experience any deflection from the 4-pole ring magnets since all the fields tend to cancel.

Orientation 1: The R beam will move up and the B beam will move down relative to G.

Orientation 2: The R beam will move up and to the right and the B beam will move down and to the left relative to G.

- The 6-pole red/blue-green rings move the RB beams with relative to the G beam but leave the G beam alone.

  The field lines go generally between adjacent N and S poles. On opposite sides of the rings, the polarity/direction of the lines are the same and thus tend to affect the R and B beams in the same direction. The G beam in the center does not experience any deflection from the 6-pole ring magnets since all the fields tend to cancel.

  Orientation 1: The R and B beams will move up relative to G.

  Orientation 2: The R and B beams will move up and to the right relative to G.

For purity to be perfect (or as good as possible), the electron beams must originate from the same effective center of deflection as used in originally laying down the phosphors. Moving the yoke forward and backward on the neck of the CRT can precisely set the deflection center along the axis of the neck. However, slight transverse errors may still exist due to imperfections in the yoke windings or positions of the electron guns. This is affected slightly by the earth's magnetic field as well. The purity magnet rings are those closest to the yoke and provide the means for moving the electron beams very slightly to compensate.

The adjustment procedures generally use the red gun for the setting purity. Intuitively, one would think this should be the center (green) gun. However, since the red beam current is the highest (red phosphor is least sensitive), problems are likely to show up first with the red purity so it is used for the adjustment. In any case, it is a good idea to check all three guns for proper purity and tweak if needed before moving on to convergence.

In an in-line gun, the green gun is always in the middle. The only reason for adjusting purity with the red beam is because it gives the greatest sensitivity:

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

- The red beam current usually has the largest amplitude.
- A landing error of the red beam gives the best visible discoloration (much better than green, better than blue).
- This makes the landing of the red beam the most critical.

Detailed Purity and Static Convergence Adjustment Procedure

Also see the adjustment information in the documents: Notes on the Troubleshooting and Repair of Computer and Video Monitors or Notes on the Troubleshooting and Repair of Television Sets.

(From: Alan McKinnon (alan.mck@pixie.co.za).)

The rearmost pair of magnets (seem from the service position behind the set in other words furthest from you nearest the front of the tube) affects purity. More on this later. The middle and front magnets are for convergence and work on pairs of colours. The effects can most easily be seen on a cross hatch test pattern (10 or so horizotal lines, 15 or so vertical lines).

But first, purity:

Without getting into the details of what happens inside the guns, I assume you need to know how to do the adjustments. You need some means of generating an evenly red screen. An (expensive) pattern generator is the preferred method. Fiddle the rear purity rings to distort the screen by bringing green and blue blobs into it. You will note that the magnets can be adjusted by moving both together, and moving them aart relative to each other. The best advice here is: adjust slowly and observe what happens. Once you have the screen evenly red, move on to convergence, which is the trick of getting the red green and blue beams to coincide on the screen to produce white, with the minimum of colour shadowing.

With a cross hatch pattern on screen, you can see easily how convergence works, and how the magnets affect the picture. Each tube type is different in exactly how this is done, but the general idea is that one set of magnets affects two specific colours only, moving them apart and bringing them nearer, while leaving the third colour alone. The other set of magnets takes the colours affected by the other set, and moves them together relative to the third colour. Also, moving a pair of magnets together adjusts the colours in one direction (vert or horiz) while moving the magents apart adjusts the other direction. With all things in life, there is some overlap, so you need to look carefully and see what happens mostly - the adjustments are not cut and dried. Oh, and they are interactive to some degree. Keep checking purity after you do convergence. All of this is best shown with a picture, the colours are arbitrary, you may well find the details do not apply to your tv, but the basic principles will. These initial converence adjustments apply only to the centre of the screen by the way, the edges are done elsewhere:

Rotating one set of magnets together might move red and blue together till they coincide vertically:

```
         | |  |           | | |           |  |
         | |  | ----->    | | |  ----->   |  |
         | |  |           | | |           |  |
         R G  B           G R B           G R&B
```

And moving them apart relative to each other might move red and blue together horizontally:

```
         R -----
                             R --------       R&B---------
         G -----  -----> G --------  -----> G ---------
                             B --------
         B -----
```

Moving the other set of magnets together might take the red and blue pair and move them to coincide with the green, vertically:

```
      |  |         | |          |
      |  | -----> | | ------> |
      |  |         | |          |
      G  R&B       G R&B      R&G&B (=white)
```

And moving them apart relative to each other might move the red and blue pair and move them to coincide with green horizontally:

```
    R&B -------
                         R&B -------
              ----->                ----> ------- R&G&B
                           G -------               (=white)
      G -------
```

Once the convergence is perfect in the centre of the screen (called static convergence) it's time to handle the edges and corners (called dynamic convergence for historical reasons). This is done by physically moving the entire yoke that is clamped around the tube neck with the deflection coild on it. It is anchored in place by a collar on the tube neck, loosen this slightly, butnot enough so that the yoke can move backwards. It is also held in place by rubber wedges glued or taped down. Take the wedges out. By gripping the yoke and levering it up and down, left and right, you will change he convergence in the corners. The effects don't work as you might at first suppose - moving the yoke left affects the lower right corner, this type of thing. Get the dynamic convergence right and stuff the wedges back under the yoke to hold it precisely in place and glue them back down. The recheck purity.

There you have it. Easy as pie. Some folk would have you believe no-one in their right minds adjusts these things. Well, balls. Someone did it at the factory, and they did it the way I just described. All you need is the right tools (pattern generator), patience, and time.

Tony's Notes on Setting Convergence on Older Delta Gun CRTs

(From: ard12@eng.cam.ac.uk (A.R. Duell))

The older delta-gun tubes (3 guns in a triangle, not in a line) can give **excellent** pictures, with very good convergence, provided:

1. You've set those 20-or-so presets correctly - a right pain as they interact to some extent.

2. The CRT is set up in the final position - this type of tube is more sensitive to external fields than the PIL type.

Both my delta-gun sets (a B&O 3200 chassis and a Barco CDCT2/51) have very clearly set out and labeled convergence panels, and you don't need a service manual to do them. The instructions in the Barco manual are something like:

"Apply crosshatch, and adjust the controls on the convergence board in the numbered order to converge the picture. The diagrams by each control show the effect".

Here's a very quick guide to delta gun convergence where the settings are done using various adjustments on the neck of the CRT (if you don't have a service manual but do know what each control does, and where they all are - otherwise, follow the instructions in the service manual --- sam):

1. Apply a white crosshatch or dot pattern to the set. Don't try and converge on anything else - you'll go insane. It's useful to be able to switch between those 2 patterns.

2. Before you start, set the height, width, linearity, pincushion, etc. They will interact with the convergence. Also check PSU voltages, and the EHT voltage if it's adjustable. That's where you do need a service manual, I guess.

3. Turn off the blue gun using the A1 switch, and use the red and green static radial controls to get a yellow croshatch in the middle of the screen. These controls may be electrical presets, or may be movable magnets on the radial convergence yoke (the Y-shaped think behind the deflection yoke).

4. Turn on the blue gun and use the 2 blue static controls (radial and lateral) to align the blue and yellow crosshatches at the center of the screen. Some manufacturers recommend turning off the green gun when doing this, and aligning red with blue (using *only* the blue controls, of course), but I prefer to align blue with yellow, as it gives a check on the overall convergence of the tube.

5. Turn off the blue gun again. Now the fun starts - dynamic convergence. The first adjustments align the red and green crosshatches near the edges - I normally do the top and bottom first. There will be 2 controls for this, either a top and a bottom, or a shift and a linearity. The second type is a *pain* to do, as it's not uncommon for it to affect the static convergence.

6. Getting the red and green verticals aligned near the edges is a similar process.

7. You now have (hopefully) a yellow crosshatch over the entire screen.

8. Now to align the blue. This is a lot worse, although the principle is the same. Turn on the blue gun again, and check the static (center) convergence

9. To align the blue lines with the yellow ones, you'll find not only shift controls, but also slope controls. Use the shift controls to align the centers of the lines and the slope controls to get the endpoints right. These interact to some extent. You'll need to fiddle with the controls for a bit to work out what they do, even if you have the manual.

The convergence over the entire screen should now be good....

A word of warning here... The purity is set by ring magnets on almost all colour CRTs, but on PIL tubes, there are other ring magnets as well - like static convergence. Make sure you know what you are adjusting.

Jerry's Comments on Convergence and Other Advanced Adjustments

(From: Jerry G. (jerryg@total.net).)

Convergence alignment is not something you can do yourself unless you have the proper calibration instruments and skills. It takes lots of experience and time. There are published specs for most of the good monitors. Most of the time they are as follows:

There is the 'A area', 'B area', and 'C area'. On a 15 inch monitor the A area would be a diameter of about 4 inches. The B area would be about 7.5 inches. The C area would be the outside areas including the corners. These numbers are approximate. There are actually standard specs for these areas. They are expressed in percentage of screen viewing area. Therefore the inches would vary with the CRT size.

The higher the price (quality) of the monitor CRT, yoke, and scanning control circuits, the tighter the convergence can be aligned by the technician. For the A area on a good monitor, the maximum error should not exceed 0.1 mm. For the B area it should not exceed more than about 0.25 mm. And for the C area, it can be allowed up to about 0.3 mm. Most of the monitors that I have repaired, seen, and used did not meet these specs unless they were rather expensive. With these specs there would not be any real visible misconvergence unless you put your nose very close to the screen... A lot of the ones in the medium price range they were about 0.15 mm error in the A area, about 0.4 in the B and greater than in the C area. This also annoys me because I am very critical.

If one has the skills and test gear he or she can do a better job on most monitors. It is a question of the time involved. To see the convergence errors a grating or crosshatch pattern is used. A full raster color generator is required for the purity adjustments as well. This is necessary to align the landing points of the CRT guns. The exact center reference and purity adjustments are done with the ring magnets on the CRT neck. The yoke position angle adjustments are also done for the side and top-bottom skewing as well. Everything interacts!

The corners are done with various sorts of slip or edge magnets. As for corner convergence skewing, button magnets are used. The color purity will be effected as you go, and must be also corrected. These adjustments interact on one another, and the processes continues until the convergence and purity are good at the same time...!

I don't recommend the amateur or hobbiest, or even the do-it-yourselfer to attempt this alignment procedure. The test gear would exceed the cost of a really good monitor anyways...!!! And without the proper skills required, he or she would only make it worse anyways...

As for purity specs, the color change from any corner to any corner must not exceed an error of more than 200 degrees Kelvin. The error in the B area should not exceed 300 degrees kelvin. This applies to a white raster. Most of the monitors I see don't get better than about 300 degrees Kelvin. And some are even 1000 out! The purity errors are best checked with a full Red raster using 100 % saturation. Then the other color vector angles are checked with cyan, and then magenta. The color temperature stability should be the same in all aspects.

A color spectrometer should be used to judge this error factor. As far as the eye is concerned, it will see a purity error of more than about 500 degrees Kelvin if the person knows what to look for...

When changing the CRT, this alignment must be done completely. Most shops do not even employ people who are skilled to a proper alignment, or don't even own the instruments to do it right, and the poor customer get back a monitor that is not in specs...!

CRTs with No Purity or Static Convergence Rings

I have a late model TV with a 13 inch tube with no static purity or convergence rings. I don't get to see that many modern tubes so this was a bit of a surprise or maybe I just hadn't noticed before on small CRTs if they didn't have purity/convergence problems. I do see it has wrapping of a rubber-ferrite-permalloy type material where the ring assembly would go. I assume that this is magnetized selectively at the factory to adjust purity/convergence? The yoke has the usual position and tilt adjustments. This one was an RCA/GE CRT.

What this means is that if you were to accidentally bring a strong permanent magnet near the base of the CRT or a strong degaussing coil, there is a slight possibility of totally messing up this compensation requiring replacement of the CRT. I don't know how possible this is without really working at it!

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

Since eternity, Philips CRTs have not had external multipole magnet rings around the neck. There is an iron ring inside the neck, at the end of the electron gun assembly. This ring is permanently magnetized in the factory by a strong outside magnetic field at a later stage of the production. Further responsibility for purity, convergence and geometry is in the design of the coil windings distribution and some metal parts. Final purity adjustment is achieved by matching a tube with a coil and then shifting and tilting the coil slightly. This explains why Philips CRTs are always sold as a matched combination of tube and coil, contrary to some other brands.

Projection Set Convergence Adjustment Principles

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

CRT projection displays require much convergence correction, especially since the 3 tubes aim at the screen under different angles. Generally the green Horizontal convergence coil is not driven because that is a geometry correction which is taken care of by the horizontal deflection circuit. The 3 vertical convergence coils usually also take care of vertical geometry correction (N-S corrrection) because the vertical deflection circuit is generally a standard direct-view type. Add to that a severe keystone correction for the Red and Blue tubes.

The convergence waveforms used to be generated from an analog polynomial generator. The components are then weighted and summed to form a Taylor polynomial. Consider the adjustment of horizontal convergence, then typical polynomial components are:

> 1 (shift),
> x (amplitude),
> x^2 (linearity),
> y (rotation or tilt),
> y^2 (bow),
> x*y (keystone),
> x^2*y (dunno if it's used).
> x*y^2 (pin-cushion),
> x^3 (side linearity).
> x*y^4 (corner pin-cushion)

Adjusting convergence is a highly iterative (read: costly) process because each potentiometer tends to influence the whole screen. Also, this method is not easily extendible to higher order adjustments for more accuracy. That's why better waveform generators have been designed, like digital look-up tables with D/A converters (which are quite expensive) and spline-like waveform generators (which are cheap and easy to adjust, the Philips design is called Convergence Spline Processor, it's digital too).

Monitor Tune-Up?

(The following from: Bob Myers (myers@fc.hp.com).)

Most manufacturers will quote an MTBF (Mean Time Before Failure) of somewhere in the 30,000 to 60,000 hour range, EXCLUSIVE OF the CRT. The typical CRT, without an extended-life cathode, is usually good for 10,000 to 15,000 hours before it reaches half of its initial brightness. Note that, if you leave your monitor on all the time, a year is just about 8,000 hours.

The only "tuneup" that a monitor should need, exclusive of adjustments needed following replacement of a failed component, would be video amplifier and/or CRT biasing adjustments to compensate for the aging of the tube. These are usually done only if you're using the thing in an application where exact color/brightness matching is important. Regular degaussing of the unit may be needed, of course, but I'm not considering that a "tuneup" or adjustment.

A Discussion on Correction Magnets

(From Ludwig (eastcomp@gmx.de).)

When repairing and recalibrating color monitors of different brands, one experiences those "dirty little tricks" called correction magnets, which have different forms, sizes and magnet strength, and which are attached at different locations somewhere near the electronic beams at the neck of the tube. These magnets are used to correct bad edge geometry/convergence and problems with color convergence at various locations on the screen.

Depending on the quality (i.e., magnetic geometry) of the tube and the deflection coils/fields there are monitors, which have only few (or even none) of these correction magnet, while others (some brands are "famous" for this) are really clustered with these magnets.

The magnets can have different forms and sizes:

1. Most often there are used small and thin, weak magnets, which are glued to the end of a plastic stripe. These stripes are inserted into the small gap between the tube and the deflection coils (ferrite coil) and the fixed by glue, silicon or plaster. This magnets are weak and therefore have to be positioned very near to the electron beam at the neck of the tube. They usually are intended to correct bad convergence at the corners and edges of the picture.

2. Plastisized magnets (e.g., 4x4x1 mm, 3x10x1 mm, or 10x10x0.2mm), which have a much bigger magnetic strength, are either glued to the the edges of the plastic case of the deflection coils or - if the magnet is not so strong - to the tube itself. These types of magnets often are used to correct larger deficiencies in geometry - and to a lesser extent - in convergence.

Those are my observations, but what I'd like to know is this:

- Why aren't such magnets demagnetized during the power-on degaussing?
- Aren't such magnets demagnetized, if one uses an extra demagnetizing coil for removing undesired magnetic fields at the tube? Are those demagnetizing coils harmful to the different correction magnets on/at the neck of the coil?

  What type of magnets are used for those correction magnets ? (barium titanate, other types of ferrites?).

(From: Sam.)

The answers to both (1) and (2) is that if using the internal degauss coil and/or properly positioned (front of CRT only) external coil, the strength of the field is (hopefully) insufficient to affect the correction magnets. That is why one should NEVER attempt to degauss in the rear of the TV or monitor or inside the case!

I don't believe the magnets are made of anything special - they appear to be similar to your typical refrigerator (note holding) magnets in composition and strength.

(From: Ludwig.)

By the way: Almost any monitor, which is older than 1-2 years has developed deficiencies in convergence, geometry and sharpness, and has to be recalibrated, if you'd prefer an optimal picture (and being careful with one's eyes). It's not quite easy to do fine recalibration of convergence and geometry (even modern monitors allow only to correct coarse via OSD menus), because during recalibration the monitor has to be at power-on state, i.e. high voltages are at every edge of the monitor. I successfully used household rubber/plastics gloves to do the recalibration by repositioning the above mentioned magnets while the monitor is powered on. Using household rubber/plastics gloves is also a valuable means to prevent beginners from electric shock, and therefore should be recommended for every job to do with the monitor case open and power on (even just for monitoring electronic signals with an oscilloscope).

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CRT and CRT Related Maintenance and Repair

Preventive Maintenance - Care and Cleaning

Preventive maintenance for a TV or monitor is pretty simple - just keep the case clean and free of obstructions. Clean the CRT screen with a soft cloth just dampened with water and mild detergent or isopropyl alcohol. This will avoid damage to normal as well as antireflection coated glass. DO NOT use anything so wet that liquid may seep inside of the monitor around the edge of the CRT. You could end up with a very expensive repair bill when the liquid decides to short out the main circuit board lurking just below. Then dry thoroughly. Use the CRT sprays sold in computer stores if you like but again, make sure none can seep inside. If you have not cleaned the screen for quite a while, you will be amazed at the amount of black grime that collects due to the static buildup from the CRT high voltage supply.

There is some dispute as to what cleaners are safe for CRTs with antireflective coatings (not the etched or frosted variety). Water, mild detergent, and isopropyl alcohol should be safe. Definitely avoid the use of anything with abrasives for any type of monitor screen. And some warn against products with ammonia (which may include Windex, Top-Job, and other popular cleaners, as this may damage/remove some types of antireflective coatings. To be doubly sure, test a small spot in corner of the screen.

In really dusty situations, periodically vacuuming inside the case and the use of contact cleaner for the controls might be a good idea but realistically, you will not do this so don't worry about it.

(From: Bob Myers (myers@fc.hp.com).)

Windex is perfectly fine for the OCLI HEA coating or equivalents; OCLI's coating is pretty tough and chemical-resistant stuff. There may be alternative (er..cheaper) coatings in use which could be damaged by various commercial cleaners, (For what it's worth, OCLI also sells their own brand of glass cleaner under the name "TFC", for "Thin Film Cleaner".)

I have cleaned monitors of various brands with both Windex and the OCLI-brand cleaner, with no ill results. But then, I'm usually pretty sure what sort of coating I'm dealing with...:-)

Monitor coatings are always changing; besides the basic "OCLI type" quarter-wave coatings and their conductive versions developed to address E-field issues, just about every tube manufacturer has their own brew or three of antiglare/antistatic coatings. There are also still SOME tubes that aren't really coated at all, but instead are using mechanically or chemically etched faceplates as a cheap "anti-glare" (actually, glare-diffusing) treatment.

In general, look in the user guide/owner's manual and see what your monitor's manufacturer recommends in the way of cleaning supplies.

Shorts in a CRT

Occasionally, small conductive flakes or whiskers present since the day of manufacture manage to make their way into a location where they short out adjacent elements in the CRT electron guns. Symptoms may be intermittent or only show up when the TV or monitor is cold or warm or in-between. Some possible locations are listed below:

- Heater to cathode (H-K). The cathode for the affected gun will be pulled to the heater (filament) bias voltage - most often 0 V (signal ground). In this case, one color will be full on with retrace lines. Where the heater is biased at some other voltage, other symptoms are possible like reduced brightness and/or contrast for that color. This is probably the most common location for a short to occur.

- Cathode to control grid (K-G1). Since the G1 electrodes for all the guns are connected together, this will affect not only the color of the guilty cathode but the others as well. The result may be a very bright overloaded *negative* picture with little, none, or messed up colors.

- Control grid to screen (G1-G2). Depending on circuitry can result in any degree of washed out or dark picture.

- Screen to focus (G2-F). Screen (G2) and focus voltage will be the same and the controls on the flyback will interact. Result will be a fuzzy white raster with retrace lines and little or very low contrast picture.

Symptoms will be similar to those of a flyback with breakdown in the focus/screen divider network.

- Focus to high voltage (F-HV). High voltage will be pulled down - probably arcing at the focus spark gaps/other protective devices. Line fuse and/or HOT may blow.

- Other locations between electron gun elements as feed wires.

Replacing the CRT may be required but there are a variety of 'techniques' that can often be used to salvage a TV that would otherwise end up in the dump since replacing a CRT is rarely cost effective:

1. Isolation - this will usually work for H-K shorts as long as only one gun is involved.

2. Blowing out the short with a capacitor - depending on what is causing the short, this may be successful but will require some experimentation.

3. Placing the CRT (TV or monitor) face down on a soft blanket and gently tapping the neck to dislodge the contamination. Depending on the location of the short, one side or the other might be better as well.

A combination of (2) and (3) may be required for intermittent shorts which don't appear until under power. See the sections below for additional details. However, for shorts involving the focus and high voltage elements, even a sharp edge can result in arcing even if there is no actual short. There is no remedy for these types of faults.

Providing Isolation for a CRT H-K Short

This procedure will substitute a winding of your own for the one that is built in to the flyback to isolate the shorted filament from the ground or voltage reference. Note that if you have a schematic and can determine where to disconnect the ground or voltage reference connection to the filament winding, try this instead.

The flyback is the thing with the fat red wire coming out of it (and perhaps a couple of others going to the CRT board or it is near this component if your set has a separate tripler) and may have a couple of controls for focus and screen. It should have some exposed parts with a ferrite core about 1/2-3/4" diameter.

The filament of the CRT is the internal heater for each gun - it is what glows orange when the set is on. What has happened is that a part of the fine wire of the bad color's filament (assuming this is indeed your problem) has shorted to the cathode - the part that actually emits the electrons. Normally, the heater circuit is grounded or tied to a reference voltage so when it shorts to the cathode, the cathode voltage level is pulled to ground or this reference.

You will need some well insulated wire, fairly thick (say #18-22). Find a spot on the flyback where you can stick this around the core. Wrap two turns around the core and solder to the CRT filament pins after cutting the connections to the original filament source (scribe the traces on the board to break them). Make sure you do not accidentally disconnect anything else.

This winding should cause the filaments to glow about the same brightness as before but now isolated from ground. If they are too dim, put another turn on the flyback to boost the voltage. (Don't go overboard as you may blow the filament totally if you put too many turns on the core - you then toss the TV or monitor.)

Route the wires so that there is no chance of them getting near the high voltage or any sharp metal edges etc. Your picture quality may be a tad lower than it was before because of the added stray capacitance of the filament wiring being attached to the the (formerly bad) video signal, but hey, something is better than nothing.

Rescuing a Shorted CRT

If the short is filament-cathode (H-K), you don't want to use the following approach since you may blow out the filament in the process. If this is the case, you may be able to float the filament and live with the short (see the document: Notes on the Troubleshooting and Repair of Television Sets.

Shorts in the CRT that are between directly accessible electrodes can be dealt with in a more direct way than for H-K shorts. At this point you have nothing to loose. A shorted CRT is not terribly useful.

If the short is between two directly accessible electrodes like cathode-grid, then as a last resort, you might try zapping it with a charged capacitor (see below for K-G1 short).

Unplug the CRT socket!

Start with a relatively small capacitor - say a few uF at a couple hundred volts. Check to see if the short is blown after each zap - few may be needed. Increase the capacitance if you feel lucky but have had little success with the small capacitor.

If the fault is intermittent, you will, of course, need to catch the CRT with the socket disconnected and the short still present. Try some gentle tapping if necessary. If you do this with the charged capacitor across the suspect electrode, you **will** know when the short occurs!

(From: Terry DeWick (dewickt@esper.com).)

I have seen this problem many times, shorted CRT red cathode, tap neck of CRT (not hard enough to brake, but close) or hit with a Tesla coil, we use one in shop, remove CRT board, run coil around pins for about 10 seconds, would you believe there is a service bulletin from Philips on this and focus shorts - I do not have a copy - I just helped write it - demonstrated use of coil to the service engineer and fixed 2 bad tubes in process.

(From: JURB6006 (jurb6006@aol.com).)

If it takes more than about 400 mA to clear the short the cathode is usually toast. The big cap makes it a big thing, but only for a certain time, this is based on thermal mass.

Recently after I had tried everything I decided to use external power to remove a G1 short. This was the most solid short I've ever seen, I used an old AT PC power supply and all I got was to make the internal "wires" to the elements RED HOT!!!

The best way to remove a G1 short is (I don't do it this way all the time it is too much trouble).

1. Completely disconnect the cathode of the offending gun.

2. Connect the cathode to a clip lead.

3. Connect the G1 to ground, not DAG on an NAP and if it's an NAP you must isolate it and connect it to ground, if not an NAP 99% of the time you don't have to do it. You still need to tie G1 to ground, but in most sets you can just do it.

4. As the short starts to manifest itself, touch the clip lead from the cathode to the video output 220 VDC source.

Determining if Your CRT is up to Air

> "I have a Compuadd monitor that's completely blank.The high voltage is very low and there's flashing inside the neck of the picture tube. I believe there may be a small hairline crack in the neck of the picture tube. I suspect that a crack has compromised the vacuum in the tube and that's what is causing the flashing and the low voltage. Is that possible, and if so, is there anything that can be done other than junking it?"

If there is a crack, then everything else is possible. However, these rarely develop on their own.

Look around the neck of the CRT for a coating - the getter. If it has turned white or red, your CRT is history. If it is still silver, the vacuum is intact and your arcing may be due to a bad flyback putting excessive voltage on the screen or focus electrode or a CRT that is bad in other ways. There are supposed to be external protection spark gaps, etc. for this but may not always work.

Sorry, junking it is probably the only realistic solution. Unless you find a cheap used CRT, the expense is not worth it. Even then, adjustments may be quite involved.

Scratches or Other Damage to the CRT Face

It is generally difficult to accidentally scratch the face of the screen but accidents do happen. The way the manufacturer would repair it is to replace the CRT. If the scratch is the result of shipping damage, file a claim with the shipping company. If it is a factory defect, get it repaired or replaced under warranty.

Barely visible scratches can be removed with jeweler's rouge or similar ultra-fine abrasive unless the CRT has an antireflective or textured surface.

Jeweler's rouge is the same stuff that is used in the final polishing of lenses and mirrors so it makes for a fine finish. However, any kind of scratch deep enough to be felt will not yield to this approach.

For larger scratches, one would normally start out with a coarser abrasive like 300 grit and work toward successively finer sizes - 600, 1200, etc. - with the final polishing being done with the rouge. However, realistically, this isn't really a viable approach for a CRT faceplate. It takes a lot of grinding to remove enough material to smooth out a scratch and you are more likely to mess things up than to improve matters.

If the CRT has an antireflective coating or textured surface, it will almost certainly be best to leave the scratch alone. Any type of polishing *will* remove affect the appearance in the vicinity and leave you with a big unsightly blob. This will be much more objectionable than a slight scratch.

The types of fillers sold in auto parts stores for repairing auto windshields may reduce the visibility of any scratches but DO NOT restore the integrity of the glass.

I don't quite know whether this is better or worse than the disease but it might be worth trying:

(From: Cooper@Hub.ofthe.NET).

> "I may have come across an easy fix for those who have scratched glass on the monitor face. I am currently using window film as an adhering material to cover and conceal the scratches. This looks much better and enables me to continue usage of the monitor without the aggravating distortion."

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CRT Degradation

CRT Aging - Effects on Electrical Characteristics and Performance

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

Specifications for Philips CRTs can be found in the regular series of data books from Philips Components. Companies and universities usually have them. Usually the data sheets show typical Ik/Vk characteristics. They also list the spread on cutoff voltage and cathode gain, and this spread is quite large even on new CRTs. They also list phosphor sensitivity (Lum/Ik), this too has a large spread. But they almost never list anything about the aging process.

Here are some of the effects:

- Phosphor ages due to burn-in, particularly on static pictures, this is immediately obvious on visual inspection. If the aging is even (no pattern) then at least the efficiency is reduced.
- Cathodes age due to loss of emission material, particularly for oxide cathodes. The central part of the cathode surface has carried the most current density and will wear out first. The surrounding area takes over, this will lead to an unsharp picture. Adjusting the focus voltage will not really improve it. The tube is worn out.
- Also poisoning of cathode surface may occur. This can be cured temporarily by short-time overheating ("re-conditioning").
- The cathode that wears out first (often the red one) also loses gain, so the white point of the image will shift (to cyan). The white point can be re-adjusted with the gain potentiometers and the contrast, but peak brightness will not be as high as new.
- The cutoff voltages of all cathodes will drift. Common drift is adjusted by the user by controlling the

brightness. Different drift leads to a coloration of the black background level. In extreme cases vertical flyback lines will appear. Cutoff voltage can be adjusted with potentiometers, or there is automatic stabilisation. Still, the VG2 (screen) may need periodic adjustment too.

- Leakage currents may disturb VG2 and focus voltage, re-adjustment has only a temporary effect.

- VG2 and focus potentiometers may wear out due to electromigration etc. A hole may form under the wiper, re-adjustment is then impossible.

- Some types of cathode wear (according to a friend in Philips Semiconductors) can cause the Ik/Vk transfer characteristic to divert so much from an ideal gamma function that no adjustment can compensate for it. Then the tube is really worn out.

I hope that this helps you to distinguish between a really worn out tube and one that still has some life in it after re-adjustment.

CRT Age Resulting in Dark Picture

Where circuit problems have been ruled out:

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

Most probably the cathodes have worn out. The emission material on the surface slowly becomes inactive. Usually you see one colour go first, then the others. At the same time you will observe a loss in sharpness, because a larger cathode area is being used, giving a bigger spot.

Rejuvenating is done by applying a (too) high filament voltage, in order to bring new emission material to the surface. It will not work for long and there is the risk of burning the filament wire for good. It may be worth a try, though.

Other wear mechanisms are:

- Glass browning (generally only for projection tubes).
- Phosphor aging (life time is defined by efficiency < 50%).
- Vacuum leaks (generally cause EHT flashover, audible).

Then again, it may also be that for some mysterious reason your VG2 voltage has dropped below spec. A too high VG2 voltage will cause a smaller cathode area to be used, leading to a sharper picture but accelerated cathode wear.

Brightening an Old CRT

If performing adjustments of the internal background and/or screen controls still results in a dark picture even after a long warmup period (and the controls are having an effect - they are not faulty), the CRT may simply be near the end of its useful life. In the old days of TVs with short lived CRTs, the CRT brightener was a common item (sold in every corner drugstore, it seemed!).

First confirm that the filaments are running at the correct voltage - there could be a marginal connection or bad resistor or capacitor in the filament power supply. Since this is usually derived from the flyback, it may not be possible to measure the (pulsed high frequency) voltage with a DMM but a service manual will probably have a waveform or other test. A visual examination is not a bad way to determine if the filaments are hot enough. They should be a fairly bright orange to yellow color. A dim red or almost dark filament is probably not getting its quota of electrons. It is not be the CRT since all three filaments are wired in parallel and for all three to be defective is very unlikely.

If possible, confirm that the video output levels are correct. For cathode driven CRTs, too high a bias voltage will result in a darker than normal picture.

CRT brighteners are available from parts suppliers like MCM Electronics. Some of these are designed as isolation transformers as well to deal with heater-to-cathode shorts.

You can try a making a brightener. Caution: this may shorten the life of the CRT - possibly quite dramatically (like it will blow in a couple of seconds or minutes). However, if the monitor or TV is otherwise destined for the scrap heap, it is worth a try.

The approach is simple: you are going to increase the voltage to the filaments of the electron guns making them run hotter. Hopefully, just hotter enough to increase the brightness without blowing them out.

Voltage for the CRT filament is usually obtained from a couple of turns on the flyback transformer. Adding an extra turn will increase the voltage and thus the current making the filaments run hotter. This will also shorten the CRT life - perhaps rather drastically. However, if the monitor was headed for the dumpster anyhow, you have nothing to lose. You can just add a turn to an existing winding or make your own separate filament winding as outlined in the section: Providing Isolation for a CRT H-K short.

In some monitors, there is a separate filament supply on the mainboard - this should be obvious once you trace the filament wires from the video driver board). In this case, it still may be possible to increase this output or substitute another supply but a schematic will be required.

There are also commercial CRT rejuvenators that supposedly zap the cathodes of the electron guns. A TV or monitor service center may be able to provide this service, though it is, at best, a short term fix.

Checking the Age of the CRT

So you have this great deal on a used TV or monitor. How can you tell if the picture tube is about to die on you?

(From: Andy Cuffe (baltimora@psu.edu).)

The best way to tell is to look at the picture quality. There is no way to tell the exact number of hours. Also, the life of CRTs varies quite a bit. some will go down hill much faster than others.

- It should be sharply focused over the entire screen and all 3 colors should be equally sharp.
- Set the picture brightness and color to maximum. If you see any bleeding or smearing to the right of bright objects don't buy it.

- When you first turn it on the picture should look normal in well under a minute. If it is dim, tinted, or blurry for more than a minute or two the CRT is getting weak.

- A B/W picture should not be tinted.

- The picture should have decent brightness with the picture at about mid range.

Apart form that, if the overall picture is good the CRT is fine. CRTs usually fail very slowly. Even if it's starting to show it's age it probably has several years left.

(Portions from: Jerry G. (jerryg50@hotmail.com).)

You cannot tell the hours used by just looking or even measuring a tube. A tube can go at any time. There are no hour counters!

Turn on the unit and see if there is any unusual bleeding of the image in the picture at high contrast levels. When turning the brightness up and down, the color temperature should not change, only the brightness. When turning the contrast up and down, the focus at the center should also be very stable. It may change only a little bit. When turning on the set, the color temperature should be stable within about 3 to 5 minutes.

Look at the colors in the corners to see if the purity is good. Bad purity can be attributed to a miss-adjusted yoke assembly, to a bad shadow mask.

To know the manufacture date of the unit, it us usually on the back with the model and serial number. Most TV sets are on about 5 to 8 hours a day if it is a family TV. If it is a bedroom TV the hours may be 1/2 that amount. Monitors may be on 24 hours a day - or much less.

A good way to know if the emission of the CRT is up to specs is to get a CRT analyzer and measure the gun emission. Some service centers own one.

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CRT Rejuvenation

What is CRT Rejuvenation?

Where one or more electron guns in the CRT have deteriorated due to wear and tear, it is sometimes possible to give them a new, but possibly, temporary lease on life through rejuvenation using a special piece of CRT service equipment.

There may be some schematics for commercial CRT rejuvenators accessible from the Sencore Service Page.

(From: Gary Klechowitz (klechowi@execpc.com).)

When I rejuvenate a tube I inform the customer that there is no warranty on the job. Rejuvenating a CRT is like when Clatuu was brought back to life by Gort in "The Day The Earth Stood Still". When asked "How long will you live"? he replied: "no one knows".

I use a Sencore Beam Builder. If your tube is just moderately dim and blurry but still shows good cut off threshold, I would just use the auto restore mode on the beam builder rather than using the restore button. If the tube is really bad with little or no cutoff threshold, then the rejuvenator is needed but that has less than a 50% chance of fixing the tube and in many cases the tube gets worse to trashed in the process.

CRT Degradation and Rejuvenation

> "As I understand it, when a CRT ages, its filament looses material. It ejects fewer electrons, and this accounts for the need to crank up the cutoff. Is the focusing problem caused by the high cutoff voltage accelerating the electrons too fast for the focusing assembly to work? And what would explain the shadowing problem?"

Replies from: Jeroen H. Stessen (Jeroen.Stessen@philips.com) and another engineer at Philips who we shall call Tom.

Tom:

Yes, the cathode surface is losing the Barium/Strontium oxide slowly and hence the working voltage to free the electrons is rising. In itself, this will not change the cut-off voltage needed for proper operation. This stays the same, only there are fewer electrons left that can be drawn towards the screen at a certain drive voltage. The focusing problem occurs at the moment that the TV-set tries to establish a certain beam current and finds out that a higher driver voltage is needed to give this current. Consequently, a larger cathode area is used to get enough electrons out of it. This larger cathode area will be imaged onto the screen and give a larger spot size.

Another point is the drift of leakage current, leading in a practical TV-set with high impedance focus circuit (this allows voltage drop) to a focus voltage at the CRT focus pin that is lower than it should be and this again leads to a bad focus performance.

Jeroen:

Readjustment of the focus voltage will be only a temporary solution.

Addressing each of the effects and CRT rejuvenation:

1. Why is poor focus sometimes a symptom of a failing CRT?

Tom:

Normally only the emission from the centre of the cathode adds to the electron beam. If the emission material in the centre is exhausted then the outer area comes in. This is a larger surface, the electron lens projects this into a larger spot. It is not that the focus is bad, the lens works OK. It is that a larger object is projected onto a larger image.

Jeroen:

This applies mainly to oxide cathodes. Impregnated cathodes are much more robust. They can be applied at a higher cutoff voltage and thus deliver a smaller spot without premature wear. They are more sensitive to a too high heater temperature, however, because they are operated at a higher temperature to begin with. They do evaporate more metal during their lifetime. At one time there was fear that they would deposit too much metal on the glass around the electrodes, leading to leakage currents. These can cause drift of focus and screen voltages and can disturb the cutoff current measurement. Those can influence the picture too.

Tom:

Impregnated cathodes contain a lot of emission material that moves more easily towards the cathode surface as time passes. Oxide cathodes have the problem that the Ba/Sr-oxide is positioned too deep to be very effective. Hence, the life time of an I-cathode should be longer than that of an oxide cathode but indeed the sensitivity to correct heater voltage is higher. Second, an impregnated cathode, being highly conductive compared to an oxide cathode which is a semi-conductor, can handle a much higher peak current since the cathode material is not locally heated up by this peak current. An oxide cathode can be destroyed by a too high peak beam current !

Jeroen:

Oxide cathodes are typically operated at cutoff voltages between 100 and 130 V. Impregnated cathodes are typically operated at cutoff voltages between 130 V and 200 V. Hence they can provide a much sharper spot, but it is also much more difficult to design a video output amplifier with sufficient bandwidth at the required large drive voltage (like 120 V peak-peak).

2. Why is horizontal streaking sometimes another symptom?

Jeroen:

Two symptoms, both related to the cutoff voltage being higher than what the video output amplifier(s) can deliver. The cutoff voltage is proportional to the VG2 (second grid voltage). The higher VG2 is the higher the cutoff voltage VK - VG1 must be to blank the beam. The video amplifier delivers VK. VG1 is fixed. Remember: cathode drive is negative, e.g. +130V = black, +30V = white.

If the video amplifier clips before cutoff is reached then the beam will not be blanked completely and you will see a lighted background with slanted retrace lines. Some class-B video amps will also show a bad recovery time from clipping to black, this may lead to black streaks after black images. Class-A amps should not have this problem. (In my experience this is more common with clipping to white, usually leading to red or yellow streaks.)

If the cutoff voltage rises (due to some unexplained wear) or because VG2 rises (due to drift or due to owner intervention: turning the Screen potmeter) then the user may compensate for the increased (background) brightness by lowering the brightness control of the set. Some televisions automatically lower the brightness of each channel because they have automatic cutoff control. Either way, the cathode voltages rise and clipping may occur with retrace lines as a result.

Tom:

Well, as said earlier, in principle the cut-off doesn't change due to cathode wear-out. The fewer electrons still need the same voltage to prevent them from reaching the accellerating lens. I have heard of cut- off drift due to distance drift between G1 and G2 for which it is very sensitive. However, this is not something that gets worse over time.

> 3. And finally, what is the real story on CRT restorers/rejuvenators?

Jeroen:

Some of the possible 'remedies' include:

- Excess heater temperature may bring some new emission material to the surface of the cathode. This is done by putting 9-10 V (?) on a 6.3 V heater. There is not emission material much left, so this will be a temporary solution at best. I don't think it is needed or recommended with I-cathodes (impregnated).

  Tom:

  This also helps for poisoned cathodes. Cathodes that have been operated too long on a too low heater voltage get poisoned, meaning that the Ba/Sr-oxide gets chemically binded, leading to a higher working voltage. Indeed, only oxide cathodes can be rejuvenated this way. Impregnated cathodes have a more sudden death mechanism and can not be regenerated in this way.

  There is also the risk of burning out a heater filament for good.

- Some type of electrode shorts may be removed by high currents.

- The vacuum may be improved by activating the getter electrode using an induction heater or RF source to heat the ring shaped getter electrode to red/orange temperature. (This probably only applies and then only in a limited way if the getter spot has faded - turned red or milky from its normal silvery appearance --- sam.)

  Tom:

- Further: burning metal whiskers off the electrodes can help reducing a leakage current problem.

  Jeroen:

  This is done by running high (flash) currents between electrodes. A similar procedure is performed on new picture tubes in the factory.

Also see the sections starting with: "Brightening an old CRT".

More Comments on CRT Rejuvenation

(From: Ren Tescher (ren@rap.ucar.edu).)

Reduced emission (dim picture) can occur when the cathode/filament has used up most of the electrons it can emit to the screen. Or, a 'crust' may have formed on the thoriated emitter material that can be 'boiled off' to expose more electrons.

A rejuvenator or restorer generally hits the cathode/filament with a higher than normal current to accomplish this.

But, while a rejuvenator gives the cathode/filament a 'blast' of power, a restorer can slowly increase the temperature while monitoring beam current on one of the grids.

So generally a rejuvenator was a 'do or die' unit and a restorer could give only what was needed to accomplish increased emission. But these definitions have always been blurred by advertising hype.

The early restorers, such as my REM, had the operator watch the grid current on a meter(s) to determine when emission was sufficient. I suppose newer units have a PIC chip or some other logic to do the job.

(From: Terry DeWick (dewickt@esper.com).)

I use a hand held Tesla coil to all pins for about 5 seconds. Then, follow up with rejuvenator for a quick check and cleanup if needed. Tesla coil is type the neon sign people use for testing. 95% or better luck - saved a lot of out of warranty Zeniths from big repair bills or junk pile.

Home-Made CRT Rejuvenator 1

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

I've read some articles in 'Television' which describe home-brew CRT rejuvenators. I've not tried any of the circuits yet...

It appears that you overrun the heater by up to 50% (for a 6V heater, try 7.5V and 9V, say). Don't blame me if it burns out ;-)

You then apply about 300V, current limited to say 50 or 60mA between cathode and 1st grid. One of the older designs used the UK 240V mains, a single diode as a half-wave rectifier, and a 15W light bulb in series for this PSU. I don't like unisolated equipment, so I'm not going to try it.

Some designs apply that voltage continuously, and you watch the emission current rising (or the bulb getting brighter...). With others you apply it for a few seconds, and then check the emission using, e.g. a 12V supply and a microammeter between cathode and grid.

One old article suggested that if you get no improvement, switch off the heater supply with the 300V still connected. As the cathode cools down, you get quite violent stripping of the cathode - observable as sparks from the electron gun area of the CRT. On the other hand, it is claimed that this can completely ruin the cathode, or even cause short-circuits to occur in the CRT.

Home-Made CRT Rejuvenator 2

I have no comments one way or another with respect to this device. Please contact the author for further information.

(From: Mario Di Stefano (mario.distefano@siemens.it).)

Here is the 'gadget' I use to rejuvenate 'tired' CRT's:

```
                T1
o---+--------+    +-------------------------------->
    |         )||(
M   |         )||(
A   |         )||( 6.3 or 12 Vac                    To Filament
I   |         )||( Secondary                        CRT Tube
N   |         )||(                                  (no Polarity)
S   |         )||(
    |         )||(
o---|-----+--+    +-------------------------------->
    |     |
    |     --------------------------------------> CRT Cathode
    |
    |                  +-----+     _|_
    ------------------| LP1 |-----o o------------> CRT 1st Grid
                       +-----+     P1
```

Where:

- T1 is a standard mains AC transformer.
- LP1 is a standard FILAMENT LAMP (60 - 100 W) working voltage according to mains.
- P1 Hand Pushbutton.

Other things needed (not shown):

- Mains switch (best if with overload protection or with fuse)
- 4 ISOLATED clips like the ones used in electronics to make contacts with the pins of ICs. These isolated clips ARE IMPORTANT. You don't have to touch any connection during the cleaning.

I think this circuit works better if the mains voltage is 220 Vac.

How to use it:

First we have an tired CRT (BW or colour is the same). We have poor image contrast, 'strange' brightness, also strange colours. Next we have to remove (if present) the CRT socket to its circuitry (beware to disconnect mains voltage FIRST!!!!!). At this point could be useful to discharge the HV using an isolated wire FIRST connected to CRT grey body and then to the make the contact UNDER the suction gummy which carries EHT. to the tube. It is not a dangerous voltage, but could be better not to discharge it over the body!

Now we have to identify the filament pins. Usually on the schematic circuitry of the Monitor/TV it is clearly written. If the schematic is not available, using an ohmmeter we should find the two contacts which gives a few ohms. These contacts usually are put aside each other) have to be connected to the transformer secondary of the circuit above. The Cathode and 1st grids can be found looking very closely into the tube glass (use lens and good light if necessary). Keep in mind the way the CRT electron sources are built. These usually follows this:

```
                    Cathode
                    |                  (B/W CRT tube)
                    V
          O------+  |  |
                 +  |  | <- 1st Grid
       Filament  +  |  |
                 +  |**| <-Spark (read text below)
          O------+  |  |
                    |  |
                    |  |
 Cathode  O---------+  |
 Connection            |
                       |
 1st Grid O------------+                  (Damn'd ASCII graphics!)
 Connection
```

Try to connect and turn on the transformer. The Filament in the CRT should turn on in a not-so-bright red (if it is a colour tube, we have 3 filaments on).

Now turn off the transformer again. Connect the Cathode wire to the cathode pin of the CRT Tube. Connect the 1st grid accordingly.

Turn on the transformer. FIRE button P1. If there is dust (due to aging) between the cathode and 1st grid, the circuit will blow-up it. If this happens, you could (but not always) even see the LP1 turn on and off randomly (a good cleaning gives a lamp OFF) and some sparks inside the tube. The tube collar glass now becomes hot: it is normal. You can even 'force' better sparks if you 'ting' your finger against the CRT glass (not so strong, of course). If it is a Colour CRT, you have 3 Cathodes, 3 1st grids a anyway 1 filament. Useless to say that the procedure have to be carried out for all these electrodes. A good cleaning, gives a LP1 steady OFF. If it is a steady bright or dim, means that a 'bridge' has been formed between the electrodes and there is no way to recover the tube. Turn off the mains, remove the connections, and re-apply the original socket. That's all. I'm not tired to say: BEWARE OF THE MAINS VOLTAGE: IT CAN KILL!! If you are not so skilled, don't try to do this procedure. I used this circuit lots of times. It worked almost anyway. I recovered lot of thrown away PC monitors, and now are working well....

Home-Made CRT Rejuvenator 3

Here's another circuit found on the Web:

- CRT Rejuvenator Description
- CRT Rejuvenator Schematic

And, some comments:

(From: Chris F. I recently built a homemade CRT tester & rejuvenator from plans I got these plans. The test mode works quite well, providing a good indication of the CRT emissions and showing the presence of H-K or K-G shorts. But the restore mode often doesn't help very much, though it has done a half-decent job on at least a few old CRTs. Anyway, I've been told that Sencores "Beam Builder" applies 450 Volts cathode to grid for a short time to restore the emissions. Now I have some old 450-volt transformers from really old TVs and I wondered if I could modify this design to use 450 VAC between cathode and grid (during restoration only). How long would the restoration process take at this voltage, would this work, and how dangerous would it be? I've heard horror stories of all kinds about CRTs during handling, rejuvenation, and so on, and I don't like taking chances with these things.

But I'd rather give this a try than spend the $2000 Cdn it would cost me for a Sencore unit.

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Items of Interest

Lifespans of Monitors

(From: Bob Myers (myers@fc.hp.com).)

Most manufacturers will quote an MTBF (Mean Time Before Failure) of somewhere in the 30,000 to 60,000 hour range, EXCLUSIVE OF the CRT. The typical CRT, without an extended-life cathode, is usually good for 10,000 to 15,000 hours before it reaches half of its initial brightness. Note that, if you leave your monitor on all the time, a year is just about 8,000 hours.

The only 'tune-up that a monitor should need, exclusive of adjustments needed following replacement of a failed component, would be video amplifier and/or CRT biasing adjustments to compensate for the aging of the tube. These are usually done only if you're using the thing in an application where exact color/brightness matching is important. Regular degaussing of the unit may be needed, of course, but I'm not considering that a tune-up or adjustment.

Monitor Life, Energy Conservation, and Laziness

A common misconception about the care and feeding of computer monitors is that they should be left on all the time. While there are some advantages to this, there are many more disadvantages:

1. CRT Life: The life of a monitor is determined by the life of the CRT. The CRT is by far the most expensive single part and it is usually not worth repairing a monitor in which the CRT requires replacement. The brightness half-life of a CRT is usually about 10-15 K hours of on time independent of what is being displayed on the screen. 10 K hours is only a little more than a year. By not turning the monitor off at night, you are reducing the life of the monitor by a factor of 2-3. Screen savers do not make any substantial difference especially with modern displays using X-Windows or MS Windows where the

screen layout is not fixed. With video display terminals, the text always came up in the same position and eventually burned impressions into the screen phosphor. With modern CRTs, the filaments can be left on to minimize the time needed for a picture to appear since this doesn't affect CRT life very much.

2. Component life: The heat generated inside a monitor tends to dry out parts like electrolytic capacitors thus shortening their life. These effects are particularly severe at night during the summer when the air conditioning may be off but it is still a consideration year around.

3. Safety: While electronic equipment designed and manufactured in accordance with the National Electrical Codes is very safe, there is always a small risk of catastrophic failure resulting in a fire. With no one around, even with sprinklers and smoke alarms, such an failure could be much more disastrous.

4. Energy use: While modern monitors use a lot less energy than their older cousins, the aggregate energy usage is not something to be ignored. A typical monitor uses between 60 and 200 Watts. Thus at a $.10 per kWH electric rate such a monitor will cost between $48 and $160 a year for electricity. During the night, 1/2 to 2/3 of this is wasted for every monitor that is left on. If air conditioning is on during the night, then there is the additional energy usage needed to remove this heat as well - probably about half the cost of the electricity to run the monitor.

The popular rationalization for what is most often just laziness is that power-on is a stressful time for any electronic device and reducing the number of power cycles will prolong the life of the monitor. With a properly designed monitor, this is rarely an issue. Can you recall the last time a monitor blew up when it was turned on? The other argument, which has more basis in reality is that the thermal cycling resulting from turning a monitor on and off will shorten its life. It is true that such thermal stress can contribute to various kinds of failures due to bad solder connections. However, these can be easily repaired and do not effect the monitor's heart - the CRT. You wouldn't leave your TV on 24 hours a day, would you? Full power saving where virtually everything including the CRT filaments is turned off is really best but the delay before a picture appears may be 20 seconds or more.

Also see the section: Thernal Cycling and Component Life.

Some of the newest ('green') monitors have energy conserving capabilities. However, it is necessary for the software to trigger these power reduction or power down modes. Few monitors in actual use and fewer workstations or PCs are set up to support these features. If you have such a monitor and computer to support it, by all means set up the necessary power off/power down timers. However, using the power saving modes of a 'green' PC with an older monitor can potentially cause damage since some of the modes disable the sync signals. A 'green' monitor which can detect a blank screen and and use this as a trigger can easily be used with a screen saver which can be set to display a blank screen - on any PC or workstation.

Even if the monitor does not support power saving modes, a blank screen or dark picture will reduce stress on the CRT and power supply. Electronic components will run cooler and last longer.

Please make it a habit to turn your monitors off at night. This will extend the life of the monitor (and your investment) and is good for the environment as well. For workstations, there are good reasons to leave the system unit on all the time. However, the monitor should be turned off using its power switch. For PCs, my recommendation is that the entire unit be turned off at night since the boot process is very quick and PCs are generally not required to be accessible over a network 24 hours a day.

(From: Jerry Greenberg (jerryg50@hotmail.com).)

This can be a complicated issue.

There is more to the CRT than just the heater. When there is cathode current, the ware is higher. There is a minimum cathode current when there is no brightness on the screen. The tube has to be biased slightly on all the time when working, even though it is in black. When there is some brightness on the screen, there is a greater amount of cathode wear in the electron-gun.

Having a black screen saver will in fact save some amount of cathode wear. If you have a small image on the screen that is moving around, this would introduce a bit more cathode current, but it would not be the same amount as having a full screen of white.

The best solution is if the screen is not being used for about a 2 to 3 hour period, turn it off, or have the Windows power savings utility turn it off. Cycling the monitor power on and off, can introduce a greater stress on the support components, and the tube, rather than simply leaving it on. This gets in to duty cycle statistics on the wear of the electronics, and tube. This can get very complicated in many cases.

The standard CRT should last about 30,000 hours. At this time factor, the brightness output should be about 50% of the nominal. This figure is with the brightness set to normal, and the contrast at about 50 to 70% of its maximum rage. If the monitor is used at about 10 hours per day, it should last about 8 years.

In reality these monitors will last about 5 to 6 years. There are many support components that can go wrong before the tube does. Cycling the power off and on will also cause the monitor to fail quicker. After about 6 years of normal use, many of the capacitors start to go bad in monitors and TV sets. Then there are many other types of components that can fail. Since most monitors, unless they are very expensive and high end models, they are designed to not be serviced. In the low to medium end monitors, many of the manufactures don't sell the parts for out of warranty servicing.

Enjoy the monitor. The way things are going obsolete these days, in a few years, your monitor will be useless, and may have to be changed anyways.

Thernal Cycling and Component Life

(From: Bob Myers (myers@fc.hp.com).)

In a CRT monitor, the shortest-lived component BY FAR is the CRT itself, and it ages (more properly, the cathode is aging) as long as the heater is on and the tube is under bias. Most monitors don't get around to turning the heater down or off until they enter the DPMS "suspend" or "off" modes. (And no, screen-savers do NOT help here - the tube is still on and the cathode is aging.)

Other factors - simply having the circuits hot and powered up in general means that they're aging. Clearly, they're NOT aging when they're off. This needs to be balanced against the thermal-cycling sort of stresses that you mention which happen during power cycling, and this is why I recommend shutting off only when you're going to be away for an extended period, such as overnight. This is, of course, most important for those components which have clear heat-related aging, but most do to some extent. Esp. vulnerable are things like electrolytic caps, for obvious reasons.

The bottom line is that nothing is ever going to last forever, and trying to maximize the life of the product is an exercise in making tradeoffs between various aging/failure mechanisms.

Expected Life of TV CRTs

(From: David (dakuhajda@aol.com).)

The "unofficial" designed life is 10,000 hours on the guns used in most Thomson manufactured sets. I got this from a Thomson engineer. They are no longer plating the guns but dipping them.

Given the number of hours most people watch TV these days, take 6 hours a day on average 365 days a year and you get 4.5 years. Also note that the 10,000 hours is at the preset way too high brightness and contrast settings that the set comes with from the factory. Since most people never adjust from these expect 5 years. We do the contract repair service for all the hospitals and hotels in our area. The sets bought in 1993 in one hospital are now coming in with complaint of green picture or bad focus at edges. All due to the picture tubes being worn out.

Zenith on the other hand has a company expected life of 3 years on new sets. Plus the hard short failures they have been having on all "L" and "M" line sets.

Thomson does have a "better" line of picture tubes for the higher end sets. They are actually plating the guns the way they use to.

Final note: we see 7 and 8 year old sets come in all the time with crappy picture tubes, and a few with really good looking pictures.

Why are Prices of Video Monitors So High Compared to Similarly Size TVs?

How come I can buy a 32" Sony Trinitron TV set for $800, but when it comes to buying a monitor for my PC, $1400 only gets me a no-name 20" tube?

Why can't a giant like Sony produce a PC monitor anywhere close in cost to an equivalently sized TV set?

(Some of this from: Mike Stewart (mstewart@whale.st.usm.edu).)

There are several significant factors being overlooked here:

1. Economy of scale. There are still *many* more TV sets being sold than computer monitors. Manufacturers order TV chipsets in much larger quantities. This drives down the price.

2. Resolution. NTSC TV signals aren't even VGA resolution. Try getting that 32" Sony Trinitron XBR to give you 1280x1024. A computer monitor has a CRT with a resolution about 2 to 3 times that of a TV of similar size in both horizontal and vertical directions. The beam is also more sharply focused.

3. Refresh rates. NTSC TV signals come at one refresh rate, period. You either watch broadcast NTSC at 59.94Hz (interlaced), or you don't watch it at all. No nice, clean 72Hz NI display on there. (NOTE: This

only refers to the 99+% of TV playback equipment that contains no line- doubling circuitry. That's fair, as you'll pay a good bit more for a non-interlaced, line-doubled NTSC picture than the previous poster was complaining about, anyway.)

Therefore, a auto-scan monitor needs more sophisticated deflection and power supply circuitry. It must run at much higher scan rates and this complicates the circuitry as well.

4. Geometry. The precision of a good computer monitor is much greater then any TV. The sides will be parallel and square. Adjustments are provided to eliminate pincushion, keystone, and trapizoid distortions.

5. Stability. The image on a high quality computer monitor is rock solid and does not shift position or change size as components warm up, or the power line voltage fluctuates, etc.

Problems with Designing a Combination TV and Computer Monitor

(The following is from: Bob Myers (myers@fc.hp.com).)

It's possible, and has been done (for instance, Toshiba has one product and offerings from other companies are available or are on the way). But such designs ARE compromises, and won't give the best performance possible in either application.

There is a fundamental difference between CRTs designed for TV use, and those used in computer monitors. It's a brightness/resolution tradeoff - TV tubes are run about 3X or so the brightness of a typical computer monitor, but sacrifice the ability to use small spot sizes and fine dot pitches to do this. You don't see very many color tubes running at 100 - 150 fL brightness and still using an 0.28 mm pitch!

Picture Tube Disassembly for Demonstration Purposes

Here are several questions from a budding exhibit constructor:

> "1. I am interested in using a dead CRT for a display at our science center on how things work and know about the safety issues. Also, I would really like to cut one (or parts of one) open, so it would be great to know what other things to worry about or what tools to use."

(Portions from: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

Back in the TV-lab we have an unassembled picture tube for that purpose. Most convenient!

- First, make sure that the electrical capacitance of the CRT is properly discharged. Pull the mains plug. Connect a wire to the outer aquadag. Then push it under the anode cap and make a good short-circuit. Remove the anode cap and EHT wire.

- Next you want to break the vacuum. This is my preferred method:

    - Use a sharp object or a drill to punch a small hole in the anode contact. It's made of really soft metal, probably copper. It takes several minutes for the air to fill the entire tube. In the mean time you can have some fun putting your finger over the hole. No, that's not harmful.

    - The other way to break the vacuum is via the thin tube that was used to pump the air out of the tube. That is located in the middle of the socket at the end of the neck. Remove the plastic part around the pins and break the little tube by hitting it with e.g. the tip of a screwdriver (+hammer). If you score it with a fine triangular file, it will crack off cleanly.

  I like this method less, for fear of breaking too much glass.

- You might also want to cut off the neck for easier manipulation and study of the electron gun parts. Use a glass cutting saw if one is available. Else, score totally around the neck with a fine triangular file or glass cutter and then it should snap fairly cleanly.

  Don't just chop off the neck - especially if you have not released the vacuum. Aside from the danger of flying bits of glass, you get a very characteristic dirty spot on the front of the screen, it looks as if the phosphor layer has been blown away from the faceplate by the strong inrush of air. Or maybe it was the shadow mask being blown against the faceplate. Very tell-tale and spoils your nice display.

- The deflection coils (and purity/convergence magnet assembly, if used) are also easily removed. Loosen the clamps and twist and slide them off of the neck. It's best to find an old tube where the coils have not been potted (against the noise they tend to make). Then you can see them very well.

- The difficult part will be to cut the connection between faceplate and funnel. Normally the two parts are glued together. I think it will require a glass cutting saw to get the tube open again.

  You want to separate it just behind the faceplate or else there will not be enough space to grab and remove the shadow mask. That's just clicked into place, very easy to unclick.

And one more question:

> "2. I would assume the phosphors are a problem... Any things I need to know about chemical hazards?"

Old tubes had environmentally unfriendly phosphors, containing heavy metals such as cadmium and some rare earths. Nothing immediately toxic but the long-term effects are not healthy either. Modern tubes should at least have cadmium-free phosphor. But the phosphor is covered with a metal layer, so normally it would not even be exposed. Just don't touch it.

> "3. Or that we would need to bond a cover over the exposed interior components both for safety and to keep them intact?"

Obviously, you will want to prevent the curious from being injured by sharp metal parts but nothing will fall apart (assuming your original disassembly was not overly violent). The internal magnetic screen is attached to the shadow mask, which is clicked into metal parts at the face plate. The whole assembly removes easily.

Have fun, this is going to be a wonderful demonstration of a very practical application of some heavy *physics*.

Turning a Large CRT Faceplate into the Side of a Fish Tank

So, you want to turn your 1950's vintage console TV into the ultimate fish tank experience.

WARNING: Make sure the CRT capacitance had been discharged and the vacuum let out first! See the section: Disposing of Dead TVs or Monitors (CRTs and Charged HV Capacitors).

Cutting the CRT apart would be a tricky business. If it is a typical color TV, the front is over an inch thick so you have to slice it around the edge behind the main faceplate. I wouldn't recommend even trying a glass cutter except as a last resort. If you can gain access to a diamond saw to cut around the edge, that is possible - a masonry dealer or industrial glass company might be talked into doing this. With the proper tools, it is a 10 minute job. The problem then becomes whether the inside surface is frosted or not. The phosphors may be at least somewhat toxic (to fish at least) so every trace of them need to be removed. Once this is done, the resulting finish (if the glass itself is frosted) may interfere with your fish viewing pleasure. :-)

Why do TVs Overscan?

(The following includes material from: Jeroen Stessen (Jeroen.Stessen@philips.com).)

TVs are always set up to generate a picture which is 10-15 percent large than the visible face of the CRT. Why?

In the early days of TV, this was probably done to make the design easier. Component tolerances and power line voltage fluctuations would be masked even if they caused changes in picture size.

There certainly is almost no reason today to have any more than a couple of percent overscan. Most modern TVs have very well regulated power supplies and component values do not really drift much.

Computer monitors, for example, are usually set up for no overscan at all so that the entire image is visible.

We are constantly reminded of that, now that we are building TV's with VGA inputs (PD5029C1 in the USA, US$ 2000). This mixed application has overscan in TV mode and underscan in VGA mode. Geometry adjustment is quite critical if you see border-on-border.

Unfortunately, TV's may be good but VCR's certainly are not. If you have too little overscan and then put the VCR in any feature mode (like picture search) then one (black) picture edge may become visible. Bad form. Viewers do not like this.

While design considerations may have been the original reason for overscan, now it has become accepted as a de facto standard, and broadcasters are counting on the overscan being a certain percentage. One wonders whether it will ever change or whether this really matters.

I suppose when we have true flat panel digitally addressed displays, we might have 0% overscan.

At the Japan Electronics Show all the signs are pointed toward flat panel displays so maybe I will not have to hold your breath for much longer.

Physically, as with an LCD display on a laptop computer, there will be 0% overscan (no need to build the extra pixels) but that doesn't mean that all 480 lines will be visible.

What is Aquadag?

You may see the term 'Aquadag' referring the the black paint covering the outside of most of the funnel section of the CRT.

(From: Nicholas Bodley (nbodley@tiac.net).)

Aquadag used to be a trademark of Acheson Colloids [Corp.?], I think around Niagara Falls or Buffalo, NY. It was one of many "-dag" colloidal graphites; they also made Oildag, Gredag (grease), and Alcoholdag, as I recall. Unfortunately, it's probably sold in 55-gallon drums minimum. I hope you can find smaller quantities. Are there any CRT rebuild shops around the USA? See the Thomas Catalog (ThomCat) in a library to find Acheson.

I am pretty sure there's nothing magic about the graphite. If you can find some reasonably-priced nickel-flake or copper-flake paint (be sure it's conductive!), you might have an affordable (?) coating. How about plain metal foil, maybe even ordinary aluminum foil? You surely don't need current-carrying capacity; you would need a decent adhesive, though. How to make sure you have continuity between pieces, I'm not so sure; shoot for really tight crimps that deform the metal and are gas-tight. (This might, however, be quite unnecessary.)

Why are Indirectly Heated Cathodes Used in CRTs

Here are three reasons:

1. The cathode can be made of and/or coated with a material optimal for emitting electrons without regard to its performance as a heater.
2. The separate cathode and filament can be electrically isolated so that the filament voltage and cathode drive signal, if any, do not interfere.
3. The cathode can have an optimal shape for the application. This would be particularly significant for CRTs. The spot on the screen is a reduced focused image of the effective shape of the emitting portion of the cathode.

Frequency Response of CRTs

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

The impedance of a gun is fairly high, with 50 to 100 V p-p swing and 1 to 5 mA p-p beam current it is in the order of 10 to 100 K Ohm. Consequently, series inductance plays no important role but parallel capacitance does! In fact, the video amplifiers supply more parasitic capacitive current than beam current!

For a TV tube the total parasitic capacitance (CRT + socket + PCB + amplifier output devices) is at least 10 pF. Assuming a beam current of 5 mA p-p at 100 V p-p swing then above 800 kHz there will be more peak-peak capacitive current than beam current !

The pull-up resistor in the typical class-A video amplifier also consumes current, about 12 mA p-p for an 8.2 K

Ohm resistor. Together with the beam current this shifts the dominant pole up to 2.7 MHz. Obviously there is a dominant pole well within the range of interest, even for TV.

Better tubes may or may not have lower C but it is not very important. The dominant pole is first shifted to a higher frequency by using lower-value pull-up resistors in the video amplifier. Of course this will increase dissipation losses.

Then the dominant pole is compensated by a zero in the emitter circuit of the output transistor. There may be other compensation networks too, often with inductors. This is what allows a better monitor chassis to achieve a higher bandwidth.

Frequency compensation alone is not enough. Without a sufficiently low value for the pull-up resistor the NPN transistor will simply switch off during a rising edge and the edge will be limited by the R*C of the dominant pole alone. The compensation network is effectively decoupled from the output by the switched-off transistor. Remember that, boys and girls!

Of course, class-B designs with active pull-up will improve much. But good wide-band high-voltage PNP transistors are still a bit hard to get.

Of course, spot size (sharpness of focus) is critical to allow a better CRT to achieve a sharper picture! A better monitor needs both a better CRT (sharper beam) and better video amplifiers (higher bandwidth).

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CRT Service Information

How to Read CRT Part Numbers

More than you ever wanted to know (but still not that useful)!

(From: Jeff Roberts (jroberts@axionet.com).)

The following information comes from the Sencore CR7000 Manual

The tube number is broken down in to 5 parts:

Example: M / 36 / KME / 20 / XX

Part 1: Tube Type:

A or W = TV picture tube.
M = Monitor tubes (differ in the size and pitch of the phosphor dots).
P = Projection tube.
D = Electrostatic deflection.

Part 2: Minimum viewable diagonal. Measurement is in cm. (1 inch = 2.54 cm).

Part 3: Family Number - Tubes Within a particular family have specific mechanical and electrical characteristics.

> These letters are assigned alphabetically beginning with "AAA", followed by "AAB", "AAC", etc.
>
> Tubes with the same sequence of letters are identical as far as their setup for the Sencore CR7000.
>
> The letter sequences are grouped according to the country they are manufactured in.

Part 4: Member of Family - This one or two digit number specifies a particular member within a family.

> A different number is assigned to tubes within the same family that have different neck diameters, for example. Single digit member #s = monochrome, double digit members = Color tubes.

Part 5: Phosphor Type.

Typical Color CRT Pinout

It is usually possible - with a little effort - to determine the pinout of a CRT from the markings and circuit configuration on the CRT neck board and by visually following the base lead wires inside the neck of the tube.

Here is one pinout common in color TVs. Note that this tube socket includes integral spark gaps and pin 12 doesn't actually go into the CRT.

> Pin 1: Focus
> Pin 2: NC
> Pin 3: NC
> Pin 4: NC
> Pin 5: G1
> Pin 6: Green Cathode
> Pin 7: G2
> Pin 8: Red Cathode
> Pin 9: Filament
> Pin 10: Filament
> Pin 11: Blue Cathode
> Pin 12: Sparkgap Ground

Here is another without sparkgaps in the socket:

> Pin 1: Focus
> Pin 2: NC
> Pin 3: Blue Cathode
> Pin 4: Filament
> Pin 5: Filament

Pin 6: G1
Pin 7: Red Cahtode
Pin 8: G2
Pin 9: Green Cathode

(There may actually be no pins present for those marked "NC" as well as a gap between the highest numbered pin and pin 1.)

CRT Substitution

> "I have an RCA TV model # f20700dg that has a bad crt #A51ABU14X what I would like to know is can I replace it with a #A51AGC14X."

(From: Tech 7 (gscivi@aol.com).)

Perhaps you need to know why the #'s are different?

The A is for the grade of the tube (AA is all new, B is rebuilt etc), the 51 is size in cm, the ABU is gun type, the 14 is # of elements used (pins), and the X is for phosphor type. Since the gun type is different in your two tubes, I would not spend the time to sub the tube without first check the voltages on the old one, get a schematic of set for new one, compare the parameters and then decide.

CRT Replacement Worth It?

The sad fact is that even if you can obtain a new CRT you won't have the proper set up for getting proper alignment and convergence. They generally use various permanent magnet glued to the perimeter of the yoke to set the geometry of the raster. It takes a special factory jig to do this step or really great persistence and patience. However, if you have the time and will resist punching a hole in the new CRT before you finish, by all means.

Also, consider the cost of a new CRT may be more than half the cost of the monitor when it was new.

Replacing a monochrome CRT is a snap in comparison.

A better (or at least less stressful) approach is to locate a monitor that died due to a circuit problem and salvage the CRT including the yoke and all the other magical magnets and coils.

(From: Andy Cuffe (baltimora@psu.edu).)

I have found that most 15" monitors use compatible CRTs. I just put the CRT from an old Gateway2000 with analog controls into a nice 2 year old monitor. As long as the yokes and CRT sockets are similar it should work fine. Don't try to swap the yokes or you will never get it converged.

Rebuilt CRTs

(From: B. K. Richardson (rchvid7@flash.net).)

Try Hawkeye. They have been giving us good service for at least 15 years. Their rebuilds are covered by warranty.

- Hawk-Eye Picture Tube Mfg., Inc.
  724 Scott Avenue, Des Moines, IA. 50309-5052
  Phone: 515-288-8567
  Fax: 515-288-8568

Suppliers of standard & high resolution color and monochrome picture tubes.

What Does It Take to be a Picture Tube Rebuilder, Really?

(From: Charles Godard (cgodard@iamerica.net).)

Back in the late 50's A Tech friend of mine built a picture tube rebuilding plant from scratch. He made a living with it for a few years selling rebuilt b&w tubes. Everybody around said he sold the best rebuilt tubes that you could get. He said the secret was in the good vacuum pump and that he used and the amount of time that he pumped down the tube.

He always said that a tube could be made to last practically forever if you could get a high enough vacuum on it. The only real money he put into his plant was in the pump.

A few years ago he retired and brought the whole thing down to my shop for storage. It was a marvel to behold. The cooker was an old upright deep freeze with a pyrex pie plate for a window. The lathe where he welded the tube necks onto the tube was built of scraps of angle iron with a washing machine motor. The device that he used to cut the necks off of the tube was a model railroad controller with a homemade foot pedal and a couple of whittled down broomsticks with metal tips shaped so that you could easily fold the nichrome wire around the tube neck. He said it was the only transformer he could find, at the time, that would hold up to heat the wire hot enough to cut the neck off of the tube. It was very low voltage but would supply hi current.

He said he had the most trouble when designing the inductance heater but finally got it built with the help of a local genius who had built one of our local TV station's nearly from scratch back in the 50's.

In addition to the tube plant, he also designed and got a patent on a cotton picker. I've got a copy of his patent on display in my shop. Some of us only half believed him for years, when he said he had the patent, but when he died, we searched the shop and found his patent papers hidden away in a file cabinet of old Sams Photofacts.

We found the contract where he sold the rights to build and market the picker for a $500 per picker royalty. The guy he sold it to took the patent and went to a nearby state, borrowed $200,000 from the bank with the Patent as collateral then skipped the country. My friend never got anything from his invention, and some of his design ideas were later stolen and incorporated into some one of the big name picker manufacture's products.

Those old guys were something else. They could start with a few old scraps and build something worthwhile and useful.

Speaking of patent's, I've also seen the original patent for the hinges RCA used to hold up the tops on the old console stereo's. I made a service call a few years ago, and the guy's widow showed me the patent and his original prototype hinges. The only thing is, they took the idea from the patent and redesigned it so they wouldn't have to pay our local guy for the hinges. RCA's redesign didn't work as well as his original, but was recognizable as his original with only a couple of changes. RCA 'did him' about the same way they 'did' Philo Farnsworth.

When I get a slack spell, I'll try the inductance heater to see if it still works. If it does, I try it on the tubes and let you know. I believe you called it a Tesla coil?

Shipping Damage: Why Monitors are Like Basketballs

(From: Stephen Swann (swann@panix.com).)

Monitors are more prone to shipping damage than most other computer components, and it doesn't help that they typically pass through several people's hands (several stages of shipping) before they get to you: factory -> distribution center -> vendor -> you.

And from what I've seen first hand of shipping practices (I put in a couple of months working in a distribution warehouse during college), you can safely assume that each stage of shipping is roughly the equivalent of your monitor being dropped down a flight of stairs.

You wouldn't *believe* the abuse that UPS and FedEx can subject packages to. In fact, putting a *FRAGILE* sign on the side of the box is about the equivalent of writing "KICK ME" on it. I remember receiving packages marked "FRAGILE" where the (originally cubical) cardboard boxes had been smashed into shapeless cardboard "bags", and it took us 20 minutes to figure out what the contents of the box had originally been. ("What are all these shards?" "I think it was some kind of vase" "No, it was some kind of lamp." "Where's the bulb socket, then?" "How about this squashed piece of aluminum?" "Yeah, you're right, but where's the cord then?" etc). :-) Shipping guys would think nothing of dropping "fragile" boxes from waist-high onto a concrete floor - safe in the knowledge that the package had passed through so many hands that the damage could never possibly be traced back to them. "Blameless is Guiltless" should be the motto of these folks.

Basically, what I'm saying is that if 1 monitor in 3 arrives arrives in workable condition, you should be surprised that even that one monitor survived.

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Notes on the Troubleshooting and Repair of Computer and Video Monitors

Version 3.09

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Working inside a CRT-based computer or video monitor, or television set can be lethal from line-connected and high voltage power supplies as well as CRT implosion. Read and follow ALL of the safety guidelines found in Safety Guidelines for High Voltage and/or Line Powered Equipment and the section "SAFETY", below. If in doubt about your abilities or experience, leave repair and internal adjustments to a professional.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Introduction

Monitors, monitors, and more monitors

In the early days of small computers, a 110 baud teletype with a personal paper tape reader was the 'preferred' input-output device (meaning that this was a great improvement over punched cards and having to deal with the bozos in the computer room. Small here, also meant something that would comfortably fit into a couple of 6 foot electronics racks!)

The earliest personal computers didn't come with a display - you connected them to the family TV. You and your kids shared the single TV and the Flintstones often won out. The Commodore 64 would never have been as successful as it was if an expensive monitor were required rather than an option.

However, as computer performance improved, it quickly became clear that a dedicated display was essential. Even for simple text, a TV can only display 40 characters across the screen with any degree of clarity.

When the IBM PC was introduced, it came with a nice 80x25 green monochrome text display. It was bright, crisp, and stable. Mono graphics (MGA or MDA) was added at 720x350, CGA at a range of resolutions from 160x200 to 640x200 at 2 to 16 colors, and EGA extended this up to a spectacular resolution of 640x350. This was really fine until the introduction of Windows (well, at least once Windows stayed up long enough for you to care).

All of these displays used digital video - TTL signals which coded for a specific discrete number of possible colors and intensities. Both the video adapter and the monitor were limited to 2, 4, 16, or a whopping 64 colors depending on the graphics standard. The video signals were logic bits - 0s and 1s.

With the introduction of the VGA standard, personal computer graphics became 'real'. VGA and its successors - PGA, XGA, and all of the SVGA (non) standards use analog video - each of the R, G, and B signals is a continuous voltage which can represent a continuous range of intensities for each color. In principle, an analog monitor is capable of an unlimited number of possible colors and intensities. (In practice, unavoidable noise and limitations of the CRT restricts the actual number to order of 64-256 distinguishable intensities for each channel.)

Note that analog video was only new to the PC world. TVs and other video equipment, workstations, and image analysis systems had utilized analog signals for many years prior to the PC's 'discovery' of this approach. In all fairness, both the display adapter and monitor are more expensive so it is not surprising that early PCs did not use analog video.

Most of the information in this document applies to color computer video monitors and TV studio monitors as well as the display portions of television sets. Black and white, gray scale, and monochrome monitors use a subset of the circuitry (and generally at lower power levels) in color monitors so much of it applies to these as well.

For most descriptions of symptoms, testing, diagnosis, and repair, an auto-scan PC SVGA monitor is assumed. For a fixed frequency workstation monitor, studio video monitor, or closed circuit TV monitor, only a subset of the possible faults and procedures will apply.

Note: we use the term 'auto-scan' to describe a monitor which accepts a wide (and possibly continuous) range of scan rates. Usually, this refers mostly to the horizontal frequency as the vertical refresh rate is quite flexible on many monitors of all types. Fixed scan or fixed frequency monitors are designed to work with a single scan rate (though a 5% or so variation may actually be accepted). Multi-scan monitors sync at two or more distinct scan rates. While not very common anymore, multi-scan monitors may still be found in some specific applications.

Related Information

See the documentss: Troubleshooting and Repair of Small Switchmode Power Supplies and Troubleshooting and Repair of Television Sets for additional useful pointers. Since a monitor must perform a subset of the functions of a TV, many of the problems and solutions are similar. For power related problems the info on SMPSs may be useful as well. If you are considering purchasing a monitor or have one that you would like to evaluate, see the companion document: Performance Testing of Computer and Video Monitors.

Monitor fundamentals

Note: throughout this document, we use the term 'raster' to refer to the entire extent of the scanned portion of the screen and the terms 'picture', 'image'. or 'display', to refer to the actual presentation content.

Monitors designed for PCs, workstations, and studio video have many characteristics in common. Modern computer monitors share many similarities with TVs but the auto-scan and high scan rate deflection circuitry and more sophisticated power supplies complicates their servicing.

Currently, most inexpensive computer monitors are still based on the Cathode Ray Tube (CRT) as the display device. However, handheld equipment, laptop computers, and the screens inside video projectors now use flat panel technology, mostly Liquid Crystal Displays - LCDs. These are a lot less bulky than CRTs, use less power, and have better geometry - but suffer from certain flaws. As the price of LCD (and other technology) flat screen technology decreases, such monitors will become dominant for desktop computers as well and CRT based monitors will eventually go the way of dinosaurs, core memory, and long playing records that dominated their respective industries for decades but eventually yielded to fundamentally new technology. :)

However, there are still problems with (low cost, at least) LCD monitors. First, the picture quality in terms of gray scale and color is generally inferior to a decent analog monitor. The number of distinct shades of gray or distinct colors is a lot more limited. They are generally not as responsive as CRTs when it comes to real-time video which is becoming increasingly important with multimedia computers. This is partly due to the response of the LCD material itself but also a result of the scan conversion that's needed for non-native resolution formats. Brightness is generally not as good as a decent CRT display. And last but not least, the cost is still somewhat higher due both to the increased complexity of flat panel technology and lower production volumes (though this is certainly increasing dramatically). It is really hard to beat the simplicity of the shadow mask CRT.

Also a note to those with less than perfect vision: If you tend to view your monitor from less than 10 to 15 inches, you may be disappointed, or at least have a hard time getting used to LCD monitors. The appearance of a CRT display is nearly independent of viewing angle. But for an LCD display, this is not the case. Only the central part of your field of vision will have the proper brightness, contrast, and color rendition. If the curser isn't within this central area, it will be harder to locate than on a CRT. In short, don't just depend on the hype. An LCD with a slightly lower contrast ratio and lower price may have a sbustantially wider viewing angle and better match to your needs than a top-of-the-line model. Test drive multiple LCD monitors before committing to one!

Nonetheless, a variety of technologies are currently competing for use in the flat panel displays of the future. Among these are advanced LCD, plasma discharge, and field emission displays. Only time will tell which, if any survives to become **the** picture-on-the-wall or notepad display - at reasonable cost.

Projection displays, on the other hand, can take advantage of a novel development in integrated micromachining - the Texas Instruments Inc. Digital Micromirror Device (DMD). This is basically an integrated circuit with a tiltable micromirror for each pixel fabricated on top of a static memory - RAM - cell. DMD technology would permit nearly any size projection display to be produced and would therefore be applicable to HDTV as well as PCs. Since it is a reflective device, the light source can be as bright as needed. This technology is already appearing in commercial high performance computer projectors and is competing for use in totally digital movie theaters to replace the film projector, but to my knowledge is not in any consumer TV sets - yet.

As noted, the plasma panel flat screen display has been around for several years in high-end TVs, typically in the 42 inch diagonal range. But they are very expensive ($5,000 to $15,000 as of Winter, 2003), and their life expectancy may be limited due to the gradual degradation of the active pixel cells - which occurs faster than for a CRT. The physical resolution is also probably still too low to really justify the large screen size for computer displays. However, there is little doubt that this or a similar technology will eventually replace the direct view CRT and 3-tube projection TVs in the mid to large screen sizes in the not too distant future. But to what extent it is used for computer monitors is still unclear.

The remainder of this document concentrates on CRT based computer and video monitors since these still dominate the market and realistically, they are the only type where there is a good chance of repair without access to specialized test equipment and parts. I wouldn't recommend any sort of attempt at repair of flat screen TVs or monitors - no matter what the size - beyond checking for bad connections, dead power supplies, or other obvious problems. The chance of success is vanishingly small and it's very likely that even with great care, damage could occur to the panels or circuitry.

Monitor characteristics

The following describe the capabilities which characterize a display:

1. Resolution - the number of resolvable pixels on each line and the number of scanning lines. Bandwidth of the video source, cable, and monitor video amplifiers as well as CRT focus spot size are all critical. However, maximum resolution on a color CRT is limited by the dot/slot/line pitch of the CRT shadow/slot mask or aperture grille.

2. Refresh rate - the number of complete images 'painted' on the screen each second. Non-interlaced or progressive scanning posts the entire frame during each sweep from top to bottom. Interlaced scanning posts 1/2 of the frame called a field - first the even field and then the odd field. This interleaving reduces the apparent flicker for a given display bandwidth when displaying smooth imagery such as for TV. It is usually not acceptable for computer graphics, however, as thin horizontal lines tend to flicker at 1/2 the vertical scan rate. Refresh rate is the predominant factor that affects the flicker of the display though the persistence of the CRT phosphors are also a consideration. Long persistence phosphors decrease flicker at the expense of smearing when the picture changes or moves. Vertical scan rate is equal to the refresh rate for non-interlaced monitors but is the twice the refresh rate for interlaced monitors (1 frame equals 2 fields). Non-interlaced vertical refresh rates of 70-75 Hz are considered desirable for computer displays. Television uses 25 or 30 Hz (frame rate) interlaced scanning in most countries.

3. Horizontal scan rate - the frequency at which the electron beam(s) move across the screen. The horizontal scan rate is often the limiting factor in supporting high refresh rate high resolution displays. It is what may cause failure if scan rate speed limits are exceeded due to the component stress levels in high performance deflection systems.

4. Color or monochrome - a color monitor has a CRT with three electron guns each associated with a primary color - red, green, or blue. Nearly all visible colors can be created from a mix of primaries with suitable spectral characteristics using this additive color system.

   A monochrome monitor has a CRT with a single electron gun. However, the actual color of the display may be white, amber, green, or whatever single color is desired as determined by the phosphor of the CRT selected.

5. Digital or analog signal - a digital input can only assume a discrete number of states depending on how many bits are provided. A single bit input can only produce two levels - usually black or white (or amber, green, etc.). Four bit EGA can display up to 16 colors (with a color monitor) or 16 shades of gray (with a monochrome monitor).

   Analog inputs allow for a theoretically unlimited number of possible gray levels or colors. However, the actual storage and digital-to-analog convertors in any display adapter or frame store and/or unavoidable noise and other characteristics of the CRT - and ultimately, limitations in the psychovisual eye-brain system will limit this to a practical maximum of 64-256 discernible levels for a gray scale display or for each color channel.

   However, very high performance digital video sources may have RAMDACs (D/A convertors with video lookup tables) of up to 10 or more bits of intensity resolution. While it is not possible to perceive this many distinct gray levels or colors (per color channel), this does permit more accurate tone scale ('gamma') correction to be applied (via a lookup table in the RAMDAC) to compensate for the unavoidable non-linearity of the CRT phosphor response curve or to match specific photometric requirements.

Types of monitors

Monitors can be classified into three general categories:

1. Studio video monitors - Fixed scanning rate for the TV standards in the country in which they are used. High quality, often high cost, utilitarian case (read: ugly), underscan option. Small closed circuit TV monitors fall into the class. Input is usually composite (i.e., NTSC or PAL) although RGB types are available.

2. Fixed frequency RGB - High resolution, fixed scan rate. High quality, high cost, very stable display. Inputs are analog RGB using either separate BNC connectors or a 13W3 (Sun) connector. These often have multiple sync options. The BNC variety permit multiple monitors to be driven off of the same source by daisychaining. Generally used underscanned for computer workstation (e.g., X-windows) applications so that entire frame buffer is visible. There are also fixed frequency monochrome monitors which may be digital or analog input using a BNC, 13W3, or special connector.

3. Multi-scan or auto-scan - Support multiple resolutions and scan rates or multiple ranges of resolutions and scan rates. The quality and cost of these monitors ranges all over the map. While cost is not a strict measure of picture quality and reliability, there is a strong correlation. Input is most often analog RGB but some older monitors of this type (e.g., Mitsubishi AUM1381) support a variety of digital (TTL) modes as well. A full complement of user controls permits adjustment of brightness, contrast, position, size, etc. to taste. Circuitry in the monitor identifies the video scan rate automatically and sets up the appropriate circuitry. With more sophisticated (and expensive) designs, the monitor automatically sets the appropriate parameters for user preferences from memory as well. The DB15 high density VGA connector is most common though BNCs may be used or may be present as an auxiliary (and better quality) input.

Why auto-scan?

Thank IBM. Since the PC has evolved over a period of 15 years, display adapters have changed and improved a number of times. With an open system, vendors with more vision (and willing to take more risks) than IBM were continuously coming up with improved higher resolution display adapters. With workstations and the Apple MacIntosh, the primary vendor can control most aspects of the hardware and software of the computer system. Not so with PCs. New improved hardware adapters were being introduced regularly which were not following any standards for the high resolution modes (but attempted to be backward compatible with the original VGA as well as EGA and CGA (at least in terms of software).) Vast numbers of programs were written that were designed to directly control the CGA, EGA, and VGA hardware. Adapter cards could be designed to emulate these older modes on a fixed frequency high resolution monitor (and these exist to permit high quality fixed scan rate workstation monitors to be used on PCs) However, these would be (and are) much more expensive than basic display adapters that simply switch scan rates based on mode. Thus, auto-scan monitors evolved to accommodate the multiple resolutions that different programs required.

Note: The generic term 'auto-scan' is used to refer to a monitor which automatically senses the input video scan rate and selects the appropriate horizontal and vertical deflection circuitry and power supply voltages to display this video. Multi-scan monitors, while simpler than true auto-scan monitors, will still have much of the same scan rate detection and selection circuitry. Manufacturers use various buzz words to describe their versions of these monitors including 'multisync', 'autosync','panasync', 'omnisync', as well as 'autoscan' and 'multiscan'.

Ultimately, the fixed scan rate monitor may reappear for PCs. Consider one simple fact: it is becoming cheaper to design and manufacture complex digital processing hardware than to produce the reliable high quality analog and power electronics needed for an auto-scan monitor. This is being done in the specialty market now. Eventually, the development of accelerated chipsets for graphics mode emulation may be forced by the increasing popularity of flat panel displays - which are basically similar to fixed scan rate monitors in terms of their interfacing requirements.

Analog versus digital monitors

There are two aspects of monitor design that can be described in terms of analog or digital characteristics:

1. The video inputs. Early PC monitors, video display terminal monitors, and mono workstation monitors use digital input signals which are usually TTL but some very high resolution monitors may use ECL instead.

2. The monitor control and user interface. Originally, monitors all used knobs - sometimes quite a number of them - to

control all functions like brightness, contrast, position, size, linearity, pincushion, convergence, etc. However, as the costs of digital circuitry came down - and the need to remember settings for multiple scan rates and resolutions arose, digital - microprocessor control - became an attractive alternative in terms of design, manufacturing costs, and user convenience. Now, most better quality monitors use digital controls - buttons and menus - for almost all adjustments except possibly brightness and contrast where knobs are still more convenient.

Since monitors with digital signal inputs are almost extinct today except for specialized applications, it is usually safe to assume that 'digital' monitor refers to the user interface and microprocessor control. And, except perhaps for the very cheapest monitors, all now have digital controls.

Interlacing

Whether a monitor runs interlaced or non-interlaced is almost always strictly a function of the video source timing. The vertical sync pulse is offset an amount equal to 1/2 the line time on alternate fields (vertical scans - two fields make up a frame when interlaced scanning is used).

- Generally, a monitor that runs at a given resolution non-interlaced can run interlaced at a resolution with the same number of pixels per line but twice the number of lines vertically at roughly the same horizontal and vertical scan rates and video bandwidth (but half the frame rate).

- Alternatively, it may be possible to increase the resolution in both directions while keeping the horizontal scan rate the same thus permitting a monitor to display the next larger size format. However, in this case, the video bandwidth will increase.

Here are a couple of examples:

- A monitor that will run 640x240 at 60 frames per second non-interlaced will run 640x480 at 30 frames per second interlaced. This would permit a monitor with a horizontal scan rate of 15.7 kHz (NTSC TV compatible) to display VGA resolution images - though they will likely flicker since the 30 Hz is way too low for most graphics.

- A resolution of 1024x768 at 50 frames per second interlaced requires roughly the same horizontal scan rate (about 42 kHz) as 800x600 at 66 frames per second non-interlaced. The flicker may be acceptable in this case being at 50 Hz for the worst case of single horizontal lines as the high 100 Hz vertical scan rate will reduce flicker otherwise.

Whether the image is usable at the higher resolution of course depends on many other factors (in addition to flicker) including the dot pitch of the CRT and video bandwidth of the video card and monitor video amplifiers, as well as cable quality and termination.

Monitor performance

The ultimate perceived quality of your display is influenced by many aspects of the total video source/computer-cable-monitor system. Among them are:

1. Resolution of the video source. For a computer display, this is determined by the number of pixels on each visible scan line and the number of visible scan lines on the entire picture.

2. The pitch of the shadow mask or aperture grille of the CRT. The smallest color element on the face of the CRT is determined by the spacing of the groups of R, G, and B colors phosphors. The actual conversion from dot or line pitch to resolution differs slightly among dot or slot mask and aperture grille CRTs but in general, the finer, the better - and more expensive.

   Typical television CRTs are rather coarse - .75 mm might be a reasonable specification for a 20 inch set. High resolution computer monitors may have dot pitches as small as .22 mm for a similar size screen.

A rough indication of the maximum possible resolution of the CRT can be found by determining how many complete phosphor dot groups can fit across the visible part of the screen.

Running at too high a resolution for a given CRT may result in Moire - an interference pattern that will manifest itself as contour lines in smooth bright areas of the picture. However, many factors influence to what extent this may be a problem. See the section: Contour lines on high resolution monitors - Moire.

3. Bandwidth of the video source or display card - use of high performance video amplifiers or digital to analog convertors.

4. Signal quality of the video source or display card - properly designed circuitry with adequate power supply filtering and high quality components.

5. High quality cables with correct termination and of minimal acceptable length without extensions or switch boxes unless designed specifically for high bandwidth video.

6. Sharpness of focus - even if the CRT dot pitch is very fine, a fuzzy scanning beam will result in a poor quality picture.

7. Stability of the monitor electronics - well regulated power supplies and low noise shielded electronics contribute to a rock solid image.

The following are only partly dependent on the monitor's design:

8. Anti-glare treatment of screen and ambient lighting conditions - No matter how good are the monitor's electronics, the display can still be washed out and difficult or tiring to view if there is annoying glare or reflections. The lighting and location are probably more important than how the screen itself is designed to minimize glare.

9. Electromagnetic interference - Proximity to sources of magnetic fields and power line noise can degrade the performance of any monitor, no matter how well shielded it might be.

Performance testing of monitors

WARNING: No monitor is perfect. Running comprehensive tests on your monitor or one you are considering may make you aware of deficiencies you never realized were even possible. You may never be happy with any monitor for the rest of your life!

Note: The intent of these tests is **not** to evaluate or calibrate a monitor for photometric accuracy. Rather they are for functional testing of the monitor's performance.

Obviously, the ideal situation is to be able to perform these sorts of tests before purchase. With a small customer oriented store, this may be possible. However, the best that can be done when ordering by mail is to examine a similar model in a store for gross characteristics and then do a thorough test when your monitor arrives. The following should be evaluated:

- Screen size and general appearance.
- Brightness and screen uniformity, purity and color saturation.
- Stability.
- Convergence.
- Edge geometry.
- Linearity.
- Tilt.

- Size and position control range.
- Ghosting or trailing streaks.
- Sharpness.
- Moire.
- Scan rate switching.
- Acoustic noise.

The companion document: Performance Testing of Computer and Video Monitors provides detailed procedures for the evaluation of each of these criteria.

CAUTION: Since there is no risk free way of evaluating the actual scan rate limits of a monitor, this is not an objective of these tests. It is assumed that the specifications of both the video source/card and the monitor are known and that supported scan rates are not exceeded. Some monitors will operate perfectly happily at well beyond the specified range, will shut down without damage, or will display an error message. Others will simply blow up instantly and require expensive repairs.

Monitor repair

Unlike PC system boards where any disasters are likely to only affect your pocketbook, monitors can be very dangerous. Read, understand, and follow the set of safety guidelines provided later in this document whenever working on TVs, monitors, or other similar high voltage equipment.

If you do go inside, beware: line voltage (on large caps) and high voltage (on CRT) for long after the plug is pulled. There is the added danger of CRT implosion for carelessly dropped tools and often sharp sheetmetal shields which can injure if you should have a reflex reaction upon touching something you should not touch. In inside of a TV or monitor is no place for the careless or naive.

Having said that, a basic knowledge of how a monitor works and what can go wrong can be of great value even if you do not attempt the repair yourself. It will enable you to intelligently deal with the service technician. You will be more likely to be able to recognize if you are being taken for a ride by a dishonest or just plain incompetent repair center. For example, a faulty picture tube CANNOT be the cause of a color monitor only displaying in black-and-white (this is probably a software or compatibility problem). The majority of consumers - and computer professionals - may not know even this simple fact.

This document will provide you with the knowledge to deal with a large percentage of the problems you are likely to encounter with your monitors. It will enable you to diagnose problems and in many cases, correct them as well. With minor exceptions, specific manufacturers and models will not be covered as there are so many variations that such a treatment would require a huge and very detailed text. Rather, the most common problems will be addressed and enough basic principles of operation will be provided to enable you to narrow the problem down and likely determine a course of action for repair. In many cases, you will be able to do what is required for a fraction of the cost that would be charged by a repair center.

Should you still not be able to find a solution, you will have learned a great deal and be able to ask appropriate questions and supply relevant information if you decide to post to sci.electronics.repair. It will also be easier to do further research using a repair text such as the ones listed at the end of this document. In any case, you will have the satisfaction of knowing you did as much as you could before taking it in for professional repair. With your new-found knowledge, you will have the upper hand and will not easily be snowed by a dishonest or incompetent technician.

Most Common Problems

The following probably account for 95% or more of the common monitor ailments:

- Intermittent changes in color, brightness, size, or position - bad connections inside the monitor or at the cable connection to the computer or or video source.

- Ghosts, shadows, or streaks adjacent to vertical edges in the picture - problems with input signal termination including use of cable extensions, excessively long cables, cheap or improperly made video cables, improper daisychaining of monitors, or problems in the video source or monitor circuitry.

- Magnetization of CRT causing color blotches or other color or distortion problems - locate and eliminate sources of magnetic fields if relevant and degauss the CRT.

- Electromagnetic Interference (EMI) - nearby equipment (including and especially other monitors), power lines, or electrical wiring behind walls, may produce electromagnetic fields strong enough to cause noticeable wiggling, rippling, or other effects. Relocate the monitor or offending equipment. Shielding is difficult and expensive.

- Wiring transmitted interference - noisy AC power possibly due to other equipment using electric motors (e.g., vacuum cleaners), lamp dimmers or motor speed controls (shop tools), fluorescent lamps, and other high power devices, may result in a variety of effects. The source is likely local - in your house - but could be several miles away. Symptoms might include bars of noise moving up or down the screen or diagonally. The effects may be barely visible as a couple of jiggling scan lines or be broad bars of salt and pepper noise, snow, or distorted video. Plugging the monitor into another outlet or the use of a line filter may help. If possible, replace or repair the offending device.

- Monitor not locking on one or more video scan ranges - settings of video adapter are incorrect. Use software setup program to set these. This could also be a fault in the video source or monitor dealing with the sync signals.

- Adjustments needed for background brightness or focus - aging CRT reduces brightness. Other components may affect focus. These are often easy internal (or sometimes external) adjustments but some manufacturers have gone to digital setup requiring expensive an adapter (serial cable) to a PC and their own (expensive and/or unavailable) software.

- Dead monitor due to power supply problems - very often the causes are simple such as bad connections, blown fuse or other component.

Repair or replace

If you need to send or take the monitor to a service center, the repair could easily exceed half the cost of a new monitor. Service centers may charge up to $50 or more for providing an initial estimate of repair costs but this will usually be credited toward the total cost of the repair (of course, they may just jack this up to compensate for their bench time). With new monitors going for under $200, the costs of any significant repair are no longer justifiable unless there is something unique about your monitor.

Some places offer attractive flat rates for repairs involving anything but the CRT, yoke, and flyback. Such offers are attractive if the repair center is reputable. However, if by mail, you will be stuck with a tough decision if they find that one of these expensive components is actually bad.

Monitors become obsolete at a somewhat slower rate than most other electronic equipment. Therefore, unless you need the higher resolution and scan rates that newer monitors provide, repairing an older one may make sense as long as the CRT is in good condition (adequate brightness, no burn marks, good focus). However, it may just be a good excuse to upgrade.

If you can do the repairs yourself, the equation changes dramatically as your parts costs will be 1/2 to 1/4 of what a professional will charge and of course your time is free. The educational aspects may also be appealing. You will learn a lot in the process. Thus, it may make sense to repair that old clunker for your 2nd PC (or your 3rd or your 4th or....).

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Monitors 101

Subsystems of a monitor

Please refer to Typical SVGA Monitor Block Diagram while reading the following description.

A computer or video monitor includes the following functional blocks:

1. Low voltage power supply (some may also be part of (2).) Most of the lower voltages used in the monitor may be derived from the horizontal deflection circuits, a separate switchmode power supply (SMPS), or a combination of the two. Rectifier/filter capacitor/regulator from AC line provides the B+ to the SMPS or horizontal deflection system. Auto-scan monitors may have multiple outputs from the low voltage power supply which are selectively switched or enabled depending on the scan rate, or an power supply with programmable output voltage for the deflection system. A common configuration is a pair of SMPSs where one provides all the fixed voltages and the other is programmable based on scan rate.

   Degauss operates off of the line whenever power is turned on (after having been off for a few minutes) to demagnetize the CRT. Better monitors will have a degauss button which activates this circuitry as well since even rotating the monitor on its tilt-swivel base can require degauss.

2. Horizontal deflection. These circuits provide the waveforms needed to sweep the electron beam in the CRT across and back at anywhere from 15 kHz to over 100 kHz depending on scan rate and resolution. The horizontal sync pulse from the sync separator or the horizontal sync input locks the horizontal deflection to the video signal. Auto-scan monitors have sophisticated circuitry to permit scanning range of horizontal deflection to be automatically varied over a wide range.

3. Vertical deflection. These circuits provide the waveforms needed to sweep the electron beam in the CRT from top to bottom and back at anywhere from 50 - 120 or more times per second. The vertical sync pulse from the sync separator or vertical sync input locks the vertical deflection to the video signal. Auto-scan monitors have additional circuitry to lock to a wide range of vertical scan rates.

4. CRT high voltage 'flyback' power supply (also part of (2).) A modern color CRT requires up to 30 kV for a crisp bright picture. Rather than having a totally separate power supply, most monitors derive the high voltage (as well as many other voltages) from the horizontal deflection using a special transformer called a 'flyback' or 'Line OutPut Transformer (LOPT) for those of you on the other side of the lake. Some high performance monitors use a separate high voltage board or module which is a self contained high frequency inverter.

5. Video amplifiers. These buffer the low level inputs from the computer or video source. On monitors with TTL inputs (MGA, CGA, EGA), a resistor network also combines the intensity and color signals in a kind of poor man's D/A. Analog video amplifiers will usually also include DC restore (black level retention, back porch clamping) circuitry stabilize the black level on AC coupled video systems.

6. Video drivers (RGB). These are almost always located on a little circuit board plugged directly onto the neck of the CRT. They boost the output of the video amplifiers to the hundred volts or so needed to drive the cathodes (usually) of the CRT.

7. Sync processor. This accepts separate, composite, or 'sync-on-green' signals to control the timing of the horizontal and vertical deflection systems. Where input is composite rather than separate H and V syncs (as is used with VGA/SVGA), this circuit extracts the individual sync signals. For workstation monitors which often have the sync combined with the green video signals, it needs to separate this as well. The output of the sync processor is horizontal and vertical sync pulses to control the deflection circuits.

8. System control. Most higher quality monitors use a microcontroller to perform all user interface and control functions from the front panel (and sometimes even from a remote control). So called 'digital monitors' meaning digital controls not digital inputs, use buttons for everything except possibly user brightness and contrast. Settings for horizontal and vertical size and position, pincushion, and color balance for each scan rate may be stored in non-volatile memory. It may communicate with the video card over the serial VESA bus to inform if of its capabilities. The microprocessor also analyzes the input video timing and selects the appropriate scan range and components for the detected resolution. While these circuits rarely fail, if they do, debugging can be quite a treat.

Most problems occur in the horizontal deflection and power supply sections. These run at relatively high power levels and some components run hot. This results in both wear and tear on the components as well as increased likelihood of bad connections developing from repeated thermal cycles. The high voltage section is prone to breakdown and arcing as a result of hairline cracks, humidity, dirt, etc.

The video circuitry is generally quite reliable. However, it seems that even after 15+ years, manufacturers still cannot reliably turn out circuit boards that are free of bad solder connections or that do not develop them with time and use.

For more information on monitor technology

The books listed in the section: Suggested references include additional information on the theory and implementation of the technology of monitors and TV sets.

Philips/Magnavox used to have a very nice on-line introduction to a variety of consumer electronics technologies. Although their site has disappeared - and even people who work for them have no clue - I have now recovered several of the articles including those on TVs, VCRs, camcorders, satellite reception, and connections. See the Introductory Consumer Electronics Technology Series.

On-line tech-tips databases

A number of organizations have compiled databases covering thousands of common problems with VCRs, TVs, computer monitors, and other electronic equipment. Most charge for their information but a few, accessible via the Internet, are either free or have a very minimal monthly or per-case fee. In other cases, a limited but still useful subset of the for-fee database is freely available.

A tech-tips database is a collection of problems and solutions accumulated by the organization providing the information or other sources based on actual repair experiences and case histories. Since the identical failures often occur at some point in a large percentage of a given model or product line, checking out a tech-tips database may quickly identify your problem and solution.

In that case, you can greatly simplify your troubleshooting or at least confirm a diagnosis before ordering parts. My only reservation with respect to tech-tips databases in general - this has nothing to do with any one in particular - is that symptoms can sometimes be deceiving and a solution that works in one instance may not apply to your specific problem. Therefore, an understanding of the hows and whys of the equipment along with some good old fashioned testing is highly desirable to minimize the risk of replacing parts that turn out not to be bad.

The other disadvantage - at least from one point of view - is that you do not learn much by just following a procedure developed by others. There is no explanation of how the original diagnosis was determined or what may have caused the failure in the first place. Nor is there likely to be any list of other components that may have been affected by overstress and may fail in the future. Replacing Q701 and C725 may get your equipment going again but this will not help you to repair a different model in the future.

Please see the document: On-Line Tech-Tips Databases for the most up to date compilation of these resources for TVs, VCRs, computer monitors, and other consumer electronic equipment.

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CRT Basics

Note: Most of the information on TV and monitor CRT construction, operation, interference and other problems. has been moved to the document: TV and Monitor CRT (Picture Tube) Information. The following is just a brief introduction with instructions on degaussing.

Color CRTs - shadow masks and aperture grills

All color CRTs utilize a shadow mask or aperture grill a fraction of an inch (1/2" typical) behind the phosphor screen to direct the electron beams for the red, green, and blue video signals to the proper phosphor dots. Since the electron beams for the R, G, and B phosphors originate from slightly different positions (individual electron guns for each) and thus arrive at slightly different angles, only the proper phosphors are excited when the purity is properly adjusted and the necessary magnetic field free region is maintained inside the CRT. Note that purity determines that the correct video signal excites the proper color while convergence determines the geometric alignment of the 3 colors. Both are affected by magnetic fields. Bad purity results in mottled or incorrect colors. Bad convergence results in color fringing at edges of characters or graphics.

The shadow mask consists of a thin steel or InVar (a ferrous alloy) with a fine array of holes - one for each trio of phosphor dots - positioned about 1/2 inch behind the surface of the phosphor screen. With some CRTs, the phosphors are arranged in triangular formations called triads with each of the color dots at the apex of the triangle. With many TVs and some monitors, they are arranged as vertical slots with the phosphors for the 3 colors next to one another.

An aperture grille, used exclusively in Sony Trinitrons (and now their clones as well), replaces the shadow mask with an array of finely tensioned vertical wires. Along with other characteristics of the aperture grille approach, this permits a somewhat higher possible brightness to be achieved and is more immune to other problems like line induced moire and purity changes due to local heating causing distortion of the shadow mask.

However, there are some disadvantages of the aperture grille design:

- Weight - a heavy support structure must be provided for the tensioned wires (like a piano frame).
- Price (proportional to weight).
- Always a cylindrical screen (this may be considered an advantage depending on your preference.
- Visible stabilizing wires which may be objectionable or unacceptable for certain applications. (Definitely on 15" and larger sizes, possibly on smaller ones as well.)

Apparently, there is no known way around the need to keep the fine wires from vibrating or changing position due to mechanical shock in high resolution tubes and thus all Trinitron monitors require 1, 2, or 3 stabilizing wires (depending on tube size) across the screen which can be see as very fine lines on bright images. Some people find these wires to be objectionable and for some critical applications, they may be unacceptable (e.g., medical diagnosis).

Degaussing (demagnetizing) a CRT

Degaussing may be required if there are color purity problems with the display. On rare occasions, there may be geometric distortion caused by magnetic fields as well without color problems. The CRT can get magnetized:

- if the TV or monitor is moved or even just rotated.
- if there has been a lightning strike nearby. A friend of mine had a lightning strike near his house which produced all of the effects of the EMP from a nuclear bomb.
- If a permanent magnet was brought near the screen (e.g., kid's magnet or megawatt stereo speakers).
- If some piece of electrical or electronic equipment with unshielded magnetic fields is in the vicinity of the TV or monitor.

Degaussing should be the first thing attempted whenever color purity problems are detected. As noted below, first try the internal degauss circuits of the TV or monitor by power cycling a few times (on for a minute, off for at least 20 minutes, on for a minute, etc.) If this does not help or does not completely cure the problem, then you can try manually degaussing.

Note: Some monitors have a degauss button, and monitors and TVs that are microprocessor controlled may degauss automatically upon power-on (but may require pulling the plug to do a hard reset) regardless of the amount of off time. However, repeated use of these 'features' in rapid succession may result in overheating of the degauss coil or other components. The 20 minutes off/1 minute on precedure is guaranteed to be safe. (Some others may degauss upon power-on as long as the previous degauss was not done within some predetermined amount of time - they keep track with an internal timer.)

Commercial CRT Degaussers are available from parts distributors like MCM Electronics and consist of a hundred or so turns of magnet wire in a 6-12 inch coil. They include a line cord and momentary switch. You flip on the switch, and bring the coil to within several inches of the screen face. Then you slowly draw the center of the coil toward one edge of the screen and trace the perimeter of the screen face. Then return to the original position of the coil being flat against the center of the screen. Next, slowly decrease the field to zero by backing straight up across the room as you hold the coil. When you are farther than 5 feet away you can release the line switch.

The key word here is ** slow **. Go too fast and you will freeze the instantaneous intensity of the 50/60 Hz AC magnetic field variation into the ferrous components of the CRT and may make the problem worse.

WARNING: Don't attempt to degauss inside or in the back of the set (near the CRT neck. This can demagnetize the relatively weak purity and convergence magnets which may turn a simple repair into a feature length extravaganza!

It looks really cool to do this while the CRT is powered. The kids will love the color effects (but then lock your degaussing coil safely away so they don't try it on every TV and monitor in the house!).

Bulk tape erasers, tape head degaussers, open frame transformers, and the "butt-end" of a weller soldering gun can be used as CRT demagnetizers but it just takes a little longer. (Be careful not to scratch the screen face with anything sharp. For the Weller, the tip needs to be in place to get enough magnetic field.) It is imperative to have the CRT running when using these whimpier approaches, so that you can see where there are still impurities. Never release the power switch until you're 4 or 5 feet away from the screen or you'll have to start over.

I've never known of anything being damaged by excess manual degaussing as long as you don't attempt to degauss *inside* or the back of the monitor - it is possible to demagnetize geometry correction, purity, and static converence magnets in the process! However, I would recommend keeping really powerful bulk tape erasers-turned-degaussers a couple of inches from the CRT.

If an AC degaussing coil or substitute is unavailable, I have even done degaussed with a permanent magnet but this is not recommended since it is more likely to make the problem worse than better. However, if the display is unusable as is, then using a small magnet can do no harm. (Don't use a 20 pound speaker or magnetron magnet as you may rip the shadow mask right out of the CRT - well at least distort it beyond repair. What I have in mind is something about as powerful as a refrigerator magnet.)

Keep degaussing fields away from magnetic media. It is a good idea to avoid degaussing in a room with floppies or back-up tapes. When removing media from a room remember to check desk drawers and manuals for stray floppies, too.

It is unlikely that you could actually affect magnetic media but better safe than sorry. Of the devices mentioned above, only a bulk eraser or strong permanent magnet are likely to have any effect - and then only when at extremely close range (direct contact with media container).

All color CRTs include a built-in degaussing coil wrapped around the perimeter of the CRT face. These are activated each time the CRT is powered up cold by a 3 terminal thermistor device or other control circuitry. This is why it is often suggested that color purity problems may go away "in a few days". It isn't a matter of time; it's the number of cold power ups that causes it. It takes about 15 minutes of the power being off for each cool down cycle. These built-in coils with thermal control are never as effective as external coils.

Note that while the monochrome CRTs used in B/W and projection TVs and mono monitors don't have anything inside to get magnetized, the chassis or other cabinet parts of the equipment may still need degaussing. While this isn't likely from normal use or even after being moved or reoriented, a powerful magnet (like that from a large speaker) could leave iron, steel, or other ferrous parts with enough residual magnetism to cause a noticeable problem.

See the document: TV and Monitor CRT (Picture Tube) Information for some additional discussion of degaussing tools, techniques, treatments for severe magnetization from lightning strikes, and cautions.

How often to degauss

Some monitor manufacturers specifically warn about excessive use of degauss, most likely as a result of overstressing components in the degauss circuitry which are designed (cheaply) for only infrequent use. In particular, there is often a thermistor that dissipates significant power for the second or two that the degauss is active. Also, the large coil around the CRT is not rated for continuous operation and may overheat.

If one or two activations of the degauss button do not clear up the color problems, manual degaussing using an external coil may be needed or the monitor may need internal purity/color adjustments. Or, you may have just installed your megawatt stereo speakers next to the monitor!

You should only need to degauss if you see color purity problems on your CRT. Otherwise it is unnecessary. The reasons it only works the first time is that the degauss timing is controlled by a thermistor which heats up and cuts off the current. If you push the button twice in a row, that thermistor is still hot and so little happens.

One word of clarification: In order for the degauss operation to be effective, the AC current in the coil must approach zero before the circuit cuts out. The circuit to accomplish this often involves a thermistor to gradually decrease the current (over a matter of several seconds), and in better monitors, a relay to totally cut off the current after a certain delay. If the current was turned off suddenly, you would likely be left with a more magnetized CRT. There are time delay elements involved which prevent multiple degauss operations in succession. Whether this is by design or accident, it does prevent the degauss coil - which is usually grossly undersized for continuous operation - to cool.

Why are there fine lines across my Trinitron monitor or TV?

These are not a defect - they are a 'feature'.

All Trinitron (or clone) CRTs - tubes that use an aperture grille - require 1, 2, or 3 very fine wires across the screen to stabilize the array of vertical wires in the aperture grille. Without these, the display would be very sensitive to any shock or vibration and result in visible shimmering or rippling. (In fact, even with these stabilizing wires, you can usually see this shimmering if you whack a Trinitron monitor.) The lines you see are the shadows cast by these fine wires.

The number of wires depends on the size of the screen. Below 15" there is usually a single wire; between 15" and 21" there are usually 2 wires; above 21" there may be 3 wires. (Some very small Trinitron CRTs may not need these but they will be present on most of the sizes of interest here.)

Only you can decide if this deficiency is serious enough to avoid the use of a Trinitron based monitor. Some people never get used to the fine lines but many really like the generally high quality of Trinitron based displays and eventually totally ignore them.

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Monitor Placement and Preventive Maintenance

General monitor placement considerations

Proper care of a monitor does not require much. Following the recommendations below will assure long life and minimize repairs:

- Subdued lighting is preferred for best viewing conditions. Avoid direct overhead light falling on the screen or coming from behind the monitor if possible.

- Locate the monitor away from extremes of hot and cold. Avoid damp or dusty locations if possible. (Right you say, keep dreaming!) This will help keep your PC happy as well.

- Allow adequate ventilation - monitors use a fair amount of power - from 60 watts for a 12 inch monochrome monitor to over 200 W for a 21 inch high resolution color monitor. Heat is one major enemy of electronics.

- Do not put anything on top of the monitor that might block the ventilation grill in the rear or top of the cover. This is the major avenue for the convection needed to cool internal components.

- Do not place two monitors close to one another. The magnetic fields may cause either or both to suffer from wiggling or shimmering images. Likewise, do not place a monitor next to a TV if possible.

- Locate loudspeakers and other sources of magnetic fields at least a couple of feet from the monitor. This will minimize the possibility of color purity or geometry problems. The exception is with respect to good quality shielded multimedia speakers which are designed to avoid magnetic interference problems.

  Other devices which may cause interference include anything with power transformers including audio equipment, AC or DC wall adapters, and laptop power supplies; fluorescent lamps with magnetic ballasts; and motorized or heavy duty appliances.

- Situate monitors away from power lines - even electric wiring behind or on the other side of walls - and heavy equipment which may cause noticeable interference like rippling, wiggling, or swimming of the picture. Shielding is difficult and expensive.

- Make sure all video connections are secure (tighten the thumbscrews) to minimize the possibility of intermittent or noisy colors. Keep the cables as short as possible. Do not add extension cables if at all possible as these almost always result in a reduction in image crispness and introduce ghosting, smearing, and other termination problems. If you must add an extension, use proper high quality cable only long enough to make connections conveniently. Follow the termination recommendations elsewhere in this document.

- Finally, store magnetic media well away from all electronic equipment including and especially monitors and loudspeakers. Heat and magnetic fields will rapidly turn your diskettes and tapes into so much trash. The operation of the monitor depends on magnetic fields for beam deflection. Enough said.

Non-standard monitor mounting considerations

Monitors normally are positioned horizontally or via the limits of their tilt swivel bases out in the open on a table or desktop. However, for use in exhibits or for custom installations, it may be desirable to mount a monitor in a non-standard position and/or inside an enclosure.

(From: Bob Myers (myers@fc.hp.com).)

Your mileage may vary, but (and please take the following for what it is, a very general answer)...

There are basically two potential problems here; one is cooling, and the other is the fact that the monitor has no doubt been set up by the factory assuming standard magnetic conditions, which probably DIDN'T involve the monitor tilting at much of an angle. If you're happy with the image quality when it's installed in the cabinet, that leaves just the first concern. THAT one can be addressed by simply making sure the cabinet provides adequate ventilation (and preferably adding a fan for a bit of forced-air cooling), and making sure that the whole installation isn't going to be exposed to high ambient temperatures. (Most monitors are speced to a 40 deg. C ambient in their normal orientation; adding forced-air cooling will usually let you keep that rating in positions somewhat beyond the normal.) Under no circumstances should you block the cabinet's vents, and - depending on the installation - it may be preferable to remove the rear case parts of the monitor (but NOT the metal covers beneath the plastic skin) in order to improve air circulation.

Your best bet is to simply contact the service/support people of the monitor manufacturer, and get their input on the installation. Failing to get the manufacturer's blessing on something like this most often voids the warranty, and can probably lead to some liability problems. (Note - I'm not a lawyer, and I'm not about to start playing one on the net.)

Preventive maintenance - care and cleaning

Preventive maintenance for a monitor is pretty simple - just keep the case clean and free of obstructions. Clean the CRT screen with a soft cloth just dampened with water and mild detergent or isopropyl alcohol. This will avoid damage to normal as well as antireflection coated glass. DO NOT use anything so wet that liquid may seep inside of the monitor around the edge of the CRT. You could end up with a very expensive repair bill when the liquid decides to short out the main circuit board lurking just below. Then dry thoroughly. Use the CRT sprays sold in computer stores if you like but again, make sure none can seep inside. If you have not cleaned the screen for quite a while, you will be amazed at the amount of black grime that collects due to the static buildup from the CRT high voltage supply.

There is some dispute as to what cleaners are safe for CRTs with antireflective coatings (not the etched or frosted variety). Water, mild detergent, and isopropyl alcohol should be safe. Definitely avoid the use of anything with abrasives for any type of monitor screen. And some warn against products with ammonia (which may include Windex, Top-Job, and other popular cleaners), as this may damage/remove some types of antireflective coatings. To be doubly sure, test a small spot in a corner of the screen.

In really dusty situations, periodically vacuuming inside the case and the use of contact cleaner for the controls might be a good idea but realistically, you will not do this so don't worry about it.

Note that a drop of oil or other contamination might appear like a defect (hole) in the AR coating. Before getting upset, try cleaning the screen.

(From: Bob Myers (myers@fc.hp.com).)

Windex is perfectly fine for the OCLI HEA coating or equivalents; OCLI's coating is pretty tough and chemical-resistant stuff. There may be alternative (er..cheaper) coatings in use which could be damaged by various commercial cleaners, (For what it's worth, OCLI also sells their own brand of glass cleaner under the name "TFC", for "Thin Film Cleaner".)

I have cleaned monitors of various brands with both Windex and the OCLI-brand cleaner, with no ill results. But then, I'm usually pretty sure what sort of coating I'm dealing with... :-)

Monitor coatings are always changing; besides the basic "OCLI type" quarter-wave coatings and their conductive versions developed to address E-field issues, just about every tube manufacturer has their own brew or three of antiglare/antistatic coatings. There are also still SOME tubes that aren't really coated at all, but instead are using mechanically or chemically etched faceplates as a cheap "anti-glare" (actually, glare-diffusing) treatment.

In general, look in the user guide/owner's manual and see what your monitor's manufacturer recommends in the way of cleaning supplies.

(From: Tom Watson (tsw@johana.com).)

If you are maintaining a site, consider periodic cleaning of the monitors. Depending on the location, they can accumulate quite a bit of dust. In normal operation there is a electrostatic charge on the face of the crt (larger screens have bigger charges) which act as 'dust magnets'. If the operator smokes (thankfully decreasing), it is even worse. At one site I helped out with, most of the operators smoked, and the screens slowly got covered with a film of both dust and smoke particles. A little bit of glass cleaner applied with reasonable caution and the decree of "adjustments" to make the screen better (these were character monochrome terminals), and lo and behold, "what an improvement!". Yes, even in my dusty house, the TVs get a coating of film/goo which needs to be cleaned, and the picture quality (BayWatch viewers beware) improves quite a bit. Try this on your home TV to see what comes off, then show everyone else. You will be surprised what a little bit of cleaning does.

(From: Bob Myers (myers@fc.hp.com).)

1. Don't block the vents; make sure the monitor has adequate ventilation, and don't operate it more than necessary at high ambient temperatures.

2. If the monitor is used in particularly dusty environments, it's probably a good idea to have a qualified service tech open it up every so often (perhaps once a year, or more often depending on just how dirty it gets) and clean out the dust.

3. The usual sorts of common-sense things - don't subject the monitor to mechanical shock and vibration, clean up spills, etc., promptly, and so forth. And if you're having repeated power-supply problems with your equipment, it may be time to get suspicious of the quality of your AC power (are you getting noise on the line, sags, surges, spikes, brownouts, that sort of thing?).

And most importantly:

4. Turn the monitor OFF when it's not going to be used for an extended period (such as overnight, or if you'll be away from your desk for the afternoon, etc.). Heat is the enemy of all electronic components, and screen-savers do NOTHING in this regard. Many screen-savers don't even do a particularly good job of going easy on the CRT. With modern power-management software, there's really no reason to be leaving a monitor up and running all the time.

These won't guarantee long life, of course - nothing can do that, as there will always be the possibility of the random component failure. But these are the best that the user can do to make sure the monitor goes as long as it can.

Monitor tuneup?

(From: Bob Myers (myers@fc.hp.com).)

Most manufacturers will quote an MTBF (Mean Time Before Failure) of somewhere in the 30,000 to 60,000 hour range, EXCLUSIVE OF the CRT. The typical CRT, without an extended-life cathode, is usually good for 10,000 to 15,000 hours before it reaches half of its initial brightness. Note that, if you leave your monitor on all the time, a year is just about 8,000 hours.

The only "tuneup" that a monitor should need, exclusive of adjustments needed following replacement of a failed component, would be video amplifier and/or CRT biasing adjustments to compensate for the aging of the tube. These are usually done only if you're using the thing in an application where exact color/brightness matching is important. Regular degaussing of the unit may be needed, of course, but I'm not considering that a "tuneup" or adjustment.

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Monitor Troubleshooting

SAFETY

TVs and computer or video monitors are among the more dangerous of consumer electronic equipment when it comes to servicing. (Microwave ovens are probably the most hazardous due to high voltage at flesh frying and cardiac arresting high power.)

There are two areas which have particularly nasty electrical dangers: the non-isolated line power supply and the CRT high voltage.

Major parts of nearly all modern TVs and many computer monitors are directly connected to the AC line - there is no power transformer to provide the essential barrier for safety and to minimize the risk of equipment damage. In the majority of designs, the live parts of the TV or monitor are limited to the AC input and line filter, degauss circuit, bridge rectifier and main filter capacitor(s), low voltage (B+) regulator (if any), horizontal output transistor and primary side of the flyback (LOPT) transformer, and parts of the startup circuit and standby power supply. The flyback generates most of the other voltages used in the unit and provides an isolation barrier so that the signal circuits are not line connected and safer.

Since a bridge rectifier is generally used in the power supply, both directions of the polarized plug result in dangerous conditions and an isolation transformer really should be used - to protect you, your test equipment, and the TV, from serious damage. Some TVs do not have any isolation barrier whatsoever - the entire chassis is live. These are particularly nasty.

The high voltage to the CRT, while 200 times greater than the line input, is not nearly as dangerous for several reasons. First, it is present in a very limited area of the TV or monitor - from the output of the flyback to the CRT anode via the fat HV wire and suction cup connector. If you don't need to remove the mainboard or replace the flyback or CRT, then leave it alone and it should not bite. Furthermore, while the shock from the HV can be quite painful due to the capacitance of the CRT envelope, it is not nearly as likely to be lethal since the current available from the line connected power supply is much greater.

Of particular note in: Major Parts of Typical SVGA Monitor with Cover Removed are the CRT HV cable and connector, flyback or LOPT, and the horizontal output transistor and its heat sink. With many TVs and some monitors, this may be line-connected and electrically hot. However, this monitor uses a separate switchmode power supply and in any case, there is likely an insulator between the transistor and heat sink.

Safety Guidelines: These guidelines are to protect you from potentially deadly electrical shock hazards as well as the equipment from accidental damage.

Note that the danger to you is not only in your body providing a conducting path, particularly through your heart. Any involuntary muscle contractions caused by a shock, while perhaps harmless in themselves, may cause collateral damage - there are many sharp edges inside this type of equipment as well as other electrically live parts you may contact accidentally.

The purpose of this set of guidelines is not to frighten you but rather to make you aware of the appropriate precautions. Repair of TVs, monitors, microwave ovens, and other consumer and industrial equipment can be both rewarding and economical. Just be sure that it is also safe!

- Don't work alone - in the event of an emergency another person's presence may be essential.

- Always keep one hand in your pocket when anywhere around a powered line-connected or high voltage system.

- Wear rubber bottom shoes or sneakers.

- Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current, or get caught in moving parts.

- Set up your work area away from possible grounds that you may accidentally contact.

- Know your equipment: TVs and monitors may use parts of the metal chassis as ground return yet the chassis may be electrically live with respect to the earth ground of the AC line. Microwave ovens use the chassis as ground return for the high voltage. In addition, do not assume that the chassis is a suitable ground for your test equipment!

- If circuit boards need to be removed from their mountings, put insulating material between the boards and anything they may short to. Hold them in place with string or electrical tape. Prop them up with insulation sticks - plastic or wood.

- If you need to probe, solder, or otherwise touch circuits with power off, discharge (across) large power supply filter capacitors with a 2 W or greater resistor of 100 to 500 ohms/V approximate value (e.g., for a 200 V capacitor, use a 20K to 100K ohm resistor). Monitor while discharging and verify that there is no residual charge with a suitable voltmeter. In a TV or monitor, if you are removing the high voltage connection to the CRT (to replace the flyback transformer for example) first discharge the CRT contact (under the suction cup at the end of the fat HV wire). Use a 1M to 10M ohm 5 W or greater wattage (for its voltage holdoff capability, not power dissipation) resistor on the end of an insulating stick or the probe of a high voltage meter. Discharge to the metal frame which is connected to the outside of the CRT.

- For TVs and monitors in particular, there is the additional danger of CRT implosion - take care not to bang the CRT envelope with your tools. An implosion will scatter shards of glass at high velocity in every direction. There are several tons of force attempting to crush the typical CRT. While implosion is not really likely even with modest abuse, why take chances? However, the CRT neck is relatively thin and fragile and breaking it would be very embarrassing and costly. Always wear eye protection when working around the back side of a CRT.

- Connect/disconnect any test leads with the equipment unpowered and unplugged. Use clip leads or solder temporary wires to reach cramped locations or difficult to access locations.

- If you must probe live, put electrical tape over all but the last 1/16" of the test probes to avoid the possibility of an accidental short which could cause damage to various components. Clip the reference end of the meter or scope to the appropriate ground return so that you need to only probe with one hand.

- Perform as many tests as possible with power off and the equipment unplugged. For example, the semiconductors in the power supply section of a TV or monitor can be tested for short circuits with an ohmmeter.

- Use an isolation transformer if there is any chance of contacting line connected circuits. A Variac(tm) is not an isolation transformer! The use of a GFCI (Ground Fault Circuit Interrupter) protected outlet is a good idea but will not protect you from shock from many points in a line connected TV or monitor, or the high voltage side of a microwave oven, for example. (Note however, that, a GFCI may nuisanse trip at power-on or at other random times due to leakage paths (like your scope probe ground) or the highly capacitive or inductive input characteristics of line powered equipment.) A fuse or circuit breaker is too slow and insensitive to provide any protection for you or in many cases, your equipment. However, these devices may save your scope probe ground wire should you accidentally connect it to a live chassis.

- Don't attempt repair work when you are tired. Not only will you be more careless, but your primary diagnostic tool - deductive reasoning - will not be operating at full capacity.

- Finally, never assume anything without checking it out for yourself! Don't take shortcuts!

Warning about disconnecting CRT neck board

Some manufacturers warn against powering a TV or monitor CRT without the CRT neck board connected. Apparently, without something - anything - to drain the charge resulting from the current flow due to residual gas ions inside the CRT, the shortest path may be through the glass neck of the tube to the yoke or from the pins outside the CRT to whatever is nearby. There aren't many ions in a modern CRT but I suppose a few here, a few there, and eventually they add up to enough to cause a major disaster at least on some CRTs.

This is probably not a problem on small CRTs but for large ones with high high voltages and high deflection angles where the glass of the neck is very thin to allow for maximum deflection sensitivity, the potential does exist for arcing through the glass to the yoke to occur, destroying the CRT.

There is really no way to know which models will self destruct but it should be possible to avoid such a disaster by providing a temporary return path to the DAG ground of the CRT (NOT SIGNAL GROUND!!) via the focus or G2 pins preferably through a high value high voltage rated resistor just in case one of these is shorted.

This probably applies mostly to large direct-view TVs since they use high deflection angle CRTs but it won't hurt to take appropriate precautions with video and computer monitors as well.

Troubleshooting tips

Many problems have simple solutions. Don't immediately assume that your problem is some combination of esoteric complex convoluted failures. For a monitor, it may just be a bad connection or blown fuse. Remember that the problems with the most catastrophic impact on operation like a dead monitor usually have the simplest solutions. The kind of problems we would like to avoid at all costs are the ones that are intermittent or difficult to reproduce: the occasional jitter or a monitor that blows its horizontal output transistor every six months.

If you get stuck, sleep on it. Sometimes, just letting the problem bounce around in your head will lead to a different more successful approach or solution. Don't work when you are really tired - it is both dangerous (especially with respect to monitors) and mostly non-productive (or possibly destructive).

Whenever working on complex equipment, make copious notes and diagrams. You will be eternally grateful when the time comes to reassemble the unit. Most connectors are keyed against incorrect insertion or interchange of cables, but not always. Apparently identical screws may be of differing lengths or have slightly different thread types. Little parts may fit in more than one place or orientation. Etc. Etc.

Pill bottles, film canisters, and plastic ice cube trays come in handy for sorting and storing screws and other small parts after disassembly. This is particularly true if you have repairs on multiple pieces of equipment under way simultaneously.

Select a work area which is wide open, well lighted, and where dropped parts can be located - not on a deep pile shag rug. The best location will also be relatively dust free and allow you to suspend your troubleshooting to eat or sleep or think without having to pile everything into a cardboard box for storage.

Another consideration is ESD - Electro-Static Discharge. Some components (like ICs) in a TV are vulnerable to ESD. There is no need to go overboard but taking reasonable precautions such as getting into the habit of touching a **safe** ground point first.

WARNING: even with an isolation transformer, a live chassis should **not** be considered a safe ground point. When the monitor is unplugged, the shields or other signal ground points should be safe and effective.

A basic set of precision hand tools will be all you need to disassemble a monitor and perform most adjustments. These do not need to be really expensive but poor quality tools are worse than useless and can cause damage. Needed tools include a selection of Philips and straight blade screwdrivers, socket drivers, needlenose pliers, wire cutters, tweezers, and dental picks. For adjustments, a miniature (1/16" blade) screwdriver with a non-metallic tip is desirable both to prevent the presence of metal from altering the electrical properties of the circuit and to minimize the possibility of shorting something from accidental contact with the circuitry. A set of plastic alignment tools will be useful for making adjustments to coils (though you can forgo these until the (rare) need arises.

A low power (e.g., 25 W) fine tip soldering iron and fine rosin core solder will be needed if you should need to disconnect any soldered wires (on purpose or by accident) or replace soldered components. A higher power iron or small soldering gun will be needed for dealing with larger components. Never use acid core solder or the type used for sweating copper pipes!

CAUTION: You can easily turn a simple repair (e.g., bad solder connections) into an expensive mess if you use inappropriate soldering equipment and/or lack the soldering skills to go along with it. If in doubt, find someone else to do the soldering or at least practice, practice, practice, soldering and desoldering on a junk circuit board first! See the document: Troubleshooting and Repair of Consumer Electronic Equipment for additional info on soldering and rework techniques.

For thermal or warmup problems, a can of 'cold spray' or 'circuit chiller' (they are the same) and a heat gun or blow dryer come in handy to identify components whose characteristics may be drifting with temperature. Using the extension tube of the spray can or making a cardboard nozzle for the heat gun can provide very precise control of which components you are affecting.

For info on useful chemicals, adhesives, and lubricants, see "Repair Briefs, an Introduction" as well as other documents available at this site.

Test equipment

Don't start with the electronic test equipment, start with some analytical thinking. Your powers of observation (and a little experience) will make a good start. Your built in senses and that stuff between your ears represents the most important test equipment you have.

However, some test equipment will be needed:

- Multimeter (DMM or VOM) - This is essential for checking of power supply voltages and voltages on the pins of ICs or other components - service literature like the SAMs Photofacts described elsewhere in this document include voltage measurements at nearly every circuit tie point for properly functioning equipment. The multimeter will also be used to check components like transistors, resistors, and capacitors for correct value and for shorts or opens. You do not need a fancy instrument. A basic DMM - as long as it is reliable - will suffice for most troubleshooting. If you want one that will last for many years, go with a Fluke. However, even the mid range DMMs from Radio Shack have proven to be reliable and of acceptable accuracy. For some kinds of measurements - to deduce trends for example - an analog VOM is preferred (though some DMMs have a bar graph scale which almost as good).

- Oscilloscope - While many problems can be dealt with using just a multimeter, a 'scope will be essential as you get more into advanced troubleshooting. Basic requirements are: dual trace, 10-20 MHz minimum vertical bandwidth, delayed sweep desirable but not essential. A good set of proper 10X/1X probes. Higher vertical bandwidth is desirable but most consumer electronics work can be done with a 10 MHz scope. A storage scope or digital scope might be desirable for certain tasks but is by no means essential for basic troubleshooting.

  I would recommend a good used Tektronix (Tek) or Hewlett Packard (HP) scope over a new scope of almost any other brand. You will usually get more scope for your money and these things last almost forever. Until recently, my 'good' scope was the militarized version (AN/USM-281A) of the HP180 lab scope. It has a dual channel 50 MHz vertical plugin and a delayed sweep horizontal plugin. I have seen these going for under $300 from surplus outfits. For a little more money, you can get a Tek 465 or 465B (newer version but similar specifications) 100 Mhz scope ($200 to $600, sometimes cheaper on eBay or elsewhere but there is more risk than buying from a reputable dealer). I have now acquired a Tek 465B and that's what I use mostly these days. The HP-180 is still fine but I couldn't pass up a really good deal. :) The Tek 465/B or other similar model will suffice for all but the most demanding (read: RF or high speed digital) repairs.

- A video signal source - depending on what type of monitor you are repairing, you may need both computer and television signals.

  Computer Monitors - a test PC is useful as a video source. Of course, it will need to support whatever scan rates and video types the monitor is designed to accept. Software programs are available to display purity, convergence, focus, color, and other test patterns. Or create your own test patterns using a program like Windows Paint. See the section: Using a PC as a monitor test pattern generator.

  Studio monitors - a baseband video source like a VCR or camcorder is useful in lieu of a test pattern generator. These will allow you to you to control the program material. In fact, making some test tapes using a camcorder or video camera to record static test patterns will allow you full control of what is being displayed and for how long.

- Color bar/dot/crosshatch signal generator. This is a useful piece of equipment if you are doing a lot of TV or studio monitor repair and need to perform CRT convergence and chroma adjustments. However, there are alternatives that are almost as good: a VHS recording of these test patterns will work for TVs. A PC programmed to output a suitable set of test patterns will be fine for monitors (and TVs if you can set up the video card to produce an NTSC/PAL signal. This can be put through a VCR to generate the RF (Channel 3/4) input to your TV if it does not have direct video inputs (RCA jacks).

  Sophisticated (and expensive) universal test pattern generators are available that will handle any possible monitor scan rate.

Incredibly handy widgets

These are the little gadgets and homemade testers that are useful for many repair situations. Here are just a few of the most basic:

- Series light bulb for current limiting during the testing of TVs, monitors, switching power supplies, audio power amplifiers, etc. I built a dual outlet box with the outlets wired in series so that a lamp can be plugged into one outlet and the device under test into the other. For added versatility, add a regular outlet and 'kill' switch using a quad box instead. The use of a series load will prevent your expensive replacement part like a horizontal output transistor from blowing if there is still some fault in the circuit you have failed to locate.

- A Variac. It doesn't need to be large - a 2 A Variac mounted with a switch, outlet and fuse will suffice for most tasks. However, a 5 amp or larger Variac is desirable. If you will be troubleshooting 220 VAC equipment in the US, there are Variacs that will output 0-240 VAC from a 115 VAC line (just make sure you don't forget that this can easily fry your 115 VAC equipment.) By varying the line voltage, not only can you bring up a newly repaired monitor gradually to make sure there are no problems; you can also evaluate behavior at low and high line voltage. This can greatly aid in troubleshooting power supply problems. Warning: a Variac is not an isolation transformer and does not help with respect to safety. You need an isolation transformer as well.

- Isolation transformer. This is very important for safely working on live chassis equipment. Since nearly all modern monitors utilize line connected switchmode power supply or line connected deflection circuits, it is essential. You can build one from a pair of similar power transformers back-to-back (with their highest rated secondaries connected together. I built mine from a couple of similar old tube type TV power transformers mounted on a board with an outlet box including a fuse. Their high voltage windings were connected together. The unused low voltage windings can be put in series with the primary or output windings to adjust voltage. Alternatively, commercial line isolation transformers suitable for TV troubleshooting are available for less than $100 - well worth every penny.

- Variable isolation transformer. You don't need to buy a fancy combination unit. A Variac can be followed by a normal isolation transformer. (The opposite order also works. There may be some subtle differences in load capacity.).

CAUTION: Keep any large transformer of this type well away from your monitor or TV. The magnetic field it produces may cause the picture to wiggle or the colors to become messed up - and you to think there is an additional problem!

- Degaussing coil. Make or buy. The internal degaussing coil salvaged from a defunct color TV or monitor doubled over to half it original diameter to increase its strength in series with a 200 W light bulb for current limiting will work just fine. Or, buy one from a place like MCM Electronics for about $15-$30 that will be suitable for all but the largest TVs and monitors. Also, see the section: Degaussing (demagnetizing) a CRT.

Safe discharging of capacitors in TVs and video monitors

It is essential - for your safety and to prevent damage to the device under test as well as your test equipment - that large or high voltage capacitors be fully discharged before measurements are made, soldering is attempted, or the circuitry is touched in any way. Some of the large filter capacitors commonly found in line operated equipment store a potentially lethal charge.

This doesn't mean that every one of the 250 capacitors in your TV need to be discharged every time you power off and want to make a measurement. However, the large main filter capacitors and other capacitors in the power supplies should be checked and discharged if any significant voltage is found after powering off (or before any testing - the CRT capacitance in a TV or video monitor, for example, can retain a dangerous or at least painful charge for days or longer!)

The technique I recommend is to use a high wattage resistor of about 100 ohms/V of the working voltage of the capacitor. This will prevent the arc-welding associated with screwdriver discharge but will have a short enough time constant so that the capacitor will drop to a low voltage in at most a few seconds (dependent of course on the RC time constant and its original voltage).

Then check with a voltmeter to be double sure. Better yet, monitor while discharging (not needed for the CRT - discharge is nearly instantaneous even with multi-M ohm resistor).

Obviously, make sure that you are well insulated!

- For the main capacitors in a TV or monitor power supply which might be 400 uF at 200 V, this would mean a 5K, 10W resistor. RC = 2 seconds. 5RC = 10 seconds. A lower wattage resistor can be used since the total energy in not that great. If you want to be more high tech, you can build the capacitor discharge circuit outlined in the companion document: Capacitor Testing, Safe Discharging, and Other Related Information. This provides a visible indication of remaining charge and polarity.

- For the CRT, use a several M ohm resistor good for 30 kV or more (or a string of lower value resistors to obtain this voltage rating). A 1/4 watt job will just arc over! Discharge to the chassis ground connected to the outside of the CRT - NOT SIGNAL GROUND ON THE MAIN BOARD as you may damage sensitive circuitry. The time constant is very short - a ms or so. However, repeat a few times to be sure, then use a shorting clip as these capacitors have a way of recovering a painful charge if left alone - there have been too many stories of painful experiences from charge developing for whatever reasons ready to bite when the HV lead is reconnected.

  Note that if you are touching the little board on the neck of the CRT, you may want to discharge the HV even if you are not disconnecting the fat red wire - the focus and screen (G2) voltages on that board are derived from the CRT HV.

  WARNING: Most common resistors - even 5 W jobs - are rated for only a few hundred volts and are not suitable for the 25 kV or more found in modern TVs and monitors. Alternatives to a long string of regular resistors are a high voltage probe or a known good focus/screen divider network. However, note that the discharge time constant with these may be a few seconds. Also see the section: Additional information on discharging CRTs.

  If you are not going to be removing the CRT anode connection, replacing the flyback, or going near the components on the little board on the neck of the CRT, I would just stay away from the fat red wire and what it is connected to including the focus and screen wires. Repeatedly shoving a screwdriver under the anode cap risks scratching the CRT envelope which is something you really do not want to do.

Again, always double check with a reliable voltmeter!

Reasons to use a resistor and not a screwdriver to discharge capacitors:

1. It will not destroy screwdrivers and capacitor terminals.

2. It will not damage the capacitor (due to the current pulse).

3. It will reduce your spouse's stress level in not having to hear those scary snaps and crackles.

Additional information on discharging CRTs

You may hear that it is only safe to discharge from the Ultor to the Dag. So, what the @#$% are they talking about? :-).

(From: Asimov (mike.ross@juxta.mnet.pubnix.ten).)

'Dag' is short for Aquadag. It is a type of paint made of a graphite pigment which is conductive. It is painted onto the inside and outside of picture tubes to form the 2 plates of a high voltage filter capacitor using the glass in between as dielectric. This capacitor is between .005uF and .01uF in value. This seems like very little capacity but it can store a substantial charge with 25,000 volts applied.

The outside "Dag" is always connected to the circuit chassis ground via a series of springs, clips, and wires around the picture tube. The high voltage or "Ultor" terminal must be discharged to chassis ground before working on the circuit especially with older TV's which didn't use a voltage divider to derive the focus potential or newer TV's with a defective open divider.

(From: Sam)

CAUTION: The Dag coating/springs/clips/etc. may not be the same as signal ground on the mainboard. Discharging to that instead could result in all sorts of expensive blown components. Discharging between the CRT anode cap and Dag should be low risk though it is best to use a HV probe or properly rated high value resistor.

For more details, see the document: TV and Monitor CRT (Picture Tube) Information.

Removing the CRT HV connector

WARNING: Make sure the CRT has been discharged FIRST!

The rubber part is usually not glued down so it can be lifted rather easily. However, there may be some silicone type grease between the rubber boot (that looks like a suction cup) and the CRT glass to seal out dust.

A metal clip with a spring keeping it spread out attaches inside the button.

While there are a variety of types of clips actually used, pushing the connector to one side and/or squeezing it in the appropriate direction (peel up one side of the rubber to inspect) while gently lifting up should free it. Probably :-).

The clip (when removed) and CRT button look sort of like this:

```
                       ||======= HV Cable
                       /\
               Clip   |  |
          (Removed)  _|  |_
                                (No DAG coating in vicinity of HV connector)
        ____________.-    -.___________
   CRT  ____________|______|___________ Glass
                  Metal Button
```

Replacement is done in reverse order!

This isn't rocket science and excessive force should not be needed! :-)

The series light bulb trick

When powering up a monitor (or any other modern electronic devices with expensive power semiconductors) that has had work done on any power circuits, it is desirable to minimize the chance of blowing your newly installed parts should there still be a fault. There are two ways of doing this: use of a Variac to bring up the AC line voltage gradually and the use of a series load to limit current to power semiconductors.

Actually using a series load - a light bulb is just a readily available cheap load - is better than a Variac (well both might be better still) since it will limit current to (hopefully) non-destructive levels.

What you want to do is limit current to the critical parts - usually the horizontal output transistor (HOT). Most of the time you will get away with putting it in series with the AC line. However, sometimes, putting a light bulb directly in the B+

circuit will be needed to provide adequate protection. In that location, it will limit the current to the HOT from the main filter capacitors of line connected power supplies. This may also be required with some switchmode power supplies as they can still supply bursts of full (or excessive) current even if there is a light bulb in series with the AC line.

Actually, an actual power resistor is probably better as its resistance is constant as opposed to a light bulb which will vary by 1:10 from cold to hot. The light bulb, however, provides a nice visual indication of the current drawn by the circuit under test. For example:

- Full brightness: short circuit or extremely heavy load - a fault probably is still present.

- Initially bright but then settles at reduced brightness: filter capacitors charge, then lower current to rest of circuit. This is what is expected when the equipment is operating normally. There could still be a problem with the power circuits but it will probably not result in an immediate catastrophic failure.

- Pulsating: power supply is trying to come up but shutting down due to overcurrent or overvoltage condition. This could be due to a continuing fault or the light bulb may be too small for the equipment.

Note: for a TV or monitor, it may be necessary (and desirable) to unplug the degauss coil as this represents a heavy initial load which may prevent the unit from starting up with the light bulb in the circuit.

The following are suggested starting wattages:

- 40 W bulb for VCR or laptop computer switching power supplies.
- 100 W bulb for small (i.e., B/W or 13 inch color) monitors or TVs.
- 150-200 W bulb for large color monitors or projection TVs.

A 50/100/150 W (or similar) 3-way bulb in an appropriate socket comes in handy for this but mark the switch so that you know which setting is which!

Depending on the power rating of the equipment, these wattages may need to be increased. I have had to go to a 300 W light bulb for some computer monitors. However, start low. If the bulb lights at full brightness, you know there is still a major fault. If it flickers or the TV (or other device) does not quite come fully up, then it should be safe to go to a larger bulb. Resist the temptation to immediately remove the bulb at this point - I have been screwed by doing this. Try a larger one first. The behavior should improve. If it does not, there is still a fault present.

Note that some TVs and monitors simply will not power up at all with any kind of series load - at least not with one small enough (in terms of wattage) to provide any real protection. The microcontroller apparently senses the drop in voltage and shuts the unit down or continuously cycles power. Fortunately, these seem to be the exceptions.

Getting inside a monitor

You will void the warranty - at least in principle. There are usually no warranty seals on a monitor so unless you cause visible damage or mangle the screws or plastic, it is unlikely that this would be detected. You need to decide. A monitor still under warranty should probably be returned for warranty service for any covered problems except those with the most obvious and easy solutions. Another advantage of using warranty service is that should your problem actually be covered by a design change, this will be performed free of charge. And, you cannot generally fix a problem which is due to poor design!

Getting into a monitor is usually quite simple requiring the removal of 2-10 Philips or 1/4" hex head screws - most around the edge of the cabinet or underneath, a couple perhaps in the rear. Disconnect the input and power cables first as it they stay with catch on the rear cover you are detaching. Reconnect whatever is needed for testing after the cover is removed. Set the screws aside and make notes if they are not all of the same length and thread type - putting a too long screw in the wrong place can short out a circuit board or break something else, for example. A screw that is too short may not be secure.

Once all visible screws are out, try to remove the cover. There still may be hidden catches or snaps around the edges or seam or hidden beneath little plastic or rubber cosmetic covers. Sometimes, the tilt-swivel base will need to be removed first. If no snaps or catches are in evidence, the cover may just need a bit of persuasion in the form of a carefully placed screwdriver blade (but be careful not to damage the soft plastic). A 'splitting' tool is actually sold for this purpose.

As you pull the cover straight back (usually) and off, make sure that no other wires are still attached. Often, the main circuit board rests on the bottom of the cover in some slots. Go slow as this circuit board may try to come along with the back. Once the back is off, you may need to prop the circuit board up with a block of wood to prevent stress damage and contact with the work surface.

Most - but not all - monitors can be safely and stably positioned either still on the tilt-swivel base or on the bottom of the frame. However, some will require care as the circuit board will be vulnerable.

Larger monitors are quite heavy and bulky. Get someone to help and take precautions if yours is one of the unstable variety. If need be, the monitor can usually safely be positioned on the CRT face if it is supported by foam or a folded blanket.

Once the cover is off, you will find anywhere from none to a frustratingly large number of sheetmetal (perforated or solid) shields. Depending on which circuit boards need to be accessed, one or more of these shields may need to be removed. Make notes of which screws go where and store in a safe place. However, manufacturers often place holes at strategic locations in order to access adjustments - check for these before going to a lot of unnecessary bother. Note: sheetmetal usually has sharp edges. Take care.

See Major Parts of Typical SVGA Monitor with Cover Removed for what will greet you. This particular sample has a shield only covering the video driver board on the neck of the CRT.

Reassemble in reverse order. Getting the circuit board to slide smoothly into its slots may take a couple of attempts but otherwise there should be no surprises.

Specific considerations before poking around inside a TV or monitor

Both electrical and mechanical dangers lurk:

- Main filter capacitor(s). This is the most dangerous (not the HV as you would expect). Fortunately, these capacitors will normally discharge in a few minutes or less especially if the unit is basically working as the load will normally discharge the capacitors nearly fully as power is turned off. With TVs, the main filter capacitor is nearly always on the mainboard. Monitors are more likely to have a separate power supply module.

  However, you should check across this capacitor - usually only one and by far the largest in the unit - with a voltmeter and discharge as suggested in the section: Safe discharging of capacitors in TVs and video monitors if it holds more than a few volts (or wait longer) before touching anything.

  Some of these are as large as 1,000 uF charged to 160 V - about 13 w-s or a similar amount of energy as that stored in an electronic flash. This is enough to be potentially lethal under the wrong circumstances.

- High Voltage capacitor formed by the envelope of the CRT. It is connected to the flyback transformer by the fat (usually red) wire at the suction cup (well, it looks like one anyhow) attached to the CRT. This capacitor can hold a charge for quite a while - weeks in the case of an old tube type TV!

  If you want to be doubly sure, discharge this also. However, unless you are going to be removing the HV connector/flyback, it should not bother you.

The energy stored is about 1 w-s but if you touch it or come near to an exposed terminal, due to the high voltage, you will likely be handed *all* the energy and you *will* feel it. The danger is probably more in the collateral damage when you jump ripping flesh and smashing your head against the ceiling.

Some people calibrate their jump based on voltage - about 1 inch/V. :-).

There will be some HV on the back of the circuit board on the neck of the CRT but although you might receive a tingle but accidentally touching the focus or screen (G2) pins, it is not likely to be dangerous.

- CRT implosion risk. Don't hammer on it. However, it is more likely that you will break the neck off the tube since the neck is relatively weak. This will ruin your whole day and the TV or monitor but will likely not result in flying glass everywhere. Just, don't go out of your way to find out.

- Sharp sheet metal and so forth. This is not in itself dangerous but a reflex reaction can send your flesh into it with nasty consequences.

Dusting out the inside of a monitor

The first thing you will notice when you remove the cover is how super dusty everything is. Complements to the maid. You never dreamed there was that much dust, dirt, and grime, in the entire house or office building!

Use a soft brush (like a new paintbrush) and a vacuum cleaner to carefully remove the built up dust. Blowing off the dust will likely not hurt the unit unless it gets redeposited inside various controls or switches but will be bad for your lungs - and will spread dirt all over the room. Don't turn anything - many critical adjustments masquerade as screws that just beg to be tightened. Resist the impulse for being neat and tidy until you know exactly what you are doing. Be especially careful around the components on the neck of the CRT - picture tube - as some of these are easily shifted in position and control the most dreaded of adjustments - for color purity and convergence. In particular, there will be a series of adjustable ring magnets. It is a good idea to mark their position in any case with some white paint, 'white out', or a Magic Marker so that if they do get moved - or you move them deliberately, you will know where you started.

Troubleshooting a monitor with the mainboard disconnected

There are times when it is desirable to remove the chassis or mainboard and work on it in a convenient location without having to worry about the attachments to the CRT and cabinet circuitry.

My approach is usually to do as much work as possible without removing the main board and not attempt to power it up when disconnected since there are too many unknowns. Professionals will plug the chassis into a piece of equipment which will simulate the critical functions but this is rarely an option for the doit-yourselfer.

Note that if you have a failure of the power supply - blown fuse, startup, etc., then it should be fine to disconnect the CRT since these problems are usually totally unrelated. Tests should be valid.

However, if you really want to do live testing with the main board removed, here are some considerations. There are usually several connections to the CRT and cabinet:

- Deflection yoke - since the horizontal coils are part of the horizontal flyback circuit, there could be problems running without a yoke. This could be anything from it appearing totally dead to an overheating or blown horizontal output transistor. There may be no problems. Vertical and any convergence coils may or may not be problems as well.

- CRT video Driver board - pulling this should not usually affect anything except possibly video output and bias voltages.

* CRT 2nd anode - without the CRT, there will be no capacitor to filter the high voltage and you would certaily want to insulate the HV connector **real** well. I do not know whether there are cases where damage to flyback could result from running in thie manner, however.

* Front panel controls - disconnecting these may result in inability to even turn the unit on, erratic operation, and other unexpected behavior.

* Degauss - you just won't have this function when disconnected. But who cares - you are not going to be looking at the screen anyhow.

* Remote sensor - no remote control but I doubt that the floating signals will cause problems.

* Speakers - there will be no audio but this should not cause damage.

  If you do disconnect everything, make sure to label any connectors whose location or orientation may be ambiguous. Most of the time, these will only fit one way but not always.

Comments on repairing modern computer monitors

(From: Wild Bill (kwag98@tcis.net).)

Without even taking into consideration all of the other features of most late model (15" or larger) monitors, such as the multisync and multi-resolution circuitry, many of these units are very complex. They combine almost every example of present circuit design technology. A vacuum display tube, digital data, HF switching, all types of regulators and sense circuits and linear power devices. Funny too, that the end result is just dots of light.

A good (perhaps the best) first action is to search the USENET newsgroup sci.electronics.repair via an archive like Deja.com for previous postings of questions on the same model with related symptoms and replies. Solder in the replacement part, and BINGO, it's repaired. Rest assured that it's always something simple. Yeah, right. :) Time to check some archive repair sites with tech-tips databases.

Typically, for a dead unit, I get a DMM, pencil and paper....

After a fairly thorough overall inspection, i generally resort to a section-by-section investigation for shorted/open power devices, followed by PN junction checks, then an overall ESR check SxS. In circuit ESR checking will nearly always convince me to replace at least a couple of caps. But if ya don't replace 'em, ya just never know. Hehehe.

By now, I'm at least an hour into this potential research project, if the unit's operation hasn't yet been restored. The next phase is usually determined by whatever i feel like doing next.. i might get a couple of datasheets, try a series lamp technique, or test the major parts.. flyback/IHVT, CRT or yokes. If one of these are faulty, it will help determine the cost effectiveness of proceeding. If it's not my monitor, i contact the owner.

Barring any major parts failure, there are several more options for a direction to proceed in.. making sense of any of the available voltages or waveforms, checking the HV semis for leakage, or as a last (but maybe not final) resort.. making circuit diagrams of specific sections. If there hasn't been any sign of progress by this point, the unit usually finds it's way to a shelf until more inspiration arrives.. that reminds me, when did i place that order?

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Monitor Adjustments

These include both controls accessible to the user (and often not understood) as well as internal adjustments that may need to be touched up due to the aging of components or following a repair.

Note that monitor (software) drivers often have the capability to provide some control of picture size, position, color balance, and other parameters via the video card. There is also third-party software for this purpose. So, before blaming the monitor, make sure your software settings (and monitor user controls) have been reset to their defaults. Then see if the monitor controls and/or the driver adjustments have enough range with the procedures described below. However, where a sudden change in behavior occurred without anything being done in either hardware or software (e.g., a new video card or OS/revision), trying to adjust out such a fault is like putting a Band-Aid on a broken bone. There is likely to be a hardware fault in the monitor which will need to be identified and repaired.

User picture adjustment

For general viewing, subdued lighting is preferred. Avoid backlighting and direct overhead lighting if possible.

Display an image with a variety of colors and the full range of brightness from deep shadows to strong highlights. For PCs, a Windows desktop is generally satisfactory. An outdoor scene on a sunny day is excellent for studio monitors. Alternatively, use a test pattern specially designed for this purpose.

Turn the BRIGHTNESS and CONTRAST controls (or use the buttons) all the way down.

Increase the BRIGHTNESS until a raster is just visible in the darkest (shadow) areas of the picture and then back off until it **just** disappears.

Increase the CONTRAST until the desired intensity of highlights is obtained.

Since BRIGHTNESS and CONTRAST are not always independent, go back and forth until you get the best picture.

On monitors with a color balance adjustment, you may want to set this but unless you are doing photorealistic work, using the manufacturer's defaults will be fine unless you need to match the characteristics of multiple monitors located side-by-side.

Focus adjustment

One of the most common complaints is that the monitor is not as crisp as it used to be - or just not as sharp as expected.

Assuming that the focus has just been gradually getting worse over time, tweaking the internal focus control may be all that is needed.

Some monitors have the focus adjustment accessible through a (possibly unmarked) hole in the side or rear of the case. If there is a single hole, it is almost certainly for overall focus. If there are two holes, one may be the screen (G2 - master brightness) or the two adjustments may be for different aspects of focus (e.g., horizontal and vertical). Just carefully observe what happens when each adjustment is moved a little so that you can return it to its original setting if you turned the wrong one. Use a thin insulated screwdriver - preferably with a plastic blade. As a extra precaution, determine of the screwdriver will mate easily with the adjustment with the monitor **off** (don't turn anything, however).

Where there are two adjustment knobs on the flyback transformer, the top one is generally for focus and the bottom one is for G2.

Most inexpensive monitors have only what is known as static focus - a constant voltage derived from the HV power supply is applied to the focus grid of the CRT. This does not allow for optimal focus across the screen and any setting is just a compromise between central and edge sharpness.

Better monitors will have separate H and V focus controls as well as dynamic focus circuitry which generates focus correction signals that are a function of screen position to compensate for changing distance to electron guns at the edges and corners of the screen. There may be some interaction between the static and dynamic adjustments. If either of these controls has no effect or insufficient range, then there may be a fault in the circuitry for that particular adjustment - a fault with the driver, waveform source, power supply, etc.

The most sophisticated schemes use a microprocessor (or at least digital logic) to specify the waveform for each section of the screen with a map of correction values stored in non-volatile memory. It would be virtually impossible to troubleshoot these systems without detailed service information and an oscilloscope - and even then you might need a custom adapter cable and PC software to adjust values!

Also see the section: About the quality of monitor focus.

If you need to go inside to tweak focus pots:

SAFETY: as long as you do not go near anything else inside the monitor while it is on AND keep one hand in you pocket, you should be able to do this without a shocking experience.

Plug it in, turn it on and let it warm up for a half hour or so. Set your PC (or other video source) to display in the resolution you use most often. First turn the user brightness and contrast fully counterclockwise. Turn brightness up until the raster lines in a totally black area appear, then back a hair until they disappear. Then, turn the contrast control up until you get a fairly bright picture. Fullly clockwise is probably ok. Adjust FOCUS for generally best focus. You will not be able to get it razor sharp all over the screen - start at the center and then try to get the edges and corners as good as you can without messing up the center too much. Double check that the focus is OK at your normal settings of brightness and contrast and at other resolutions that you normally use.

The focus pot is usually located on the flyback transformer or on an auxiliary panel nearby. The focus wire usually comes from the flyback or the general area or from a terminal on a voltage the multiplier module (if used). It is usually a wire by itself going to the little board on the neck of the CRT.

The SCREEN control adjusts background brightness. If the two controls are not marked, you will not do any damage by turning the wrong one - it will be immediately obvious as the brightness will change rather than focus and you can then return it to its original position (or refer to the section on brightness adjustments to optimize its setting).

On a decent monitor, you should be able to make out the individual scanning lines at all resolutions though it will be toughest at the highest scan rates. If they lines are fuzzy, especially in bright areas, then focus may need to be adjusted or there may be an actual fault in the focus circuitry or a defective or just marginal CRT.

Brightness and color balance adjustment

A monitor which has a picture that is too dark or too bright and cannot be adequately set with the user brightness and contrast controls may need internal adjustment of the SCREEN (the term, screen, here refers to a particular electrode inside the CRT, not really the brightness of the screen you see, though it applies here), MASTER BRIGHTNESS, or BACKGROUND level controls. As components age, including the CRT, the brightness will change, usually decrease. The following procedure will not rejuvenate an old CRT but may get just enough brightness back to provide useful functionality for a few months or longer. If the problem is not with the age of the CRT, then it may return the monitor to full brightness. The assumption here is that there is a picture but the dark areas are totally black and the light areas are not bright enough even with the user brightness control turned all the way up.

Note that circuit problems can also cause similar symptoms. These are particularly likely if the brightness descresed suddenly - CRT emission problems will result in a gradual decrease in brightness over time.

In most cases, the cover will need to be removed. The controls we are looking for may be located in various places. Rarely, there will be access holes on the back or side. However, if there are unmarked holes, then the FOCUS and SCREEN controls are the most likely possibilities.

The controls may be located on the:

- Flyback (LOPT) transformer. Usually there is a master screen control along with a focus control on the flyback transformer.

- A little board on the neck of the CRT. There may be a master screen control. a master brightness control, a master background level control, or individual controls for red, green, and blue background level. Other variations are possible. There may also be individual gain/contrast controls.

- Main video board is less common, but the background level controls may be located here.

Display a black and white picture at the video resolution you consider most important. Select one that has both full blacks and full whites - an nice sunny outdoor scene that has been converted from a color image, for example.

Set the user brightness control to its midpoint and the user contrast control as low as it will go - counterclockwise.

Let the monitor warm up for at least 15 minutes so that components can stabilize.

If there is a MASTER BRIGHTNESS or BACKGROUND level control, use this to make the black areas of the picture just barely disappear. Them, increase it until the raster lines just appear. (They should be a neutral gray. If there is a color tint present, then the individual color background controls will need to be adjusted to obtain a neutral gray.) If there is no such control, use the master screen control on the flyback. If it is unmarked, then try both of the controls on the flyback - one will be the screen control and the other will be focus - the effects will be obvious. If you did touch focus, set it for best overall focus and then get back to the section on focus once you are done here.

If there are individual controls for each color, you may use these but be careful as you will be effecting the color balance. Adjust so that the raster lines in a black area are just visible and dark neutral gray.

If there is a 'service switch' you may prefer to make the adjustment with this in the service position. The raster will collapse to a single horizontal line and the video input will be disabled and forced to black. The BACKGROUND or SCREEN control can then be adjusted as above.

Now for the gain controls. On the little board on the neck of the CRT or on the video or main board there will be controls for R, G, and B DRIVE (also may be called GAIN, or CONTRAST - they are the same). The knobs or slots may even be color coded as to which primary (R,G,B) it affects.

If there are only two then the third color is fixed and if the color balance in the highlights of the picture was ok, then there is nothing more you can do here.

Set the user contrast control as high as it will go - clockwise.

Now adjust each internal color DRIVE control as high as you can without that particular color 'blooming' at very bright vertical edges. Blooming means that the focus deteriorates for that color and you get a big blotch of color trailing off to the right of the edge. You may need to go back and forth among the 3 DRIVE controls since the color that blooms first will limit the amount that you can increase the contrast settings. Set them so that you get the brightest neutral whites possible without any single color blooming.

Note that this is ignoring the effects of any beam current or brightness limiter circuitry. Any recommendations in the service manual should be followed to minimize the chance of excess X-ray emissions as well as to avoid burn-in of the phosphor screen.

Now check out the range of the user controls and adjust the appropriate internal controls where necessary. You may need to touch up the background levels or other settings. Check at the other resolutions and refresh rates that you normally use.

If none of this provides acceptable brightness, then either your CRT is in its twilight years or there is something actually broken in the monitor. If the decrease in brightness has been a gradual process over the course of years, then it is most likely the CRT. As a last resort you can try increasing the filament current to the CRT the way CRT boosters that used to be sold for TVs worked. See the section: Brightening an old CRT.

Optimal procedure for setting brightness/background and screen adjustments

For slight tweaks, the following is not necessary. However, if someone turned all the internal controls, if you are making significant changes that affect G2 (screen), or you are setting up a new or replacement CRT for the first time, then following the procedure below is desirable to achieve best performance and maximize life of the CRT.

The typical user controls - brightness and contrast can, of course, be set arbitrarily, depending on video content and ambient lighting conditions.

Set the user brightness and contrast controls in the middle for the following adjustments and let the monitor warm up for 20 minutes or so.

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

Now the screen control, that's another matter. It sets the voltage on the second grid of the electron guns, typically between +500 and +1000 V. You will want to use a well-isolated screwdriver for that if it is a naked potentiometer. In the old days there used to be 3 separate potentiometers for 3 G2s, now there is generally only one.

Its purpose is to set the cutoff voltage for the guns, i.e. the voltage between K and G1 at which the beam is just off. The higher you set the VG2, the higher VK - VG1 must be to cut off the beam.

If you set VG2 too low then your picture will be dark. You can compensate for that with the brightness control, which in effect will lower the VKs. A disadvantage is that you will not get optimum sharpness and peak brightness from your picture tube.

If you set VG2 too high then your picture will be bright. You can compensate for that with the brightness control, which in effect will raise the VKs. You might even get retrace lines which can usually not be made to disappear with the brightness control. Another disadvantage is that you will not get optimum LIFETIME from your picture tube. With a too high cutoff voltage the cathode (electron emitting surface) will wear out too soon.

You will need to see the picture tube specifications (or possibly the service manual for the monitor --- sam) in order to find the correct setting for the cutoff voltage. This is measured as VK - VG1 (for each channel RGB) and is typically 130-160 V max. There will be spread between the 3 channels, typically the highest of the 3 measured values will be set against the upper limit.

The usual adjustment procedure is as follows:

- Use any low-level adjustments to set a black picture with all 3 cathode voltages at the specified level (e.g. 130 V) above the VG1 voltage (may be 0 V or 12 V or 20 V ?). (These are typically called RGB brightness, bias, or background level and are often on the little board on the neck of the CRT but not always --- sam).

- Adjust VG2 (screen) until one colour just starts too light up, turn it back down until the screen is just black again. (Occasionally, there are two G2 controls - one on the flyback and another on the CRT neck board or elsewhere. If so, they control are basically in series - leave the one on the flyback alone if the other one has enough range.)

- Now adjust 2 of the 3 low-level black controls until the other 2 colours just light up, and then back to black again.

- Select a white picture and use 2 low-level white (RGB drive or gain, also generally on the neck board --- sam) controls to set the proper colour temperature for white to your own taste.

- Check your black calibration again, may have to iterate a bit.

Position, size, and linearity adjustment

Position and size are usually user controls on computer and video monitors but not on TVs. On monitors with digital controls, they may usually be set for each resolution and (automatically) stored in non-volatile memory so they will be retained when the monitor is turned off. On cheaper monitors, there may be a knobs on the front or back panel and may need to readjusted whenever the scan rate/resolution is changed. Sometimes, there are located internally. There may be separate adjustments for each scan range and may or may not be accessible through holes in the back panel.

There may also be an adjustment called 'horizontal phase' which controls the relative timing of the horizontal sync pulse with respect to retrace. Its effect is subtly different than horizontal position which actually moves the raster. If possible, center the raster and then use H Phase to center the picture.

In monochrome monitors (mostly), position may be set via a pair of rings on the neck of the CRT.

Size can be set to your preference for each scan rate (if they are independent). For computer work, slight underscan is often preferred as all of the frame buffer is visible. However, any slight geometric problems with the raster will be all too visible when compared with the straight sides of the CRT bezel.

Note that resolutions like 640 x 480, 800 x 600, and 1024 x 768 all have a 4:3 aspect ratio. The edge of the image will line up with the bezel on most if not all monitors since CRTs are made to a 4:3 aspect ratio. However, resolutions like 1280 x 1024 and 1600 x 1280 have a 5:4 aspect ratio. With these, in order to get (highly desirable) square pixels, the horizontal size must be adjusted slightly smaller than that required to fill the screen.

For normal viewing of video (television) monitors, raster size should be set so that there is about 10-15 percent overscan all around. This will allow ample margin for power line voltage fluctuations, component aging, and the reduction in raster size that may occur with some VCR special effects (CUE and REV) modes. However, for studio use, underscan is often preferred or at least an option to permit the entire raster to be inspected.

Modern color monitors may not have any horizontal linearity control but you may find this on older models. There may be an internal vertical linearity adjustment. I am not aware of any that have user accessible linearity controls. If there are internal pots or coils, you will need to go back and forth between size and linearity as these adjustments are usually not independent.

Of course, parameters controlling your video card also affect position and size. There is no best approach to reconciling the effects of monitor and video card position adjustments. But, in general, start with the monitor controls centered within their range or use the memory defaults as appropriate. Then, use the video card setup program to optimize the settings. Only if these do not have enough range should you use the monitor controls.

Comments on linearity or lack thereof

(From: Jerry Greenberg (jerryg50@hotmail.com).)

If you can get a grating test generator this would be the proper way to test for non-linearity. Using a camera or device other than that would not be an acceptable reference if you call any engineer from the manufacture. If you mention a grating generator, he will certainly listen.

You would need the service manual for the model to know the specs. Some of these sets can have a non-linearity of up to about 2% near to the edges. Only professional broadcast monitors will be down to the 0.5% and less error factor near to the corners.

On a 27 inch screen 2% can mean an error of can give a visible non-linearity of 0.5 inches. Convergence errors can be as much as 0.25 or 1/4 inch at the corners. Generally they are more accurate than these figures. This is the worse case that is generally accepted on a consumer TV by the manufactures.

I have found that on flat screen consumer TV sets, the linearity sort of gets a bit stretched towards the ends of the scan. This is because of the beam angle. There is compensation for azimuth of beam focus (dynamic focus) and for the scans to a degree that keeps the price of the TV within consumer range.

The screens that are a bit more spherical or rounded will have less of this effect because it is lower in cost to compensate for these errors. A true accurate screen would be one that is spherical following exactly to the beam angle. But, for viewing this would not be very desirable.

Pincushion adjustments

Horizontal pincushion refers to any bowing in or out on the vertical sides of the raster. There is not usually any explicit vertical pincushion adjustment. Adjustment usually uses two controls - amplitude and phase. Pincushion amplitude as its name implies, controls the size of the correction. Pincushion phase affects where on the sides it is applied. Don't expect perfection.

If the controls have no effect, there is probably a fault in the pincushion correction circuitry.

It is best to make these adjustments with a crosshatch or dot test pattern

Geometry adjustment

This refers to imperfections in the shape of the picture not handled by the pincushion and size adjustments. These types of defects include a trapezoidal or keystone shaped raster and jogs or wiggles around the periphery of the raster. Unfortunately, one way these are handled at the factory is to glue little magnets to strategic locations on the CRT and/or rotate little magnets mounted on the yoke frame. Unless you really cannot live with the way it is (assuming there isn't something actually broken), leave these alone! You can end up with worse problems. In any case, carefully mark the position AND orientation of every magnet so that if this happens, you can get back to where you started. If the magnets are on little swivels, some experimenting with them one at a time may result in some improvement. Of course it is best to obtain a service manual and follow its instructions. However, this may not be possible at reasonable cost or at all for many computer monitors.

Why is the convergence on my monitor bad near the edges

Very simple - nothing is quite perfect. Perfect convergence is not even necessarily possible in theory with the set of adjustments available on a typical monitor. It is all a matter of compromises. Consider what you are trying to do: get three electron beams which originate from different electron guns to meet at a single point within a fraction of a mm everywhere on the screen. This while the beams are scanning at an typical effective writing rate of 50,000 mph across the face of a 17" CRT (assumed resolution: 1024x768 at 75 Hz) in a variable magnetic environment manufactured at a price you can afford without a second mortgage!

The specifications for misconvergence have two parts: a center error and a corner error. The acceptable center error is always the smaller of the two - possibly .1-.2 mm. compared to .3-.5 mm in the corners. Very often, you will find that what you are complaining about is well within this specification.

CRT purity and convergence

Purity assures that each of the beams for the 3 primary colors - R, G, B, - red, green, and blue - strikes only the proper phosphor for that color. A totally red scene will appear pure red and so forth. Symptoms of poor purity are blotches of discoloration on the screen. Objects will change shades of color when the move from one part of the screen to another. There may even be excess non-uniformity of pure white or gray images.

Convergence refers to the control of the instantaneous positions of the red, green, and blue spots as they scan across the face of the CRT so that they are as nearly coincident as possible. Symptoms of poor convergence are colored borders on solid objects or visible separate R, G, and B images of fine lines or images,

Note: It is probably best to face the monitor East-West (front-to-back) when performing any purity and convergence adjustments. Since you probably do not know what orientation will eventually be used, this is the best compromise as the earth's magnetic field will be aligned mostly across the CRT. This will minimize the possible rotation of the picture when the unit is moved to its final position but there may be a position shift. Neither of these is that significant so it probably doesn't really matter that much unless you are super fussy. Of course, if you know the final orientation of the monitor use that instead. Or, plan to do the final tilt and position adjustments after the monitor is in position - but this will probably require access to the inside!

First, make sure no sources of strong magnetic fields are in the vicinity of the monitor - loudspeakers, refrigerator magnets, MRI scanners, etc. A nearby lightning strike or EMP from a nuclear explosion can also affect purity so try to avoid these.

Cycle power a couple of times to degauss the CRT (1 minute on, 20 minutes off) - see the section: Degaussing (demagnetizing) a CRT. If the built in degaussing circuits have no effect, use an external manual degaussing coil to be sure that your problems are not simply due to residual magnetism.

Assuming this doesn't help, you will need to set the internal purity and/or convergence adjustments on the CRT.

First, mark the positions of all adjustments - use white paint, 'White out', or a Magic Marker on the ring magnets on the neck of the CRT, the position and tilt of the deflection yoke, and any other controls that you may touch deliberately or by accident.

Note: if your monitor is still of the type with a drawer or panel of knobs for these adjustments, don't even think about doing anything without a service manual and follow it to the letter unless the functions of all the knobs is clearly marked (some manufacturers actually do a pretty good job of this).

CRT purity adjustment

Purity on modern CRTs is usually set by a combination of a set of ring magnets just behind the deflection yoke on the neck of the CRT and the position of the yoke fore-aft. As always, mark the starting position of all the rings and make sure you are adjusting the correct set if rings!

Use the following purity adjustment procedure as a general guide only. Depending on the particular model monitor, your procedure may substitute green for red depending on the arrangement of guns in the CRT. The procedures for dot-mask, slot mask, and Trinitron (aperture grille) CRTs will vary slightly. See you service manual!

Obtain a white raster (sometimes there is a test point that can be grounded to force this). Then, turn down the bias controls for blue and green so that you have a pure red raster. Let the monitor warm up for a minimum of 15 minutes.

Loosen the deflection yoke clamp and move the yoke as far back as it will go,

Adjust the purity magnets to center the red vertical raster on the screen.

Now, move the yoke forward until you have the best overall red purity. Tighten the clamp securely and reinstall the rubber wedges (if your CRT has these) to stabilize the yoke position. Reset the video adjustments you touched to get a red raster.

CRT convergence adjustment

In the good old days when monitors were monitors (and not just a mass produced commodity item) there were literally drawers or panels full of knobs for setting convergence. One could spend hours and still end up with a less than satisfactory picture. As the technology progressed, the number of electronic adjustments went down drastically so that today there are very few if any. However, some high end monitors do have user accessible controls for minor adjustment of static (center) convergence.

Unless you want a lot of frustration, I would recommend not messing with convergence. You could end up a lot worse. I have no idea what is used for convergence on your set but convergence adjustments are never quite independent of one another. You could find an adjustment that fixes the problem you think you have only to discover some other area of the screen is totally screwed. In addition, there are adjustments for geometry and purity and maybe others that you may accidentally move without even knowing it until you have buttoned up the set.

Warning: Accurately mark the original positions - sometimes you will change something that will not have an obvious effect but will be noticeable later on. So it is extremely important to be able to get back to where you started. If only red/green vertical lines are offset, then it is likely that only a single ring needs to be moved - and by just a hair. But, you may accidentally move something else!

If you really cannot live with it, make sure you mark everything very carefully so you can get back to your current state. A service manual is essential!

Convergence is set using a white crosshatch or dot test pattern. For PCs (a similar approach applies to workstations) If you do not have a test pattern generator, use a program like Windows Paint to create a facsimile of a crosshatch pattern and use this for your convergence adjustments. For a studio video monitor, any static scene (from a camcorder or previously recorded tape, for example) with a lot of fine detail will suffice.

Static convergence sets the beams to be coincident in the exact center of the screen. This is done using a set of ring magnets behind the purity magnets on the CRT neck. (Set any user convergence controls to their center position).

Adjust the center set of magnets on the CRT neck to converge blue to green at the center of the screen. Adjust the rear set of magnets to converge red to green at the center of the screen." Your monitor may have a slightly different procedure.

Dynamic convergence adjusts for coincidence at the edges and corners.

On old tube, hybrid, and early solid state monitors, dynamic convergence was accomplished with electronic adjustments of which there may have been a dozen or more that were not independent. With modern monitors, convergence is done with magnet rings on the neck of the CRT, magnets glued to the CRT, and by tilting the deflection yoke. The clamp in conjunction with rubber wedges or set screws assures that the yoke remains in position.

Remove the rubber wedges.

Loosen the deflection yoke clamp just enough so that it can be tilted but will remain in the position you leave it. Rock the yoke up and down to converge the right and left sides of the screen. Rock the yoke from side to side to converge the top and bottom of the screen. The rubber wedges can be used as pivots to minimize the interaction between the two axes but you may need to go back and forth to optimize convergence on all sides. Reinstall the wedges firmly and tape them to the CRT securely. Tighten the yoke clamp enough to prevent accidental movement.

Some monitors may use a plastic frame and set screws instead of just a clamp and rubber wedges but the procedure is similar.

Refer to your service manual. (Is this beginning to sound repetitious?)

For additional comments on convergence adjustments, see the section: Tony's notes on setting convergence on older delta gun CRTs.

Tilted picture

You have just noticed that the picture on your fancy (or cheap) monitor is not quite horizontal - not aligned with the front bezel. Note that often there is some keystoning or other geometric distortion as well where the top and bottom or left and right edges of the picture are not quite parallel - which you may never have noticed until now. Since this may not be correctable (at least, not without a lot of hassle), adjusting tilt may represent a compromise at best between top/bottom or left/right alignment of the picture edges. You may never sleep again knowing that your monitor picture is not perfect! BTW, I can sympathize with your unhappiness. Few things are more annoying than a just noticeable imperfection such as this.

This is probably one reason why older monitors tended not to be able to expand the picture to totally fill the screen - it is easier to overlook imperfect picture geometry if there is black space between the edges of the picture and the bezel!

There are several possible causes for a tilted picture:

1. Monitor orientation. The horizontal component of the earth's magnetic field affects this slightly. Therefore, if you rotate the unit you may be able to correct the tilt. Of course, it will probably want to face the wall!

2. Other external magnetic fields can sometimes cause a rotation without any other obvious effects - have you changed the monitor's location? Did an MRI scanner move in next door?

3. Need for degaussing. Most of the time, magnetization of the CRT will result in color problems which will be far more obvious than a slight rotation. However, internal or external shields or other metal parts in the monitor could become magnetized resulting a tilt. More extensive treatment than provided by the built-in degaussing coil may be needed. Even, the normal manual degaussing procedure may not be enough to get close enough to all the affected parts.

4. You just became aware of it but nothing has changed. Don't dismiss this offhand. It is amazing how much we ignore unless it is brought to our attention. Are you a perfectionist? Did your friend just visit boasting about his P8-1000 screamer and point the tilt out to you?

5. There is an external tilt control which may be misadjusted. Newer Sony monitors have this (don't know about TVs) - a most wonderful addition. Too bad about the stabilizing wires on Trinitron CRTs. A digital control may have lost its memory accidentally. The circuitry could have a problem.

   For example, on the Sony CPD1730, you press the left arrow button and blue '+' button at the same time. Then adjust the tilt with the red buttons.

6. There is an internal tilt control that is misadjusted or not functioning. The existence of such a control is becoming

more common.

7. The deflection yoke on the CRT has gotten rotated or was not oriented correctly at the time of the set's manufacture. Sometimes, the entire yoke is glued in place in addition to being clamped adding another complication.

   If the monitor was recently bumped or handled roughly, the yoke may have been knocked out of position. But in most cases, the amount of abuse required to do this with the yoke firmly clamped and/or glued would have totally destroyed it in the process.

   There is a risk (in addition to the risk of frying yourself on the various voltages present inside an operating monitor) of messing up the convergence or purity when fiddling with the yoke or anything around it since the yoke position on the neck of the tube and its tilt may affect purity and convergence. Tape any rubber wedges under the yoke securely in place as these will maintain the proper position and tilt of the yoke while you are messing with it. (Don't assume the existing tape will hold - the adhesive is probably dry and brittle).

8. The CRT may have rotated slightly with respect to the front bezel. Irrespective of the cause of the tilt, sometimes it is possible to loosen the 4 (typical) CRT mounting screws and correct the tilt by slightly rotating the CRT. This may be easier than rotating the yoke. Just make sure to take proper safety precautions when reaching inside!

Monochrome monitor size, position, and geometry adjustments

These tend to be a lot simpler and less critical than for color monitors or TV sets.

On a monochrome (B/W) monitor you will probably see some of the following adjustments:

1. Position - a pair of rings with tabs on the neck of the CRT. There may be electronic position adjustements as well.

2. Width and height (possibly linearity as well) controls. There may be some interaction between size and linearity - a crosshatch test pattern is best for this. Vertical adjustments are almost always pots while horizontal (if they exist) may be pots and/or coils. Where desired, set sizes for 5-10% overscan to account for line voltage fluctuations and component drift. Confirm aspect ratio with test pattern which includes square boxes.

3. Geometry - some little magnets either on swivels around the yoke or glued to the CRT. If these shifted, the the edges may have gotten messed up - wiggles, dips, concave or convex shapes. There may be a doxen or more each mostly affecting a region around the edge of the raster. However, they will not be totally independent.

Check at extremes of brightness/contrast as there may be some slight changes in size and position due to imperfect HV regulation.

There may be others as well but without a service manual, there is no way of knowing for sure.

Just mark everything carefully before changing - then you will be able to get back where you started.

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Low Voltage Power Supply Problems

Low voltage power supply fundamentals

Monitors require a variety of voltages (at various power levels) to function. The function of the low voltage power supply is to take the AC line input of either 115 VAC 60 Hz (220 to 240 VAC 50 Hz or other AC power in Europe and elsewhere) and produce some of these DC voltages.

- In all cases, the power to the horizontal output transistor (HOT) of the horizontal deflection system (B+) is obtained directly from the low voltage power supply.

  Note: we will often use the term 'B+' to denote the main DC voltage that powers the horizontal deflection system of most monitors.

- In some cases, some other DC voltages are also derived directly from the AC line by rectification, filtering, and possibly regulation.
- With small video monitors which operate at a fixed scan rate (e.g., TV monitors), many or most of the low voltages may be derived from secondary windings on the flyback (LOPT) transformer of the horizontal deflection system.
- The typical SVGA autoscan monitor will use one or more switchmode power supplies (SMPSs) to provide most or all of the low voltages - the flyback isn't used for this purpose. (High voltage is obtained from a flyback type supply or a separate HV module in which case there may be no flyback at all!)
- There are also various (and sometimes convoluted) designs using combinations of any or all of the above.

Typical Switchmode Power Supply for Small SVGA Color Monitor shows the complete schematic for the SMPS from a "I guarantee you never heard of the brand name" monitor.

The AC line input and degauss components are at the upper left, the SMPS chopper, its controller, and feedback opto-isolator are lower left/middle, and the secondaries - some with additional regulation components - occupy the entire right side of this diagram. Even for relatively basic application such as this, the circuitry is quite complex. There are more than a half dozen separate outputs regulated in at least 3 different ways!

For large high performance auto-scan monitors, it becomes even worse as highly stable voltages need to be programmed based on a wide range of scan rates. Several common design approaches are used to generate the required variable regulated B+ voltage:

1. A separate programmable SMPS generates the B+. This is done by selecting its reference voltage or the fraction of the output voltage that is fed back to the regulator.
2. A voltage from the main SMPS is fed through an additional series switchmode or linear regulator that drops it down to the required value.
3. One of several fixed post-regulators is selected based on scan rate.

Technique (2) is used by the power supply is the diagram, above. Can you locate the circuitry? Hint: Look in the upper right hand corner of the schematic.

The need for a variable B+ is one area where a typical PC monitor departs significantly in design compared to a TV or fixed scan rate studio or workstation monitor. Nearly everything is made more complex as a result of this requirement.

Components of the low voltage power supply

All monitor low voltage power supplies will have:

1. A power switch, relay, or triac to enable main power.

2. Various line filter, RFI, and surge suppression components (coupled inductors, LCL filter networks, MOVs, etc.).

3. A set of rectifiers - usually in a bridge or doubler configuration - to turn the AC into DC. Additional small ceramic capacitors are normally placed across the diodes to reduce RF interference. There may be an inrush current limiter in the form of an NTC (Negative Temperature Coefficient) resistor.

4. One or more large filter capacitors to smooth the unregulated DC. This voltage is either around 300 to 320 VDC (doubled from 115 VAC or bridge rectified from 230 VAC) for compatibility with U.S. and foreign power or 150 to 160 VDC bridge rectifier from the 115 VAC line.

   Many monitors permit the input voltage to be either 115 or 230 VAC depending on a switch or jumper, or automatically adapt to these or a range of input voltages - usually 100 to 240 VAC or DC. The latter are termed 'universal' power supplies.

5. A discrete, hybrid, IC, or switchmode regulator to provide B+ to the horizontal deflection.

6. Some means of generating the various other DC voltages required by the monitor's analog and logic circuitry.

Items (1) to (6) may be part of a separate low voltage power supply module or located on the mainboard.

7. Zero or more voltage dividers and/or regulators to produce additional voltages directly from the line power. This relatively rare except for startup circuits. THESE VOLTAGES WILL NOT BE ISOLATED FROM THE AC LINE!

8. A degauss control circuit usually including a thermistor or Posistor (a combination of a heater disk and Positive Temperature Coefficient (PTC) thermistor in a single package). Monitors having manual degauss buttons will include additional circuitry.

9. A startup circuit for booting the horizontal deflection if various voltages to run the monitor are derived from the flyback. This may be an IC, discrete multivibrator, or something else running off a non-isolated voltage or the standby power supply, or it may be derived from the video input. (Mostly small video monitors, not autoscan types.) However, the SMPS itself will have a startup circuit!

10. A standby power supply if the monitor doesn't use a latching power switch. Usually, this is a separate low voltage power supply using a small power transformer for line isolation.

What symptoms are likely the result of a low voltage power supply problem?

There are an almost unlimited number of possibilities but the following probably covers the most likely:

- Monitor is as dead as a concrete block - no picture or raster, no LEDs lit, no sounds of life (like degauss) of any kind.

  Most likely causes: No power at AC outlet or outlet strip, bad or loose line cord, bad power switch, blown fuse due to internal short or overload.

- No picture but unusual sounds like a whine, periodic clicks, tweets, or flubs, and/or possibly flickering or flashing front panel LEDs.

  Most likely causes: Excessive load or short on output of power supply (shutdown or cycling due to overcurrent) or loss of horizontal drive (cycling from overvoltage due to lack of load).

- Unusual aromas, smoke, or six foot flames coming from inside the case.

  Most likely causes: Failed parts in low voltage power supply, deflection, or high voltage sections.

  Actually, while burning smells and even smoke aren't that unusual when parts overheat as a result of a short circuit, actual fire is quite unlikely due to regulatory design requirements for materials and protection devices UNLESS safety systems have been tampered with or the monitor has been operated in an environment where there is lots of flammable dust.

- Jittering, vibrating, or unstable picture.

  Most likely causes: External magnetic interference or power line noise, hum in various power supply voltages resulting from dried up main filter capacitor(s) or other capacitors, resistors out of tolerance - all affecting power supply regulation.

- Loss of video, deflection, geometry or size problems, or some or all adjustments have no effect.

  Most likely causes: Failure of one or more power supply voltages, selection circuitry not selecting properly (autoscan monitors), bad connections.

- Monitor doesn't power up immediately.

  Most likely causes: Dried up electrolytic capacitors in power supply or bad connections.

- Interaction of adjustments. For example, turning up the brightness results in a loss of sync or a wavy raster.

  Most likely causes: Poor power supply regulation due to bad capacitor, resistor, regulator, or other component - or bad connections.

Note that the underlying cause may not be in the low voltage power supply itself but may actually be elsewhere - a shorted horizontal output transistor or deflection yoke, for example. This results in either the power supply shutting down, becoming extremely unhappy, blowing a fuse, or just plain dying. Thus, we cannot really limit our investigation to only the power supply! In fact, with so many interconnected systems in a monitor, particularly a high performance SVGA model - it can require the services of a master sleuth Sherlock Holmes type to identify the perpetrator!

However, before you break out the socket wrenches and DMM (or 10 pound hammer!) or call Scotland Yard, double check that:

- your AC outlet is live, the power cord is intact (not chewed by the dog), is firmly seated, and the monitor is switched on.

- that you have a valid video signal, the video cables are securely attached to the proper connectors (e.g., BNCs) and/or there are no bent over pins (e.g., VGA/SVGA HD15 or Mac DB15).

- the monitor isn't being commanded to go into a power savings mode because your computer thinks it is smarter than you!

- you have the front panel switches and controls set properly and the video source selection is correct. Reset it to factory defaults.

If possible, try the monitor with another known good video input that is compatible with its scan rates and signal levels or substitute a known good monitor for the suspect unit. In other words, try to rule out external problems and 'cockpit error'.

Monitor power supply problems

WARNING: Always use an isolation transformer when working on a monitor but this is especially important - for your safety - when dealing with the non-isolated line operated power supply section. Read and follow the safety guidelines presented last month and at my Web site.

The following can cause symptoms of a dead or mostly dead monitor:

1. Shorted Horizontal output transistor (HOT). This will usually blow a fuse or fusable resistor as well if fed directly from the AC line. However, when fed by a SMPS, the result may just be a soft audible whine or periodic tweet or flub possibly accompanied by flashing front panel LEDs. Here, the failure is not in the power supply itself but may result in damage to it or other components especially if it continues to run in this state.

2. Shorted output rectifier diodes can load down the outputs to the point of shutting down or resulting in the same audible symptoms as (1) above.

3. Flyback transformer can have shorted windings or shorts in the focus/screen divider network which load down the output.

   These (primary shorts in particular) may cause the horizontal output transistor to fail as well. This is a common problem with older MacIntosh computers and video terminals. Some secondary faults may not be instantly destructive but result in little or no high voltage and eventual overheating.

4. Some load or even the CRT could be shorted leading similar behavior or blowing fuses or fusable resistors which then result in no power to that circuitry.

5. Failure in horizontal drive chain - horizontal oscillator, driver, or driver transformer. Newer monitors may use an IC for the oscillator and this can fail. Without drive, there will be no deflection and this will either result in no high voltage directly (when it is derived from the horizontal deflection) or cause it to be shut down to prevent CRT screen burn (from a stationary spot or line). When powered by an SMPS, there may be an audible ticking from the SMPS cycling on overvoltage due to lack of load. This is also not a failure of the power supply itself.

6. Failure of an SMPS to start. There can be any number of causes though dried up electrolytic capacitors and open high value startup resistors are high on the list if the chopper transistor is not blown.

7. Cold solder joints or other bad connections - monitors tend to have these as a result of temperature cycling and with all too many - poor manufacturing quality control. It is possible that no parts have been damaged - at least not yet. Resoldering may be all that is needed.

If there is B+ (typically 60 to 150 VDC depending on the scan rate) at the output of the power supply but nothing on the HOT collector, an open fusable resistor, blown fuse, or bad connection, is likely.

If there is voltage on the HOT collector, there is probably a drive problem.

Troubleshooting the switchmode power supply

If the SMPS is a separate module, it may be possible to unplug its output connector and test it for proper operation independently of the monitor circuitry. However, a minimum load may be needed at least on the output that is used for regulation feedback and there could be other interlocks that will complicate your testing.

The most common failures in monitor SMPSs are:

- Main chopper transistor - in a monitor, this is often an expensive power MOSFET.
- Other shorted semiconductors - particularly high speed rectifiers on the secondary side of the high frequency transformer.
- Dried up electrolytic capacitors leading to startup and regulation problems.
- Open high value startup resistors resulting in no initial drive to chopper.
- Bad connections (is this sounding repetitive?).

See the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies for more information.

Common problems

Here are just a few of those that you may come across:

Power button on monitor is flakey

If the on/off (or other button) on the monitor itself behaves erratically then the most likely cause is the obvious - the button or switch is dirty or worn. Believe it or not, this isn't as unusual as you might think On a momentary pushbutton, if you can get at it, some contact cleaner may help. Replacement with a common pushbutton or toggle type switch (as appropriate) available at Radio Shack may be much easier than attempting to locate the original part!

Dead monitor

This means that there is absolutely no evidence of anything happening when the power switch is activated.

The most like causes are:

- Outlet isn't live, power cord is loose or defective. Try something else in the outlet, inspect/replace the power cord.
- Bad power switch. With plug pulled, check for continuity in the on or pressed position.
- Blown fuse or fusable resistor (probably from shorted parts in power supply or elsewhere like the HOT). It usually won't hurt to try a replacement fuse with exactly the same ratings but don't be surprised if it blows.
- Bad power supply (not starting up or just dead), bad connections. However, degauss would likely still operate in this case.

Monitor blows fuse

A blown fuse is a very common type of fault due to poor design very often triggered by power surges due to outages or lightning storms. However, the most likely parts to short are easily tested, usually in-circuit, with an ohmmeter and then easily removed to confirm.

Note that it *may be* useful to replace a fuse the *first* time it blows (though it would be better to do some basic checks for shorted components first as there is a small chance that having a fuse blow the second time could result in additional damage which would further complicate the troubleshooting process). However, if the new one blows, there is a real problem and the only use in feeding the TV fuses will be to keep the fuse manufacturer in business!

Sometimes, a fuse will just die of old age or be zapped by a power surge that caused no damage to the rest of the monitor. However, it must be an EXACT replacement (including slo-blow if that is what was there originally). Else, there could be safety issues (e.g., fire hazard or equipment damage from too large a current rating) or you could be chasing a non-existent problem (e.g., if the new fuse is not slo-blow and is blown by the degauss circuit inrush current but nothing is actually wrong).

If the fuse blows absolutely instantly with no indication that the circuits are functioning (no high pitched horizontal deflection whine (if your dog hides under the couch whenever the monitor is turned on, something is probably working).) then this points to a short somewhere quite near the AC power input. However, if there is indication of life - for a second or two, or longer, and then the fuse blows, the cause is likely an overload on the power supply. See the section: Dead monitor with audible whine, periodic tweet or flub, and low-low voltage since similar causes apply.

For the instantly blown fuse case, the most common places to look would be:

- Degauss Posistor. This is a combination of a heater and PTC thermistor which controls current to the degauss coil upon power-on. These tend to like to turn into short circuits.
- Shorted parts in the AC input line filter caps and MOVs.
- Diode(s) in main bridge.
- Main filter capacitor(s).
- SMPS chopper (usually a MOSFET) if there is a line operated SMPS or HOT (if a deflection derived power supply).

You should be able to eliminate these one by one using a multimeter to check for short circuits/low resistance. It is best to remove at least one side of each component while testing to avoid sneak paths which can fool your meter.

WARNING: Make sure to unplug the monitor and discharge the main filter capacitor(s) before attempting any of the following measuremente!

Unplug the degauss coil as this will show up as a low resistance.

- Measure across the input to the main power rectifiers - the resistance should not be that low (though it may start out at zero and climb as the main filter capacitors charge). A reading of only a few ohms may mean a shorted rectifier or two, a shorted Posistor, or a fried MOV.
- Test the posistor (if present). Trace back from the degauss connector - it will probably be nearby. The posistor is a little cubical component (about 1/2" x 3/4" x 1") with 3 legs. It includes a line operated heater disk (which often shorts out) and a PTC (Positive Temperature Coefficient) thermistor to control current to the degauss coil. The easiest thing to do it so remove the posistor and try power. If the monitor now works, obtain a replacement but in the meantime you just won't have the automatic degauss.
- Remove and test the HOT or chopper with an ohmmeter. A reading of less than 10 ohms between any combination of pins means the device is shorted.

For everything but the HOT or chopper, replacing the bad parts should be all that is needed - these rarely fail due to OTHER parts going bad.

However, if the HOT or chopper tests bad, it is possible (though not always the case) that something downstream is causing an excessive load which caused the part to fail. Therefore, don't put the cover back on just yet!

With the HOT or chopper removed, it should be possible to power the monitor with your series light bulb. Of course, not much will work - surprise, surprise. :-) With the deguass coil unplugged, the light should flash once as the main filter caps charge and then remain dark.

WARNING: Unplug the monitor and discharge the main filter caps after trying this experiment!

Install a new transistor and power the monitor using your series light bulb.

- If the bulb now flashes once and then settles down to a low brightness level, the monitor may be fine. See if there is an indication of deflection and HV - look for the glow of the CRT filaments and turn up the brightness to see if there is any indication of a raster. With the light bulb, not everything will be normal but some life would be a good sign. Even a pulsating light bulb may just mean that the light bulb is too small for the monitor power requirements. It may be safe to try a higher wattage bulb.

- However, if the bulb glows at close to full brightness, there is probably still some fault elsewhere. Don't be tempted to remove the light bulb just yet. There is still something wrong. Continue to search for shorted parts.

  See if you can locate any other large power transistors in metal (TO3) cans or large plastic (TOP3) cases. There may be a separate power transistor that does the low voltage regulation or a separate regulator IC or hybrid. As noted, some monitors have a switchmode power supply that runs off a different transistor than the HOT. There is a chance that one of these may be bad.

  If it is a simple transistor, the same ohmmeter check should be performed.

If none of this proves fruitful, it may be time to try to locate a schematic or a service center.

Internal fuse blew during lightning storm (or elephant hit power pole)

Power surges or nearby lightning strikes can destroy electronic equipment. However, most of the time, damage is minimal or at least easily repaired. With a direct hit, you may not recognize what is left of it!

Ideally, electronic equipment should be unplugged (both AC line and phone line!) during electrical storms if possible. Modern TVs, VCRs, microwave ovens, and even stereo equipment is particularly susceptible to lightning and surge damage because some parts of the circuitry are always alive and therefore have a connection to the AC line. Telephones, modems, and faxes are directly connected to the phone lines. Better designs include filtering and surge suppression components built in. With a near-miss, the only thing that may happen is for the internal fuse to blow or for the microcontroller to go bonkers and just require power cycling. There is no possible protection against a direct strike. However, devices with power switches that totally break the line connection are more robust since it takes much more voltage to jump the gap in the switch than to fry electronic parts. Monitors and TVs may also have their CRTs magnetized due to the electromagnetic fields associated with a lightning strike - similar but on a smaller scale to the EMP of a nuclear detonation.

Was the monitor operating or on standby at the time? If it was switched off using an actual power switch (not a logic pushbutton), then either a component in front of the switch has blown, the surge was enough to jump the gap between the switch contacts, or it was just a coincidence (yeh, right).

If it was operating or on standby or has no actual power switch, then a number of parts could be fried.

Monitors usually have their own internal surge protection devices like MOVs (Metal Oxide Varistors) after the fuse. So it is possible that all that is wrong is that the line fuse has blown. Remove the case (unplug it first!) and start at the line connector. If you find a blown fuse, remove it and measure across the in-board side of fuse holder and the other (should be the neutral) side of the line. The ohmmeter reading should be fairly high - more than 100 ohms in at least one direction. You may need to unplug the degaussing coil to get a reasonable reading as its resistance may be less than 30 ohms. If the reading is really low, there are other problems. If the resistance checks out, replace the fuse and try powering the monitor. There will be three possibilities:

1. It will work fine, problem solved.

2. It will immediately blow the fuse. This means there is at least one component shorted - possibilities include an MOV, line rectifiers, main filter cap, regulator transistor, horizontal output transistor, etc. You will need to check with your ohmmeter for shorted semiconductors. Remove any that are suspect and see of the fuse now survives (use the series light bulb to cut your losses - see the section: The series light bulb trick.

3. It will not work properly or appear dead. This could mean there are open fusable resistors other defective parts in the power supply or elsewhere. In this case further testing will be required and at some point you may need the schematic.

If the reading is very low or the fuse blows again, see the section: Monitor blows fuse.

Fuse replaced (doesn't blow) but monitor is still nearly dead

There may be a click indicating that the power relay is engaging (there could be bad contacts though this isn't that likely) and the degauss is probably working now.

Since the fuse doesn't blow now (you did replace it with one of the same ratings, right?), you need to check for:

- Other blown fuses. Occasionally there are more than one in a monitor.

- Open fusable resistors. These are usually low values (a few ohms or less) and are in big rectangular ceramic power resistor cases or smaller blue or gray colored cylindrical power resistors. They are supposed to protect expensive parts like the HOT but often blow at the same time - or the expensive HOT or SMPS chopper sacrifices itself to save the 25 cent resistor.

If any of these test open, they will need to be replaced with flameproof resistors of the same ratings. However, you can substitute an ordinary resistor for testing purposes ONLY as long as you don't leave the monitor unattended.

If you find one bad part, still check other power components for shorts or opens as more than one part may fail and just replacing that one may cause it to fail again. These include (depending on your monitor): Rectifier diodes, main filter capacitor(s), fuses and fusable resistors, horizontal output transistor, regulator pass or chopper transistor.

Assuming nothing tests faulty so far, clip a voltmeter set on its 500 V or higher scale across the horizontal output transistor and turn the power on. Warning - never measure this point if the horizontal deflection is operating. It is OK now since the monitor is dead. If the voltage here is 60 to 150 V, then there is a problem in the drive to the horizontal output circuit. If it is low or 0, then there are still problems in the power supply.

No picture but indications of power

The screen is blank with no raster at all. There are indications that the power is alive - the status LEDs are lit and you can hear the normal relay clicking sounds when you change video modes. This indicates that some of the low voltages are present but these may be derived from the standby supply.

Assuming there is no deflection and no HV, you either have a low voltage power supply problem, bad startup circuit, or bad horizontal output transistor (HOT)/bad parts in the horizontal deflection.

Check for bad fuses.

(If you have HV as indicated by static electricity on the front of the screen and you hear the high pitched whine of the horizontal deflection when it is turned on, then the following does not apply).

1. Use an ohmmeter to test the HOT for shorts. If it is bad, look for open fusable resistors or other fuses you did not catch.

2. Assuming it is good, measure the voltage on the collector-emitter of the HOT (this is safe if there is no deflection). You should see the B+ of between 60 and 150 V (typical) depending on mode (for a auto-scan monitor).

3. If there is no voltage, you have a low voltage power supply problem and/or you have not found all the bad/open parts. The flyback primary winding may be open as well.

4. If there is voltage and no deflection, you probably have a startup problem - all TVs and most monitors need some kind of circuit to kick start the horizontal deflection until the auxiliary power outputs of the flyback are available. Some designs use a simple multivibrator for this - a couple of transistors. Others power the horizontal oscillator IC from a special line-derived voltage.

   Look for pulses at the HOT base. If there are none, trace back to the driver and oscillator. Most likely: the power for startup is missing.

   Test the transistors if it is that type with an ohmmeter. If one is shorted, you have a problem. The usual way a TV service person would test for startup problems is to inject a signal to the base of the HOT of about 15.75 kHz. If the TV then starts and runs once this signal is removed, the diagnosis is confirmed. This is very risky for monitors and I would not recommend it - you can all too easily blow things up if not careful (including yourself).

If you hear the high pitched whine of the deflection (probably not for workstation or SVGA computer monitors unless you are a bat) and/or feel some static on the scree, confirm that the horizontal deflection and high voltage are working by adjusting the SCREEN control (probably on the flyback). If you can get a raster then your problem is probably in the video (or chroma) circuits, not the deflection or high voltage.

Monitor deflection derived power supply faults

This section applies to studio video monitors, small computer terminals, and most TVs, which derive many of their supply voltages from auxilary windings on the flyback transformer.

The following are common areas of failure:

- Horizontal output transistor (usually a TO3 metal or TOP3 plastic case shorts out. This will usually blow a fuse or fusable resistor as well.

- Horizontal drive chain - horizontal oscillator, driver, or driver transformer. Newer monitors may use an IC for the oscillator and this can fail.

- Startup - There may be some kind of startup circuit which gets the whole thing going until the auxiliary voltages are available. This could be as simple as a multivibrator or transistor regulator to provide initial voltage to the horizontal oscillator chip or circuit.

- Output rectifier diodes can fail shorted and load down the outputs to the point of shutting down.

- Some load could be shorted or a capacitor could be shorted leading to overload and shutdown.

- Flyback transformer can have shorted windings which load down the output. These (primary shorts in particular) may cause the horizontal output transistor to fail as well. Common problem with older MacIntosh computers and video terminals. Some secondary faults may not be instantly destructive but result in little or no high voltage and overheating.

- Cold solder joints or other bad connections - monitors tend to have these as a result of temperature cycling and bad manufacturing. (Is this sounding repetitive yet?)

- Sometimes there is a series regulator after the filter cap and this could be bad as well.

Without a schematic, I would attempt to trace the circuit from the main filter cap or output of the line operated switchmode power supply assuming that has the proper (approx. 60-120 VDC depending on scan range) voltage.

If you can locate the horizontal output transistor, see if there is voltage on its collector, should be the same. If there is, then there is probably a drive problem. If you have an ECG or similar semi cross reference, that will help you identify the ICs and transistors and locate the relevant portions of the circuitry.

If there is no voltage at the horizontal output transistor, then there is probably a blown fuse or bad connection somewhere or a fault in the line operated SMPS if there is one. However, the fuse may have blown due to a fault in the SMPS or horizontal deflection.

Power-on tick-tick-tick or click-click-click but no other action

A variety of problems can result in this or similar behavior. This applies to both monitors using SMPSs and flyback derived power supplies. Possibilities include:

- Lack of horizontal drive. The main regulator is cycling on overvoltage due to very little load.

- Excessive load or faulty power supply cycling on its overcurrent protection circuit. The sound in this case may be more like a tweet-tweet-tweet or flub-flub-flub, however - see the section: Dead monitor with audible whine, periodic tweet or flub, and low-low voltage.

- HV shutdown, or some other system detecting an out of regulation condition. However, in this case, there should be some indication that the deflection and HV is attempting to come up like momentary high pitched deflection whine, static on the screen, etc.

- A dried up main filter capacitor or other filter capacitor in the low voltage power supply that is producing an out-of-regulation condition

- A problem with the microcontroller, relay or its driver, or standby power supply.

If you have a Variac, vary the line voltage and observe the monitor's behavior. It may work fine at one extreme (usually low) or the other. This might give clues as to what is wrong.

Dead monitor with audible whine, periodic tweet or flub, and low-low voltage

A monitor which appears to be dead except for an audible whine or a once a second or so tweet or flub coming from the SMPS usually indicates an overload fault in the power supply itself or a short in one of its load circuits (usually the main B+). In most cases, the voltages (including B+) will be reduced to a fraction of their normal value (and/or be pulsing along with the animal sounds) as a result of the overload. The power (or other) LED may be weak or flashing as well. Flyback derived power supplies are less likely to exhibit these symptoms.

Note: using too small a series light bulb while testing for the size of the monitor may also result in this condition. If you have found and replaced a bad part, it increase the wattage of the light bulb and try again. If the frequency of the cycling decreases - i.e., it stays up longer, it may be safe to remove the light bulb entirely.

Summary of possible causes:

- Shorted rectifiers or capacitors on secondary side of SMPS.
- Other problems in the power supply or its controller like bad caps.
- Shorted HOT.
- Flyback with shorted turns or breakdown in focus/screen divider network.
- Short or excessive load on secondary supplies fed from flyback.
- Short in horizontal yoke windings.
- Bad solder connections.

Note that a whine may be perfectly normal for your monitor if there is no video input - confirm that there is a signal that is compatible with the monitor's scan rate(s) and type of sync (e.g., separate, composite, or sync-on-green).

However, where a confirmed good video input is present, this may indicate an overloaded low voltage switching power supply.

The whine is caused by the switching power supply's chopper frequency dropping down due to the overload. The periodic tweet or flub is caused by the SMPS attempting to come up, sensing the excessive load, and restarting.

Test the B+ input to the flyback.

If it is near zero, test the HOT for shorts and replace if defective, but continue testing with a series light bulb and/or Variac. There may be something causing the HOT to go bad like a shorted flyback or bad damper diode or snubber cap.

If the voltage is not zero but is low (e.g., it should be 120 V but is only 60 V) or fluctuating in time with the tweet or flub, there may be a problem with:

1. The SMPS. Test with a substitute load like a 40 W light bulb or power resistor. If the supply now outputs full voltage, it is probably fine. For a power resistor, select a value such that the load at the expected voltage will be about 1/2 to 2/3 of the nameplate power rating of the monitor.

   One common type of failure are shorted rectifiers in the switching supply or secondary supplies running off the flyback. The HFR854s (one popular type in monitors) or other high speed high efficiency rectifiers in the output side of the switching power supply or flyback seem to like to turn into short circuits. (I had a couple of DOA monitors where this was the problem. so much for quality control!)

   WARNING: Unplug the monitor and discharge the main filter caps before attempting the following tests!

   Use an ohmmeter to check the various diodes in the power supply. The higher power diodes appear commonly as black cylinders about 3/8" long by 1/4 diameter - kind of like 1N400Xs on steroids. The resistance of the diodes in at least one direction should be greater than 50 ohms in-circuit. If you find one that is much less (like 0 or 5 ohms), then it is probably bad. Unsolder and check again - it should test infinite (greater than 1M ohms) in one direction. If it now tests good, there may be something else that is shorted.

Replacements are available for about $0.25 from places like MCM Electronics.

2. Flyback (LOPT) transformer - shorted windings. See the document: Testing of Flyback (LOPT) Transformers.

3. Deflection yoke - shorted turns in the horizontal or geometry correction windings. See the section: Deflection yoke testing.

4. Excess load on one of the flyback's secondaries. Disconnect all secondary output pins from the flyback if possible and see if your B+ returns to normal.

5. Improper drive to HOT. Inspect with an oscilloscope. The drive should match the horizontal rate of the video input with a high time (at .7 to 1 V or so) typically 75 to 95% of the total line time.

Monitor power cycling on and off

The power light may be flashing or if you are runing with a series light bulb it may be cycling on and off continuously. There may be a chirping or clicking sound from inside the set. (Note: using too small a light bulb for the size of the monitor may also result in this condition.)

If there is a low voltage regulator or separate switching supply, it could be cycling on and off if the horizontal output, flyback, or one of its secondary loads were defective.

These symptoms are slightly different than those discussed in the section: Dead monitor with audible whine, periodic tweet or flub, and low-low voltage in that a picture may actually appear for an instant.

Verify that the main filter capacitor is doing its job. Excessive ripple on the rectified line voltage bus can cause various forms of shutdown behavior. An easy test is to jumper across the capacitor with one of at least equal voltage rating and similar capacitance (make connections with power off!).

Use a Variac, if possible, to bring up the input voltage slowly and see if the monitor works at any point without shutting down. If it does, this could be an indication of X-ray protection circuit kicking in, though this will usually latch and keep the set shut off if excessive HV were detected.

Something could be breaking down like a capacitor or the flyback as the voltage builds up to normal values

Startup problems - nothing happens, click, or tick-tick-tick sound

TVs and and small fixed scan rate monitors (e.g., CCTV or TV monitors, video display terminals) usually incorporate some kind of startup circuit to provide drive to the horizontal output transistor (HOT) until the flyback power supply is running. Yes, TVs and many monitors boot just like computers.

There are two typical kinds of symptoms: power on click but nothing else happens or a tick-tick-tick sound indicating cycling of the low voltage (line regulator) but lack of startup horizontal drive.

Check the voltage on the horizontal output transistor (HOT). If no voltage is present, there may be a blown fuse or open fusable resistor - and probably a shorted HOT.

However, if the voltage is normal (or high) - usually 60-150 V depending on scan rate (for an auto-scan monitor), then there is likely a problem with the startup circuit not providing initial base drive to the HOT.

The startup circuits may take several forms:

1. Discrete multivibrator or other simple transistor circuit to provide base drive to the HOT.

2. IC which is part of deflection chain powered off of a voltage divider or transformer.

3. Other type of circuit which operates off of the line which provides some kind of drive to the HOT.

The startup circuit may operate off of the standby power supply or voltage derived from non-isolated input. Be careful - of course, use an isolation transformer whenever working on TVs and especially for power supply problems.

Note that one common way of verifying that this is a startup problem is to inject a 15 kHz signal directly into the HOT base or driver circuit (just for a second or two). If the TV then starts up and continues to run, you know that it is a startup problem.

Caution: be careful if you do this. The HOT circuit may be line-connected and it is possible to destroy the HOT and related components if this is not done properly. I once managed to kill not only the HOT but the chopper transistor as well while working in this area. An expensive lesson.

I have also seen startup circuits that were designed to fail. Turning the TV on and off multiple times would exceed the power ratings of the components in the startup circuit. Some Zenith models have this 'feature'.

When this situation exists, it could be that the circuit is not providing the proper drive or that due to some other circuit condition, the drive is not always sufficient to get the secondary supplies going to the point that the normal circuits take over.

I would still check for bad connections - prod the circuit board with an insulated stick when the problem reoccurs.

Reduced width picture and/or hum bars in picture

The most likely cause is a dried up main filter capacitor. Once the effective capacitance drops low enough, 120 Hz (or 100 Hz in countries with 50 Hz power) ripple will make its way into the regulated DC supply (assuming full wave rectification).

Another likely cause of similar symptoms is a defective low voltage regulator allowing excessive ripple. The regulator IC could be bad or filter capacitor following the IC could be dried up.

Either of these faults may cause:

1. A pair of wiggles and/or hum bars in the picture which will float up the screen. For NTSC where the power line is 60 Hz but the frame rate is 59.94 Hz, it will take about 8 seconds for each bar to pass a given point on the screen. (On some sets, a half wave recitifier is used resulting in a single wiggle or hum bar).

   For high scan rate computer monitors, the this may result in horizontal hum bars, wiggles, or other distortions that will drift up or down the screen based on the difference frequency between the power line and video refresh rate being supplied by the PC or workstation. A confirmation can be obtained by varying the scan rate and seeing if the rate of drift changes predictably.

2. Possible regulation problems resulting in HV or total shutdown or power cycling on and off.

The best approach to testing the capacitors is to clip a good capacitor of approximately the same uF rating and at least the same voltage rating across the suspect capacitor (with the power off). A capacitor meter can also be used but the capacitor may need to be removed from the circuit.

Once the capacitors have been confirmed to be good, voltage measurements on the regulator should be able to narrow down the problem to a bad IC or other component.

Wiggling or jiggling picture

Depending on the frequency of the instability relative to the scan rate in use, the symptoms may be that the entire picture is vibrating, that ripples are moving up or down the screen, or something else. There may also be variatons in brightness - hum bars - in the picture.

- Very high frequency oscillations will result in multiple waves or scalloped edges on the sides of the raster possibly extending into the picture itself. These patterns may or may not remain stationary.

- Low or power line frequency oscillations will result in the entire raster moving back and forth, vibrating, or 1 or 2 wiggles along the sides of the raster that move up or down the screen. The actual behavior will depend on the relative frequencies of the oscilations and the vertical scan rate.

When the vertical scan rate is set close to the local power line frequency, effects resulting from power line interference or bad filter capacitors will produce 1 or 2 wiggles or bars, and these will remain almost stationary on the screen. Those caused by internal power supply stability problems may or may not do this.

First, eliminate the possibility of external magnetic interference, power line noise, or a video card/computer problem. Try the monitor in another location and on another computer if possible. Or, try another similar monitor in its place.

Once these causes have been ruled out, the most likely ones are:

- Dried up electrolytic capacitors in the power supply.

- A resistor or other component has changed value in the B+ (or other) regulator.

  For example, one very common monitor - the Gateway CS1572FS - uses a 91K, 1W resistor (R331) to set its 180 V B+ output. Invariably with use and age, its resistance increases in value leading to a vibrating raster and eventual failure of other parts.

- Bad connections.

Monitor doesn't power up immediately

The monitor may do nothing, cycle on and off for a while, power up and then shutdown in an endless cycle - or at least for a while. Then it comes on and operates normally until it is turned off.

A couple of possibilities:

1. The main filter capacitor or other filter capacitors in the low voltage power supply is dried up and this can cause all kinds of regulation problems. Other regulating components may be marginal. This may be allowing excessive voltage to reach the output of the power supply and then the X-ray protection circuitry shuts you down.

   Try powering the monitor on a Variac when cold. Bring up the voltage slowly and see if there is some point at which it would stay on. If there is, then a regulation problem is likely. If the picture has serious hum bars in it, check the main filter capacitor(s) first.

2. Bad connections may be preventing the power supply from operating normally until the mainboard or components heat up a bit.

   Inspect the solder side of the mainboard for cracked solder connections. Some gentle poking and prodding with a well insulated stick may reveal the location though a problem that goes away once the unit heats up can be tough to identify!. The use of 'cold spray' may help. Also, clean and reseat internal connectors.

   Also see the section: Old monitor requires warmup period.

Old monitor requires warmup period

So, what else is new? In the old days, a TV or monitor was expected to take a few minutes (at least) to warm up. We are all spoiled today. Of course, you usually maintained a full time technician or engineer to fiddle with the convergence adjustments!

If it just takes a while for the picture to become as bright as you like, this is probably just a result of an old tired CRT (see the section: Monitor Monitor life, energy conservation, and laziness and Brightening an old CRT. If, however, nothing happens for a few minutes, then some component needs to be powered for a while before it starts cooperatings. This is probably a dried up capacitor in the power supply since that is drifting with temperature and needs to be located with cold spray or a heat gun.

Adjustment or picture interactions

This describes problems such as turning up the brightness causes a loss of sync or adjusting height also affects width or produces a wavy raster. Or, a bright picture or opening a bright window results in a significant change in picture size or wiggly edges. Or, the monitor simply decides to shut down!

These may be caused by poor regulation in one or more low voltage power supplies or and interaction between the high voltage and low voltage power supplies - possibly a dried up capacitor if it is relatively old, bad connections, or another faulty component. Measure the B+ to the horizontal deflection (to the flyback, not the horizontal output transistor). If it is changing with the problem, then a regulation problem is confirmed. If this voltage is solid, you will need to check the others to see which one is actually changing.

Shorted Components

A failure of the horizontal output transistor or power supply switchmode transistor will blow a fuse or fusable resistor.

Look for blown fuses and test for open fusable resistors in the power circuits. If you find one, then test the HOT and/or switchmode transistor for shorts.

Other possibilities: rectifier diodes or main filter capacitor.

While you are at it, check for bad connections - prod the circuit board with an insulated stick when the problem reoccurs - as these can cause parts to fail.

Monitor turns off after warming up

If you can turn it back on with the s momentary key or power button:

When it shuts off, do you need to push the power button once or twice to get it back on? Also, does anything else about the picture or sound change as it warms up?

1. If once, then the controller is shutting the TV down either as a result of a (thermally induced) fault in the controller or it sensing some other problem. Monitoring the voltage on the relay coil (assuming these is one) could help determine what is happening. The controller thinks it is in charge.

2. If twice, then the power supply is shutting down as the controller still thinks it is on and you are resetting it. A couple of possibilities here would be low voltage or high voltage regulation error (excessive high voltage is sensed and causes shutdown to prevent dangerous X-ray emission). A partially dried up main filter capacitor could also cause a shutdown but there might be other symptoms like hum bars in the picture just before this happened. Clipping a good capacitor across the suspect (with power off!) would confirm or eliminate this possibility.

If it uses a hard on/off switch, then this may be like pulling the plug and would reset any abnormal condition.

Monitor shuts down with bright picture or when brightness is turned up

This is probably a protection circuit kicking in especially if turning power off or pulling the plug is required to restore operation.

The detection circuit could be in the power supply or horizontal deflection output circuit. It may be defective or the current may be too high for some other reason. A couple of tests can be performed to confirm that it is due to beam current:

- Determine if behavior is similar when adjusting the user brightness control and the screen (G2) pot (on the flyback) or master brightness control. If the monitor quits at about the same brightness level, overcurrent protection is likely.

- Disconnect the filaments to the CRT (unsolder a pin on the CRT socket) and see if it still shuts down under the same conditions. If it is overcurrent protection, shut down should now *not* take place since there is no beam current.

Relays in the Power Circuitry of monitors

What exactly is the purpose of such a relay? Why doesn't the power switch on the monitor just apply power directly instead of through a relay?

On a TV, the usual reason for a relay instead of a knob switch is to permit a remote control to turn power on and off. If your TV does not have a remote, then it is simply the same chassis minus 24 cents worth of circuitry to do the remote function. Isn't marketing wonderful?

On a monitor without any remote control, there can be two likely reasons:

1. Reduce the needed capacity of the on/off switch. High resolution monitors do consume a fair amount of power. A soft touch button may be more elegant or cheaper.

2. Allow for automatic power saving 'green' operation.

When replacing a relay, only unknown is the coil voltage. It is probably somewhere in the 6-12 volt range. You should be able to measure this on the coil terminals in operation. It will be a DC coil.

However, the relay controls the 125 VAC (or 220) which you should treat with respect - it is a lot more dangerous than the 25kV+ on the CRT!

Almost certainly, the relay will have 4 connections - 2 for power and 2 for the coil. If it is not marked then, it should be pretty easy to locate the power connection. One end will go to stuff near the AC line and the other end will go to the rectifier or maybe a fusable resistor or something like that. These will likely be beefier than the coil connections which will go between a transistor and GND or some low voltage, or maybe directly into a big microcontroller chip.

Of course, the best thing would be to get the schematic but with monitors this may not be easy.

Once you are sure of the AC connections - measure across them while it is off and also while it is on. While off, you should get 110-125 VAC. While on and working - 0. While on and not working either 110-125 VAC if the relay is not pulling in or 0 if it is and the problem is elsewhere. We can deal with the latter case if needed later on. Note the even if the relay contacts are not working, the problem could still be in the control circuitry not providing the correct coil voltage/current, though not likely.

It may be expensive and/or difficult to obtain an exact replacement, but these are pretty vanilla flavored as relays go. Any good electronics distributor should be able to supply a suitable electrical replacement though you may need to be creative in mounting it.

What is a posistor?

A posistor is a combination of a PTC (Positive Temperature Coefficient) resistor and another resistor-element to heat it up and keep it hot. Sometimes, these will go by the name posistor or thermistor. The heater is a disk shaped resistor across the power line and the themister is a disk shaped device in series with the degauss coil. They are in clamped together to be in close contact thermally. You can pry off the lid and see for yourself.

The most common failure mode is for the part to short across the line.

Its function is to control degauss, so the only thing you lose when you remove one of these is the degauss function on power-on. When you turn the TV or monitor on, the PTC resistor is cold and low resistance. When heated, it becomes very high resistance and turns off the degauss coil but gradually - the current ramps down to zero rather than being abruptly cut off..

Computer Component Source stocks a wide variety, I believe but it may be cheaper to go direct to the manufacturer if they will sell you one.

Flameproof Resistors

Flameproof Resistor or Fusable Resistor are often designated by the symbol 'FR'. They are basically the same. The designation "Flameproof" means that if they fail due to excessive current, there will be no chance of, well, them going up in flames. :) They will also have a power rating and thus can act as a protective device, though a specific circuit may not depend on a precise fuse rating, rather that the resistor will open with massively excessive current.

You may see these in the switchmode power supplies used in TVs and monitors. They will look like power resistors but will be colored blue or gray, or may be rectangular ceramic blocks. They should only be replaced with flameproof resistors with identical ratings. They serve a very important safety function.

These usually serve as fuses in addition to any other fuses that may be present (and in addition to their function as a resistor, though this isn't always needed). Since your FR has blown, you probably have shorted semiconductors that will need to be replaced as well. I would check all the transistors and diodes in the power supply with an ohmmeter. You may find that the main switch mode transistor has decided to turn into a blob of solder - dead short. Check everything out even if you find one bad part - many components can fail or cause other components to fail if you don't locate them all. Check resistors as well, even if they look ok.

Since they function as fuses, flameproof resistors should not be replaced with higher wattage types unless specifically allowed by the manufacturer. These would not blow at the same level of overload possibly resulting in damage to other parts of the circuitry and increasing the risk of fire.

Then, with a load on the output of the power supply use a Variac to bring up the voltage slowly and observe what happens. At 50 VAC or less, the switcher should kick in and produce some output though correct regulation may not occur until 80 VAC or more. The outputs voltages may even be greater than spec'd with a small load before regulation is correct.

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Deflection Problems

Deflection fundamentals

Note: the following is just a brief introduction. For more detailed deflection system theory of operationo and sample circuits, see the document: TV and Monitor Deflection Systems.

The electron beams in the CRT need to be scanned horizontally and vertically in a very precise manner to produce a raster - and a picture.

For NTSC and PAL, the horizontal scan rates are 15,734 and 15,625 Hz respectively, the vertical scan rates are 60 and 50 Hz (approximately) respectively.

For PCs and workstation monitors, a wide range of scan rates are used.

For example:

```
   Standard      Horizontal, kHz  Vertical, Hz
 ------------------------------------------------
    MDA               18.43           50
    CGA               15.75           60
    EGA               15.75-21.85     60
    VGA               31.4            60-70
    SVGA (800x600)    35-40           50-75+
    SVGA (1024x768)   43-52+          43-75+
    SVGA (1280x1024)  64-72+          60-75+
    Workstations      64-102+         60-76+
```

Even in high resolution fixed frequency monitors, these high horizontal (in particular) scan rates necessitate some fancy circuit design. All components are running under stressful conditions and it is amazing that failures are not more common.

With auto-scan monitors, the complexity of the circuits increases dramatically to accommodate the wide range of horizontal scan rates. Relays or electronic switches are used to select power supply voltages, tuning components, and to make other alternations in the deflection circuits to handle DOS VGA one minute and Autocad 1280x1024 the next. It comes as no surprise that the most stressful time for a monitor may be when switching scan rates.

Unfortunately, successfully diagnosing problems dealing with the scan switching logic and circuitry is virtually impossible without a schematic.

The deflection yoke includes sets of coils for horizontal and vertical scanning oriented at 90 degrees with respect to each other. Additional coils are needed to correct for pincushion and other geometric defects.

The deflection circuits must be synchronized and phase locked to the incoming video signal.

Therefore, we have the following functions:

1. Sync separator to obtain horizontal and vertical synchronization pulses for monitors with composite video or sync inputs. Input sync detectors and auto polarity switching circuits as needed for separate horizontal and vertical sync inputs.

2. Horizontal oscillator which locks to horizontal sync pulses.

3. Horizontal drive followed by horizontal output which feeds deflection yoke (and flyback for HV and other voltages), Yoke requires a sawtooth current waveform for linear horizontal deflection. Horizontal output in all but the smaller TVs or monitors is a large discrete power transistor, most often an NPN bipolar type.

4. Vertical oscillator which locks to vertical sync pulses. Yoke requires sawtooth waveform for linear vertical deflection.

5. Vertical drive/output which feeds vertical deflection yoke. Newer TVs and monitors use ICs for vertical drive and output.

6. Various additional deflection signals to correct for the imperfections in the geometry of large angle deflection CRTs. These may be fed into the normal deflection coils and/or there may be separate coils mounted on the neck of the CRT.

7. Auto-scan deflection control and selection circuitry (auto-scan monitors only), probably controlled by a microprocessor which stores scan parameters for each scan rate and automatically detects the appropriate settings to use by analyzing the input video. For horizontal deflection, the usual way of size constant regardless of scan rate is to scale the B+ to the HOT with horizontal frequency. Thus, VGA resolution may us 60 V B+ while 1280x1024 at 75 Hz may require 150 V. Various other components may need to be selected based on scan rate. Relays are often used for this selection since they are easy to control and can handle the voltages and currents in the various deflection circuits reliably.

See Symptoms of Some Common Deflection Problems when referring to the specific descriptions below.

Monitor display is off-center

These sorts of problems usually relate to the picture shifting when switching between applications or between DOS and Windows. First, make sure you are using the correct monitor settings and video drivers. Note that a fraction of a mm offset may be normal and you are just too fussy!

If you have a setup program for your video card:

1. Make sure you are running well within the accepted scan rates for each resolution.

2. Toggle sync polarity and see if this makes any difference.

3. Adjust H position or phase and see what this does.

Also make sure your cables are secure. While a bad connection would likely messed things up worse, it won't hurt to check. Assuming none of this helps, your monitor may have a problem though it is not likely to be major (in a relative way). If you still like the monitor, repair may be worth the money.

Gross problems in size or position at certain scan rates

First, make sure you are not specifying incorrect scan rate for your monitor. Check your video card setup and/or monitor selection in Win95/98 as above.

Assuming you are not violating the scan rate specifications but have a picture that is twice the height of the screen and one half the width, for example, this could indicate a failure in the scan rate switching circuitry of an auto-scan monitor. Either the logic is faulty and ordering the wrong selections for power supply voltage and tuning components or the relays or the relevant parts are faulty. This could be due to bad connections as well - quite likely in fact. Also, try to reset the afflicted parameters using the digital controls (if relevant) and confirm that your video card is putting out the correct scan rate - try another monitor or examine the video signals with an oscilloscope.

Try prodding the circuit boards with an insulated stick - this may identify bad connections or unstick a sticky relay.

A schematics will likely be needed to proceed further with these sorts of problems.

Reduced width

Complaints about the picture not filling the screen with computer monitors are common but may not indicate problems (except with your expectations). Older monitors, in particular, often did not allow a full screen display at certain resolutions. There may be underscan modes/switches as well. Keep in mind that advertizing a large diagonal CRT does not necessarily imply that you can fill it!

However, if this problem just happened with no changes to your computer system (video card, scan rates, O/S), then the following are possibilities:

- The B+ to the horizontal output is lower than normal. The way width control functions is that as you increase the horizontal scan rate, the B+ to the HOT must increase to keep the width constant. It could be that yours is low to start with and not tracking scan rate changes either.

- A bad capacitor might also result in reduced width but I would expect non-linearity as well.

- As noted in the section: Gross problems in size or position at certain scan rates, there could be problems in the scan rate switching circuitry selecting incorrect components for certain scan rates.

- There might be a bad (low value or high ESR) decoupling capacitor. Scope the rail after the low-value decoupling R for H-rate stuff. There shouldn't be anything significant. If there is, the ESR of the decoupling capacitor is too high or its value is too low. Seen it often where it also cooks the decoupling R, because the efficiency of the H-out becomes poor. (gwoods@albany.net (Gary Woods).)

- A more unlikely possibility is a open yoke winding. The horizontal deflection yoke consists of multiple windings in parallel so it is theoretically possible for one or more of these to open up. I don't know what effects the associated detuning of the horizontal output circuit would have in this case.

Can incorrect or missing video damage my monitor?

The short answer is - quite possibly. Don't push your luck.

Mostly, there are problems at scan rates which exceed the monitor's specifications (low or high). However, some poorly designed monitors or just a particular combination of events can blow a monitor with too low a scan rate or an absent or corrupted signal input. There was one case where a very expensive high performance monitor would consistently blow its horizontal deflection circuits when driven by a particular ATI video card. It turned out that during the power-on self test of the ATI BIOS, just the wrong video timing was being generated for a fraction of a second - but that was enough.

As far as scan rate limits, there is no way of knowing - it really all depends on the quality of the design of your monitor. Some will happily run continuously at 25% above specifications. Other will blow out totally at the first excuse.

The specification that is likely to be more critical is the horizontal rate as it probably puts more stress on the components than the vertical rate. I have found that as you approach the upper limits, there is a good chance that the geometric accuracy of the raster near the top of the screen may start to deteriorate due to lock in problems as well. However, it would be foolhardy to depend on this sort of behavior as an indication of going over the edge.

It will be much too late when you find out. If the manual says 75 Hz V and 64 kHz H, stay below **both** of these. If you exceed the safe ratings and the design isn't really good, there is the possibility of blowing components in the horizontal deflection and high voltage sections which will result in expensive repair bills. You will likely get no warning of impending failure. In addition, even if the monitor does not immediately turn into a pile of smoking silicon and plastic, components may be under more stress and running at higher levels of power dissipation. Total failure may be just around the corner. More subtle degradation in performance may occur over time as well.

You won't see the difference anyhow beyond 75 Hz and your programs may run slightly faster at lower refresh rates since the video is not using as much bandwidth (however, the difference here may be very slight or non-existent depending on your board, computer, applications, etc.).

Picture squeezed in then died

You were happily playing 'Doom' when the sides of the picture squeezed in two inches or so when the entire monitor went dead - has remained like this since. There is no activity at all from the tube. Has it died? How much time, effort, and expense to fix?

No, it's not dead, at least it certainly is not the picture tube.

You probably shot the monitor instead of the bad guys!

Is there any indication of light on the screen? Any indication of the horizontal deflection running at all as evidenced by static on the screen?

In any case, there is a problem in the horizontal deflection and you probably have no high voltage as well assuming no light on the screen.

The fact that it squeezed in first indicates that a partial short or other fault may have developed in the horizontal deflection circuits - possibly the deflection yoke or flyback transformer. It could also have been a bad connection letting loose. Once it failed completely, the horizontal output transistor may have bought the farm or blown a fuse.

Horizontal deflection shutting down

Confirm that the horizontal deflection is shutting down along with the high voltage if it is derived from horizontal deflection: listen for the high pitched deflection whine (NTSC/PAL/CGA), test for static on the screen, see if the CRT filaments are lit, turn up the brightness and/or screen control to see if you can get a raster. Some possibilities:

- Power is failing to the horizontal output transistor - this could be due to a low voltage power supply problem, bad connection, etc.
- Base drive to the horizontal output transistor is failing - could be a fault in the horizontal oscillator or bad connection.
- Problem with the flyback transformer or its secondary loads (flyback may provide other power voltages).
- X-ray protection is activating - either due to excess HV or due to a fault in the X-ray protection circuitry.

If the problem comes and goes erratically it sounds like a bad connection, especially if whacking has an effect. If it comes and goes periodically, then a component could be heating up and failing, then cooling, etc.

Horizontal squashed

A very narrow picture may indicate problems with the power supply to the horizontal deflection circuits, incorrect scan rate selection or defective components, faulty deflection yoke, or bad connections.

If the size is erratic and/or gently whacking the monitor makes the width change, bad connections are likely. See the section: Monitor manufacturing quality and cold solder joints.

Confirm that your video card is running at the proper scan rate - particularly that it is not violating the monitor's specifications. An excessive horizontal scan rate is a common cause of a reduced width raster. Try its software setup adjustments as these may have been lost.

Beyond this, a schematic will probably be needed to isolate the fault.

Monitor non-linearity

Most modern monitors are nearly perfect with respect to linearity. There are almost never any user adjustments and there may not even be any internal adjustments. See the section: Position, size, and linearity adjustment.

A sudden change in linearity or a monitor that requires a warmup period before linearity becomes acceptable may have a bad component - probably a capacitor in the horizontal deflection circuits. For the latter, try some cold spray or a heatgun to see if you can locate the bad part.

(From: helio (mmccann@usa.pipeline.com).)

You should likely begin in the area immediately around the HOT, perhaps there might be a high frequency NP (non polarized) electrolytic just starting to go. Some larger monochrome monitors actually have working H-lin adjustment coils (believe it or not) especially if they are older ones. But most are glued/potted down or fixed value. If you locate it (the coil) the problem should be nearby.

Picture squeezed on both left and right side of screen

> "I'm trying to repair a Target DN-1564 monitor with a problem in the horizontal deflection: on both the left and right side of the screen the picture gets squeezed together, regardless of H-width and other settings. I've checked most semiconductors in this part, but I can't find anything wrong there."

This sounds like an S-correction capacitor may have too small a value or failed open. Check the capacitors in the vicinity of the deflection yoke connector and HOT. It could be due to bad connections as well.

S-correction is needed to linearize the horizontal scan (and vertical as well scan but that is a separate circuit). Without S-correction, the scan current would be nearly linear. This would result in greater coverage in a given time near the edges of high deflection angle CRTs. The picture would appear stretched near the edges In this case, the correction appears excessive.

(From: David Henniker (david.henniker@cableinet.co.uk).)

I had a similar problem with a monitor (here in Edinburgh Scotland). The S-correction cap was open-circuit altogether. Other caps in parallel allowed the distorted scan. If it had been a TV there wouldn't have been other caps in parallel and the result would have been no line scan, maybe a vertical line (line collapse) or nothing at all.

Vertical squashed

This means the vertical size is reduced with or without distortion.

Before attacking the circuitry, make sure your vertical scan rate is within the monitor's capabilities and that the user vertical size control is adjusted properly. If there is no distortion, this is likely as many (but not all) circuit problems would result in non-linearity or cutoff of the top or bottom portions of the picture. All you may need to do is change your computer's video settings! Swap the monitor or computer to be sure it is not a problem with the video card.

However, if failure happened suddenly and the vertical is squashed at all scan rates, this is likely a vertical deflection problem - possibly a bad capacitor, bad connection, bad flyback/pumpup diode, or other component. None of these should be very expensive (in a relative sort of way).

If the symptoms change - particularly if they become less severe - as the unit warms up, a dried up electrolytic capacitor is most likely. If they get worse, it could be a bad semiconductor. Freeze spray or a heat gun may be useful in identifying the defective component.

It is often easiest to substitute a good capacitor for each electrolytic in the vertical output circuit. Look for bad connections (particularly to the deflection yoke), then consider replacing the vertical output IC or transistor(s).

A defective deflection yoke is also possible or in rare cases, a bad yoke damping resistor (e.g., 500 ohms, may be mounted on the yoke assembly itself).

Where the entire top half or botton half of the picture is squashed into into the center (i.e., only half the picture shows), a missing power supply voltage, defective vertical output IC, or a component associated with it is likely bad. A bad connection or blown fusable resistor may be the cause of a missing power supply voltage.

The following are NOT possible: CRT or flyback (except possibly where it is the source for a missing power supply voltage but this is more likely just a bad solder connection at a flyback pin). I am just trying to think of really expensive parts that cannot possibly be at fault. :-)

Keystone shaped picture

This means that the size of the picture is not constant from top to bottom (width changes) or left to right (height changes). Note that some slight amount of this is probably just within the manufacturing tolerance of the deflection yoke and factory setup (geometry magnet placement, if any). With a monitor, such defects are more noticeable than with a TV since much of the display is of rectangular boxes - i.e., windows, lines of text, graphics, etc. Furthermore, the monitor is usually run just barely underscanned to maximize the viewing area without cutting anything off. Any deviations from perfection show up in relation to the CRT bezel.

However, a sudden increase may indicate a problem with the deflection yoke.

An open or short in a winding (or any associated components mounted on the yoke assembly) will result in the beam being deflected less strongly on the side where that winding is located. However, with a high scan rate monitor, there may be many individual windings connected in parallel in the yoke so the effect of only one opening up may not be as dramatic as with a TV where there may only be a single pair of windings for the horizontal and another for the vertical.

A simple test of the yoke in this case can be performed by simply swapping the connections to the yoke for the affected direction (i.e., if the width changes from top to bottom, interchange the connections to the vertical windings).

- If the keystone shape remains the same (but of course the picture flips), it is likely the yoke. The bad yoke winding is the one for the other axis (than what you swapped - if you just swapped the vertical, it is the horizontal yoke that has a short or open).

- If the keystone shape flips, it is a circuit problem (see below).

See the section: Deflection yoke testing.

If the monitor has been dropped off a 20 story building, the yoke may have shifted its position on the neck, of the CRT resulting in all sorts of geometry and convergence problems (at the very least).

(From: James Poore (aw133@lafn.org).)

I have seen the 'reverse keystoning' in several monitors and the fix is usually the same. In the horizontal leg of the pincushion transformer are 1 or more electrolytics to ground. The caps have + going to transformer and - to ground. Anyway when they start loosing capacitance and/or become leaky the reverse keystoning effects become more pronounced.

Picture size changing

If the picture area is expanding or contracting without any changes to your video card settings or other software. then there is a problem with the power supplies in the monitor. This would be confirmed if the change is (1) gradual over the course of say, an hour, and/or (2) gently whacking the monitor has some effect indicating bad internal connections. Software problems would not result in either of these characteristics.

Note that if the change is very small - say, less than 1 or 2%, then it may simply be normal for your monitor due to poor design or the use of inferior components - some parts associated with power supply regulation may be changing value as the monitors warms up.

A way to confirm that something is drifting due to thermal problems would be the monitor from another computer and see if the same thing happens. Just powering the monitor by itself (but not in any power saving mode) might also work for this test.

One possible cause could be that the high voltage is drifting gradually due to a faulty component - increasing and making the beam 'stiffer' or vice-versa. If this is the case there might also be a gradual change in brightness as well (decreasing image size -> increase in brightness). Alternatively, the HV may be stable but the power to both H and V deflection is gradually changing.

Excess high voltage can increase the X-ray emissions and any kind of power supply problems may ultimately result in total failure and an expensive repair. Therefore, these symptoms should not be ignored. See the sections on low voltage and high voltage power supply problems.

Monitor will not sync

For SVGA monitors, check that the sync pins in the video connector are not broken or bent. On the VGA HD15 connector, these are pin 13 (H) and 14 (V).

For monitors using BNC cables, first make sure that the cable connections are correct - interchange of H and V sync or G with one of the other video signals (sync-on-gree setups) can result in all kinds of weird sync problems.

There are a wide variety of causes for a monitor that will not display a stable or properly configured image. Among the symptoms are:

- Lack of sync horizontal - drifts smoothly horizontally. Depending on the difference between the video horizontal rate and the free-run frequency of the horizontal oscillator, the picture may be torn left or right (as shown in Symptoms of Some Common Deflection Problems or have multiple images superimposed horizontally. The situation where the picture is neatly split horizontally (which is what you might expect) is a special case where the frequencies are virtually the same. The key symptom common to all these is that there IS vertical lock (no blanking bar visible) AND there is no evidence that the deflection is even attempting to lock horizontally.

  This may mean that the horizontal sync signal is missing due to a bent, pushed in, or broken connector pin (pin 13) or other bad connection or a fault in the sync processing circuitry.

- Incorrect lock horizontal - torn picture (like a TV with the horizontal hold control misadjusted - if you remember these). This means that the sync signal is reaching the monitor but that it is having problem locking to it. Check the rate specifications - you may be exceeding them.

- Lack of sync vertical - rolls smoothly vertically. This may mean that the vertical sync signal is missing due to a bent, pushed in, or broken connector pin (pin 14) or other bad connection or a fault in the sync processing circuitry.

- Lock not stable vertical - jumps or vibrates vertically. This may be due to scan rate problems or a fault in the vertical sync circuitry of the monitor.

- Multiple or repeated images horizontally or vertically. There may be multiple images side-by-side, on top of each other, or interleaved. Most likely cause is driving the monitor with an incorrect scan rate. However, faulty circuitry could also be to blame.

Additional comments on some of these problems follow in the next few sections.

Horizontal lock lost

A monitor which loses horizontal lock when changing resolutions, momentarily losing the signal, or switching inputs may have a horizontal oscillator that is way out of adjustment or has drifted in frequency due to aging components. Alternatively, you may be running at scan rates that are not supported by your monitor. Check its user manual (yeh, right, like you have it!). Use the setup program that came with your video card to adjust the default scan rates to match the monitor. Not only will it lock better, you are less likely to damage the monitor by feeding it improper scan rates.

Note that the characteristics of this are distinctly different than for total loss of sync. In the latter case, the picture will drift sideways and/or up and down while with an off frequency oscillator, the torn up picture will try at least to remain stationary.

Assuming you are have your video card set up properly - double check anyhow - this could be a capacitor or other similar part. Or, the oscillator frequency may just need to be tweaked (particularly with older monitors). There may be an internal horizontal frequency adjustment - either a pot or a coil - which may need a slight tweak. If a coil, use a plastic alignment tool, not metal to avoid cracking the fragile core. There may be several adjustments for auto-scan monitors - one for each major scan range.

A schematic will be useful to locate the adjustment if any or to identify possible defective parts. If it is a heat related problem try cold spray or a heat gun in an effort localize the offending part.

Insufficient width (without hum bars)

If there are hum bars or wiggles in the picture, see the section: Reduced width picture and/or hum bars in picture.

If both width and height are affected, the cause is likely something common: low, low voltage power supply voltages or excessive high voltage (resulting in a 'stiffer' beam).

(From: Jerry G. (jerryg@total.net).)

Lack of width is usually caused by defective power supply, low horizontal drive to the yoke and flyback, defective circuits in the pincushioning amplifier section, excessive high-voltage caused by defective voltage regulation, and or excessive loading on the secondary side of the flyback.

Loss of horizontal sync (also applies to vertical) after warmup

The problem lies either in the horizontal oscillator or in the sync system. If it really is a problem with sync pulses not reaching the oscillator, the picture will move around horizontally and can be brought to hold momentarily with the hold control. If the picture breaks up into strips, there is a problem in the horizontal oscillator. If there is an accessible hold control try rotating it: if the frequency is too far off, the picture will not settle into place at any adjustment of the hold control. Look around the horizontal oscillator circuit: all of the oscillator parts will be right there, or check on the horizontal oscillator module. If only one resolution on a auto-scan monitor is affected, the there could be a separate oscillator circuit for each range.

Replicated or offset multiple images

Multiple images on the screen horizontally or vertically indicate that the scan rate is way off (by a factor equal to the number of complete pictures.) This could be a fault in the monitor or you could be running way outside of the monitor's specifications. Even slightly exceeding these for the horizontal or vertical may confuse the scan rate selection logic and result in the monitor setting itself with incorrect scan rate settings.

A situation where successive sweeps alternate position slightly resulting in double or triple images may be caused by a incorrect or out of range video timing, a bad component, or improper sync signals.

Check the settings of the video card and any sync termination or selection on the monitor. Beyond this, a schematic will be required.

Part of picture cut off

The following applies if the part of the picture is missing but not otherwise squashed or distorted. For example, 85% is missing but the portion still visible is normal size.

Wow! That's an interesting one, more so than the typical run-of-the-mill "my TV just up and died on me". Or, "my pet orangutan just put a hole in the CRT, what should I do"?

With a monitor, this is more likely than a TV. But the cause is probably not in the monitor (though not impossible). Check that your video parameters are set up correctly (particularly if you have full control of them as with Linux). You may have set the active too short or blanking too long.

If your video is confirmed to be OK (looking at it with an oscilloscope would be best), then with the size of the picture fragment correct but 85% missing, check waveforms going into the vertical output stage. The supply voltage is probably correct since that often determines the size. It almost sounds like the waveform rather than being mostly on (active video) and off for the short blanking period is somehow only on during the last part of the active video thus giving you just the bottom of the picture. If there is a vertical output IC, it may be defective or the blanking input to it may be corrupted. The problem may be as far back as the sync separator. Then again who knows, schematics would be really handy.

Bright or dark bars on edge of picture (horizontal or vertical)

These may be sharp-edged or blurry. The latter could result when a portion of the active video is unblanked during retrace.

- Where the entire picture is present, the problem is one of the video blanking not occurring properly beyond the picture boundary.

- Where part of the picture is cut off with a bright horizontal or vertical line at that point, it is either a video timing problem or a fault in the deflection circuitry preventing the beam from being where it is supposed to scan in enough time.

  You may be seeing part of the active video during retrace or as the beam reverses direction at the start or end of retrace. Horizontal timing problems would produce vertical bars on the right or left edge; vertical timing problems would produce horizontal bars at the top or bottom edge.

- If your video card permits control of video timing parameters, try reducing the relevant active time relative to the blanking period. The relevant software settings might be horizontal position, phase, size, and sync polarity. If this does not work, your video card may be incompatible with the monitor.

- If the problem just happened without any changes to the video source, the monitor may have a problem:

  - Deflection circuits - coil or capacitor, a power supply fault, position or size settings or control, or deflection yoke.

  - Video amplifier or drive (CRT neck board), or blanking circuits - chip decoupling capacitors or filter capacitors in scan derived power supplies. If the bars are significantly colored - not just shades of gray - then a video problem is likely.

An oscilloscope would help greatly in identifying the source of the problem.

Single Vertical Line

CAUTION: To prevent damage to the CRT phosphors, immediately turn down the brightness so the line is just barely visible. If the user controls do not have enough range, you will have to locate and adjust the master brightness or screen/G2 pots.

Since you have high voltage, the horizontal deflection circuits are almost certainly working (unless there is a separate high voltage power supply - almost unheard of in modern TVs but possible in some higher performance monitors).

Check for bad solder connections between the main board and the deflection yoke. Could also be a bad horizontal coil in the yoke, linearity coil, etc. There is not that much to go bad based on these symptoms assuming the high voltage and the horizontal deflection use the same flyback. It is almost certainly not an IC or transistor that is bad.

Single Horizontal Line

CAUTION: To prevent damage to the CRT phosphors, immediately turn down the brightness so the line is just barely visible. If the user controls do not have enough range, you will have to locate and adjust the master brightness or screen/G2 pots.

A single horizontal line means that you have lost vertical deflection. High voltage is most likely fine since there is something on the screen.

This could be due to:

1. Dirty service switch contacts. There is often a small switch on the located inside on the main board or perhaps accessible from the back. This is used during setup to set the color background levels. When flipped to the 'service' position, it kills vertical deflection and video to the CRT. If the switch somehow changed position or got dirty or corroded contacts, you will have this symptom. Flip the switch back and forth a couple of times. If there is some change, then replace, clean, resolder, or even bypass it as appropriate.

2. Bad connection to deflection yoke or other parts in vertical output circuit. Bad connections are common in TVs and monitors. Check around the pins of large components like transformers, power transistors and resistors, or connectors for hairline cracks in the solder. Reseat internal connectors. Check particularly around the connector to the deflection yoke on the CRT.

3. Bad vertical deflection IC or transistor. You will probably need the service manual for this and the following. However, if the vertical deflection is done with an IC, the ECG Semiconductor Master Substitution guide may have its pinout which may be enough to test it with a scope.

4. Other bad parts in vertical deflection circuit though there are not that many parts that would kill the deflection entirely.

5. Loss of power to vertical deflection circuits. Check for blown fusable resistors/fuses and bad connections.

6. Loss of vertical oscillator or vertical drive signals.

The most likely possibilities are in the deflection output stage or bad connections to the yoke. To locate the vertical output circuitry without a service manual, trace back from the deflection yoke connector. The vertical coils will be the ones with the higher resistance if they are not marked.

Intermittent jumping or jittering of picture or other random behavior

This has all the classic symptoms of a loose connection internal to the TV or monitor - probably where the deflection yoke plugs into the main PCB or at the base of the flyback transformer. TVs and monitors are notorious for both poor quality soldering and bad connections near high wattage components which just develop over time from temperature cycling. The problem may happen any time or more when cold or hot.

The following is not very scientific, but it works: Have you tried whacking the monitor when this happened and did it have any effect? If yes, this would be further confirmation of loose connections.

What you need to do is examine the solder connections on the PCBs in the monitor, particularly in the area of the deflection circuits and power supply. Look for hairline cracks between the solder and the component pins - mostly the fat pins of transformers, connectors, and high wattage resistors. Any that are found will need to be reflowed with a medium wattage (like 40W) or temperature controlled soldering iron.

It could also be a component momentarily breaking down in the power supply or deflection circuits.

Another possibility is that there is arcing or corona as a result of humid weather. This could trigger the power supply to shut down perhaps with a squeak, but there would probably be additional symptoms including possibly partial loss of brightness or focus before it shut down. You may also hear a sizzling sound accompanied by noise or snow in the picture, static in the sounds, and/or a smell of ozone.

If your AC power fluctuates, an inexpensive monitor may not be well enough regulated and may pass the fluctuations on as jitter. The video card is unlikely to be the cause of this jitter unless it correlates with computer (software) activity.

Horizontal output transistors keep blowing (or excessively hot)

Unfortunately, these sorts of problems are often difficult to definitively diagnose and repair and will often involve expensive component swapping.

You have just replaced an obviously blown (shorted) horizontal output transistor (HOT) and an hour (or a minute) later the same symptoms appear. Or, you notice that the new HOT is hotter than expected:

Would the next logical step be a new flyback (LOPT)? Not necessarily.

If the monitor performed normally until it died, there are other possible causes. However, it could be the flyback failing under load or when it warms up. I would expect some warning though - like the picture shrinks for a few seconds before the poof.

Other possible causes:

1. Improper drive to horizontal output transistor (HOT). A weak drive might cause the HOT to turn on or (more likely) shut off too slowly (greatly increasing heat dissipation. Check driver and HOT base circuit components. Dried up capacitors, open resistors or chokes, bad connections, or a driver transformer with shorted windings or a loose or broken core can all affect drive waveforms.

2. Excessive voltage on HOT collector - check LV regulator (and line voltage if this is a field repair), if any.

3. Defective safety capacitors or damper diode around HOT. (Though this usually results in instant destruction with little heating).

4. New transistor not mounted properly to heat sink - probably needs mica washer and heat sink compound.

5. Replacement transistor not correct or inferior cross reference. Sometimes, the horizontal deflection is designed based on the quirks of a particular transistor. Substitutes may not work reliably.

6. CRT shorting internally. If this happens only once in two weeks, it may be diffuclt to track down :-(.

The HOT should not run hot if properly mounted to the heat sink (using heatsink compound). It should not be too hot to touch (CAREFUL - don't touch with power on - it is at over a hundred volts with nasty multihundred volt spikes and line connected - discharge power supply filter caps first after unplugging). If it is scorching hot after a few minutes, then you need to check the other possibilities.

However, it is possible that the deflection circuit is just poorly designed in the first place and it has always run hot (though it is unlikely to have always been scorching hot). There is no way to know for sure without a complete analysis of the circuit - not something that is a realistic possibility. In this case, the addition of a small fan may make a big difference in HOT survival. If you have it mounted on the case blowing on the HOT, add a filter to minimize dust infiltration.

It is also possible that a defective flyback - perhaps one shorted turn - would not cause an immediate failure and only affect the picture slightly. This would be unusual, however. See the section: Testing of flyback (LOPT) transformers.

Note that running the monitor with a series light bulb may allow the HOT to survive long enough for you to gather some of the information needed to identify the bad component.

Horizontal output transistors blowing at random intervals

The HOT may last a few minutes, days, months or years but then blow again.

These are among the hardest problems to locate. It could even be some peculiar combination of user cockpit error - customer abuse - that you will never identify. Yes, this should not happen with a properly designed monitor.

However, a combination of mode switching, loss of sync during bootup, running on the edge of acceptable scan rates, and frequent power cycles, could test the monitor in ways never dreamed of by the designers. It may take only one scan line that is too long to blow the HOT. Newer horizontal processor chips are quite smart about preventing HOT killing signals from reaching the horizontal driver but they may not be perfect.

On the other hand, the cause may be along the lines of those listed in the section: Horizontal output transistors keep blowing (or excessively hot) and just not as obvious - blowing in a few days or weeks instead of a few seconds but in this case, the HOT will likely be running very hot even after only a few minutes.

Another possible cause for random failures of the HOT are bad solder connections in the vicinity of the flyback and HOT (very common due to the large hot high power components) as well as the horizontal driver and even possibly the sync and horizontal oscillator circuits, power supply, or elsewhere.

Steve's comments on HOT replacement

(From: Steve Bell (service@bell-electronics.freeserve.co.uk).)

A HOT can fail on its own, but to save possibly having to change it again, I always check the following:

If there is an electrolytic capacitor in the base circuit, check it with an ESR meter. If you don't have one, change it, they are cheap. Check the tuning capacitor on the HOT collector for low value or open circuit. These are low value and fairly critical, a capacitance meter is ideal. If you don't have one, a crude way to check is to use an analogue meter on x100 ohms and watch the needle kick as the cap charges and compare to another cap same value. Follow the HOT collector to the FBT, then from the FBT to a B+ regulator circuit if used. These often use a T0220 style FET or power transistor, check for shorts. Locate the B+ filter cap on the feed from the regulate to the FBT. Look for bulges and check with ESR meter. These caps are typically 22 - 100 uF, 160 or 200V. Also visibly check the FBT for bulges or splits. The only way to be sure the FBT is OK is to check with a FBT tester/ringer or similar test equipment. Generally FBT's in monitors are quite reliable. This might sound like a lot to do, but when familiar with the circuitry it doesn't take long.

You could of course just change the HOT and all will be OK.

Vertical foldover

The picture is squashed vertically and a part of it may be flipped over and distorted.

This usually indicates a fault in the vertical output circuit. If it uses an IC for this, then the chip could be bad. It could also be a bad capacitor or other component in this circuit. It is probably caused by a fault in the flyback portion of the vertical deflection circuit - a charge pump that generates a high voltage spike to return the beam to the top of the screen.

Test components in the vertical output stage or substitute for good ones.

Jagged or uneven vertical sweep

(From: Matthias Meerwein (Matthias.Meerwein@rt.bosch.de).)

I recently fixed two CRT display devices that both developed a very similar problem: The vertical deflection was severely "jagged" with uneven line spacing and partial vertical foldover. One patient was a nameless el-cheapo 28-inch TV (1988 made), the other one a 14 inch ADI SVGA monitor (1991 vintage).

My first suspicions were bad contacts on the PCB or yoke connectors or isolation / connectivity problems inside the yoke. However, as the picture didn't change with warmup or tapping, those causes could be ruled out. Examining the vertical deflection waveform with the scope showed the problem being a parasitic high frequency oscillation around the vertical output ic. On the TV, the oscillation extended over the entire scan period, while the monitor exhibited the problem only near the vertical current zero cross.

In both cases I found the capacitor of the RC damping network on the amp output to be at fault. Replacing it fixed the problem in both sets. This is not the well-known dried-up-electrolytic problem described in the FAQ. The culprits were mylar caps (.1 and .47 uF) looking completely unsuspicious. They were probably a bit underrated voltage-wise (40 volts) so I replaced them with 100 volts rated ones. The 2.2 ohms resistor in series with the cap was fine in both cases.

Excessive width/pincushioning problems

This would mean that the left and right sides of the picture are 'bowed' and the screen looks something like the diagram below (or the opposite - barrel distortion).

However, the obvious symptoms may just be excess width as the curved sides may be cut off by the CRT bezel.

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This geometry is the natural state of affairs with linear scan waveforms if there were no correction. Normally, a signal from the vertical deflection that looks something like a rectified sinewave is used to modify width based on vertical position. There is usually a control to adjust the magnitude of this signal and also often, its phase. It would seem that this circuit has ceased to function.

If you have the schematics, check them for 'pincushion' adjustments and check signals and voltages. If not, try to find the 'pincushion' magnitude and phase adjustments and look for bad parts or bad connections in in the general area. Even if there are no adjustment pots, there may still be pincushion correction circuitry.

If the pincushion controls have absolutely no effect, then the circuit is faulty. With modern digital setup adjustments, then it is even tougher to diagnose since these control a D/A somewhere linked via a microprocessor.

Pincushion adjustment adds a signal to the horizontal deflection to compensate for the geometry of the CRT/deflection yoke. If you have knobs, then tracing the circuitry may be possible. With luck, you have a bad part that can be identified with an ohmmeter - shorted or open. For example, if the pincushion correction driver transistor is shorted, it will have no effect and the picture will be too wide and distorted as shown above.

However, without a schematic even this will be difficult. If the adjustments are digital this is especially difficult to diagnose since you don't even have any idea of where the circuitry would be located.

Faulty capacitors in the horizontal deflection power supplies often cause a similar set of symptoms.

Uncorrectable pincushion distortion with new monitor

> "I just bought a new Sony 200SX 17" monitor and I just can't get the pin-cushion control to work right. If I get the outer edges straight then any window an inch or so from the edge will curve like crazy. The only way around this is to shrink my screen size so I'll have 3/4 in or so of black space. This is very irritating since I am not getting the 15.9" viewable size as advertised. Is this normal?"

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The distortion that you describe is called 'inside pincushion'. Normally it can be corrected by a dynamic S-correction circuit. Maybe Sony didn't do a too good job on this, or none at all. It may also be that the correction is optimized for certain horizontal scan frequencies only, as dynamic S-correction is a resonant circuit. You might want to test at another frequency.

(From: markmtf@earthlink.net).)

You may have a monitor that is at the edge of the acceptance tolerance, (which is a defined acceptable variation for cost and production yield reasons). A typical worse case tolerance may be up to 3mm of a deviation from a straight line for the edges. This applies for all monitors and all manufacturers. Of course some companies actually control the variation better than others, (and some just say they do).

For reference; try using the "Recall" function which will set the adjustments to the original factory settings. (This assumes that your video timing matches the preset timing used in the factory). Check the infamous user manual.

Deflection yoke testing

A faulty deflection yoke can affect the geometry (size and shape) of the raster, result in insufficient high voltage and/or other auxiliary power problems, and blow various components in the low voltage power supply or elsewhere.

- A simple test to determine if the yoke is at fault for a major geometry problem (e.g., a keystone shaped picture) is to interchange the connections to the yoke for the axis that is not affected (i.e., the vertical coils if the width is varying from top to bottom). If the raster/picture flips (indicating that you swapped the proper connections) but the shape of the raster remains the same - the geometry is unchanged, the problem is almost certainly in the deflection yoke.

- Where high voltage (and other flyback derived voltages) are reduced and other problems have been ruled out, unplugging the deflection yoke (assuming no interlock) may reveal whether it is likely at fault. If this results in high voltage and a relatively clean deflection waveform or returns the power supply or deflection chip load to something reasonable, a defective yoke is quite possible.

  CAUTION: powering a TV or monitor with a disconnected yoke must be done with care for several reasons:

  - The CRT electron beam(s) will not be deflected. If it turns out that the yoke is the problem, this may result in a very bright spot in the center of the screen (which will turn into a very dark permanent spot quite quickly) :-(. Disconnecting only the winding that is suspect is better. Then, the other direction will still scan resulting in a very bright line instead of a super bright spot. In any case, make sure the brightness is turned all the way down (using the screen/G2 control on the flyback if necessary). Keep an eye on the front of the screen ready to kill power at the first sign of a spot or line. Disconnecting the CRT heater as an added precaution would be even better unless you need to determine if there is a beam.

  - Removing the yoke (which is effectively in parallel with the flyback) increases the inductance and the peak flyback voltage on the HOT. In the extreme, this may blow the HOT if run at full line voltage/normal B+. It is better to perform these tests using a Variac at reduced line voltage if possible.

  - The deflection system will be detuned since the yoke inductance plays a very significant role in setting the resonance point in most designs. Don't expect to see totally normal behavior with respect to high voltage. However, it should be much better than with the faulty yoke.

- If possible, compare all measurements with a known good identical deflection yoke. Of course, if you have one, swapping is the fastest surest test of all! In many cases, even a not quite identical yoke will be close enough to provide useful information for testing. However, it must be from a similar piece of equipment with similar specifications - size and scan range. Don't expect a color TV yoke to work in a high performance SVGA monitor!

Note: the substitute yoke doesn't have to be mounted on the CRT which would disturb purity and convergence adjustments but see the caution above about drilling holes in the CRT face plate!

The deflection yoke consists of the horizontal coils and vertical coils (wound on a ferrite core), and mounting structure. Little magnets or rubber/ferrite strips may be glued in strategic locations. DO NOT disturb them! In rare instances, there may be additional coils or other components mounted on the same assembly. The following deals only with the actual deflection coils themselves - the other components (if any) can be tested in a similar manner.

Where the test procedure below requires removal of the yoke, see the section: Removing and replacing the deflection yoke first.

- Horizontal - the horizontal section consists of an even number of windings hooked up in parallel/interleaved with half of the windings on each of the two ferrite core pieces.

  The horizontal windings will be oriented with the coil's axis vertical and mounted on the inside of the yoke (against the CRT neck/funnel). They may be wound with thicker wire than that used for the vertical windings.

  - Resistance check - This may be possible without removing the yoke from the CRT if the terminal block is accessible. Disconnect the individual windings from each other and determine if the resistances are nearly equal. Check for shorts between windings and between the horizontal and vertical windings as well.

    Typical resistance of the intact windings (at the yoke connector assuming no other components): TV or NTSC/PAL monitor - a few ohms (3 ohms typical), SVGA monitor - less than an ohm (.5 ohms typical).

  - Inspection - Look for charring or other evidence of insulation breakdown due to arcing or overheating. For the horizontal windings, this will require removing the yoke from the CRT since little if any of the windings are visible from the outside. However, even then, most of the windings are hidden under layers of wire or behind the ferrite core.

  - Ring test. See the document "Testing of Flyback (LOPT) Transformers". This deals with flyback transformers but the principles are the same. Disconnecting the windings may help isolate the location of a fault. However, for windings wound on the same core, the inductive coupling will result in a short anywhere on that core reducing the Q.

- Vertical - The vertical section is usually manufactured as a pair of windings wired in parallel (or maybe in series) though for high vertical scan rate monitors, multiple parallel/interleaved windings are also possible.

  The vertical windings will be oriented with the coil's axis horizontal and wound on the outside of the yoke. The wire used for the vertical windings may be thinner than that used for the horizontal windings.

  - Resistance check - This may be possible without removing the yoke from the CRT if the terminal block is accessible. Disconnect the individual windings from each other and determine if the resistances are nearly equal. Check for shorts between windings and between the horizontal and vertical windings as well.

    Typical resistance of the intact windings (at the yoke connector assuming no other components): TV or NTSC/PAL monitor - more than 10 ohms (15 ohms typical), SVGA monitor - at least a few ohms (5 ohms typical).

  - Inspection - Look for charring or other evidence of insulation breakdown due to arcing or overheating.

The accessible portions of the vertical windings are mostly visible without removing the yoke from the CRT. However, most of the windings are hidden under layers of wire or behind the ferrite core.

- Ring test - Since the vertical windings have significant resistance and very low Q, a ring test may be of limited value.

Deflection yoke repair

So you found a big black charred area in/on one of the yoke windings. What can be done? Is it possible to repair it? What about using it for testing to confirm that there are no other problems before ordering a new yoke?

If the damage is minor - only a few wires are involved, it may be possible to separate them from each other and the rest of the winding, thoroughly clean the area, and then insulate the wires with high temperature varnish. Then, check the resistances of each of the parallel/interleaved windings to make sure that you caught all the damage.

Simple plastic electrical tape can probably be used for as insulation for testing purposes - it has worked for me - but would not likely survive very long as a permanent repair due to the possible high temperatures involved. A new yoke will almost certainly be needed.

Testing of flyback (LOPT) transformers

How and why do flyback transformers fail?

Flybacks fail in several ways:

1. Overheating leading to cracks in the plastic and external arcing. These can often be fixed by cleaning and coating with multiple layers of high voltage sealer, corona dope, or even plastic electrical tape (as a temporary repair in a pinch).

2. Cracked or otherwise damaged core will effect the flyback characteristics to the point where it may not work correctly or even blow the horizontal output transistor.

3. Internal shorts in the FOCUS/SCREEN divider network, if present. One sign of this may be arcover of the FOCUS or SCREEN sparkgaps on the PCB on the neck of the CRT.

4. Internal short circuits in the windings.

5. Open windings.

More than one of these may apply in any given case.

First, perform a careful visual inspection with power off. Look for cracks, bulging or melted plastic, and discoloration, Look for bad solder connections at the pins of the flyback as well. If the TV or monitor can be powered safely, check for arcing or corona around the flyback and in its vicinity,

Next, perform ohmmeter tests for obvious short circuits between windings, much reduced winding resistances, and open windings.

For the low voltage windings, service manuals may provide the expected DC resistance (SAMs PhotoFact, for example). Sometimes, this will change enough to be detected - if you have an ohmmeter with a low enough scale. These are usually a fraction of an ohm. It is difficult or impossible to measure the DC resistance of the HV winding since the rectifiers are usually built in. The value is not published either.

Caution: make sure you have the TV or monitor unplugged and confirm that the main filter capacitor is discharged before touching anything! If you are going to remove or touch the CRT HV, focus, or screen wires, discharge the HV first using a well insulated high value resistor (e.g., several M ohms, 5 W) to the CRT ground strap (NOT signal ground. See the section: Safe discharging of capacitors in TVs and video monitors.

Partially short circuited windings (perhaps, just a couple of turns) and sometimes shorts in the focus/screen divider will drastically lower the Q and increase the load the flyback puts on its driving source with no outputs connected. Commercial flyback testers measure the Q by monitoring the decay time of a resonant circuit formed by a capacitor and a winding on the flyback under test after it is excited by a pulse waveform. It is possible to easily construct testers that perform a well. See the companion document "Testing of Flyback (LOPT) Transformers" for further information.

Picture size suddenly becomes larger (or smaller)

You are playing your favorite game (read: addiction) and suddenly, the picture size increases by 20% and the brightness may have changed as well. What part should I replace? I only used my phasers on the #3 setting!

Unfortunately, I do not have a crystal ball. There are a number of parts that could be faulty and no way of know for your monitor and your symptoms which it is. Sorry, you will almost certainly have to have it professionally repaired or replaced.

What it sounds like is happening is that the circuitry that selects internal components depending on scan rate have failed in some way. They could be making an incorrect selection or the power supply could be faulty and applying an incorrect voltage to the horizontal and vertical deflection circuits. The brightness changes since it is not compensated for properly.

Burning up of various size or centering resistors

Check the capacitors that couple the yoke to to ground. If they become reduced in value or develop a high ESR, the current will be diverted to other components with unfortunate and rapid consequences.

Picture shifted horizontally

The first thing to determine is if this is a position or phase problem:

- A fault with horizontal position means that the entire raster is shifted left or right. This is almost certainly a monitor problem. If you turn up the brightness control, the edges of the scan lines will probably be visible on one side.

    - Assuming the position or centering controls do not work at or or have insufficient range, check for a defective centering pot and bad centering diodes and other components in their vicinity. If digitally controlled, you will probably need a schematic to find the cause.

    - If the monitor was dropped, the yoke or other assembly on the CRT neck may have shifted (though there would probably be other symptoms as well).

    - Monochrome monitors have centering rings on the CRT neck which may have be knocked out of adjustment. Color monitors adjust the centering electronically since magnetic rings would mess up the purity and/or convergence.

- A fault with horizontal phase means that the raster is still centered on the screen but the picture itself is shifted (and may have some wrap-around) within the raster. This could be a fault in the monitor or video card or incorrect settings in the software setup for the video card.

    - If this happened while trying out this monitor on a different or modified computer, just after you have done a software upgrade, or just after something strange happened (like your PC's CMOS settings got corrupted - monitor settings are generally not in the CMOS setup but may have been affected at the same time), reset the monitor's controls to their default or middle position and then use the software setup or install program that came with your video card to set scan rates, size, position, and sync polarity.

    - Some monitors have a user accessible horizontal phase control in addition to horizontal position. This adjusts the delay in the sync circuits so check that area of the electronics if the control doesn't work or have enough range.

- There could also be a problem with base drive to the HOT. This may result in position, phase, size, and linearity errors as the scan being initiated too soon or too late.

    - Weak drive to the HOT due to faulty components in the base circuit or driver stage might result in the HOT coming out of saturation early. The picture would be shifted to the right and the HOT might run excessively hot and blow.

      WARNING: The case of the HOT has >1,000 V spikes and B+ when off - don't touch with power on or until you confirm no voltage is present after pulling plug.

    - If marginal, a drift of position, phase, size, and linearity with warmup is also likely. Check for dried up electrolytic capacitors and use cold spray to isolate other bad components. If the drive becomes too weak, the HOT may blow after after being on for a while.

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High Voltage Power Supply Problems

Identifying HV voltage problems

In addition to the obvious "monitor screen is as black as a coal mine" symptom, problems in the high voltage power supply can result in a variety of brightness, raster geometry, and other picture problems as well as arcing, corona, or other sights, sounds, and smells not normally associated with a properly functioning monitor. This chapter deals with some of these. Other video related problems will be dealt with in the chapter: "Raster, Color, and Video Problems".

High voltage power supply fundamentals

Most, monitors derive the high voltage for the CRT second anode (THE high voltage, focus, and (sometimes) screen (G2) from the horizontal deflection system. This technique was developed quite early in the history of commercial TV and has stuck for a very simple reason - it is very cost effective. A side effect is that if the horizontal deflection fails and threatens to burn a (vertical) line into the CRT phosphors, the high voltage dies as well. Of course, if the vertical deflection dies....

Some auto-scan monitors utilize a separate high voltage supply. One reason for this approach is to decouple the horizontal deflection from the HV in auto-scan monitors thus simplifying the design.

Usually it is a self contained inverter module. It if can be opened, then repair may be possible. With a separate HV supply, there is no need for a HV flyback transformer on the mainboard. Some designs may use a separate HV supply including a flyback which is part of the mainboard but is self contained and independent of the horizontal deflection system.

Most TV and monitor (flyback) high voltage supplies operate as follows:

1. Horizontal output transistor (HOT) turns on during scan. Current increases linearly in primary of flyback transformer since it appears as an inductor. Magnetic field also increases linearly. Note: flyback is constructed with air gap in core. This makes it behave more like an inductor than transformer as far as the primary drive is concerned.

2. HOT shuts off at end of scan. Current decreases rapidly. Magnetic field collapses inductively coupling to secondary and generates HV pulse. Inductance and capacitance of flyback, snubber capacitors, and parasitic capacitance of circuitry and yoke form a resonant circuit. Ideally, voltage waveform across HOT during flyback (retrace) period will be a single half cycle and is clamped by damper diode across HOT to prevent undershoot.

3. Secondary of flyback is either a single large HV winding with HV rectifiers built in (most often) or an intermediate voltage winding and a voltage multiplier (see the section: What is a tripler?). The output will be DC HV pulses.

4. The capacitance of the CRT envelope provides the needed filtering to adequately smooth the HV pulses into a DC voltage. Sometimes there is a separate HV capacitor as well.

5. A high resistance voltage divider provides the several kV focus voltage and sometimes the several hundred volt screen (G2) voltage as well. Often, the adjustments for these voltages are built into the flyback. The focus and screen are generally the top and bottom knobs, respectively. Sometimes they are mounted separately. This or a similar divider may also provide feedback to control high voltage regulation.

What is a tripler?

In some TVs and monitors, the flyback transformer only generates about 6-10 kV AC which is then boosted by a capacitor-diode ladder to the 18-30 kV needed for modern color CRTs. The unit that does this is commonly called a tripler since it multiplies the flyback output by about 3 times. Some TVs use a quadrupler instead. However, many TVs and monitors generate the required HV directly with a winding with the required number of turns inside the flyback transformer.

Triplers use a diode-capacitor ladder to multiply the 6-10 kV AC to 18-30 kV DC. Many triplers are separate units, roughly cubical, and are not repairable. Some triplers are built in to the flyback - it is probably cheaper to manufacture the HV diodes and capacitors than to wind a direct high voltage secondary on the flyback core. In either case, failure requires replacement of the entire unit.

For external multipliers, the terminals are typically marked:

- IN - from flyback (6-10 kV AC).
- OUT - HV to CRT (20-30 kV DC).
- F - focus to CRT (2-8 kV).
- CTL - focus pot (many megohm to ground).
- G, GND, or COM - ground.

Symptoms of tripler failure are: lack of high voltage or insufficient high voltage, arcing at focus protection spark gap, incorrect focus voltage, other arcing, overload of HOT and/or flyback, or focus adjustment affecting brightness (screen) setting or vice-versa. Where there is overloading, if you disconnect the tripler and everything else comes back to life (obviously, there will be no HV or picture), then it is very likely bad.

High voltage shutdown due to X-ray protection circuits

A monitor that runs for a while or starts to come on but then shuts down may have a problem with the X-ray protection circuitry correctly or incorrectly determining that the high voltage (HV) is too great (risking excessive X-ray emission) and shutting everything down.

A side effect of activation of this circuitry is that resetting may require pulling the plug or turning off the real (hard) power switch.

Was there anything else unusual about the picture lately that would indicate an actual problem with the HV? For example, has it suddenly gotten brighter than normal or has the size decreased? If this is the case, then there may be some problem with the HV regulation. If not, the shutdown circuit may be overly sensitive or one of its components may be defective - a bad connection of leaky cap (or zener).

If the horizontal frequency is not correct (probably low) due to a faulty horizontal oscillator or sync circuit or bad horizontal hold control (should one exist!), HV may increase and trigger shutdown. Of course, the picture won't be worth much either! With a multiscan monitor, this could happen if the mode switching is faulty resulting in incorrect component settings for a given scan rate. A symptom might be HV shutdown when switching into scan ranges.

The HV shutdown circuit usually monitors a winding off of the flyback for voltage exceeding some reference and then sets a flip flop shutting the horizontal drive off.

On some Sony models, a HV resistive divider performs this function and these do fail - quite often. The red block is often called a 'HV capacitor' (but is technically the 'HSTAT' unit because it has a control for horizontal static convergence) and is a common cause of immediate or delayed shutdown on certain Sony monitors and TVs. With these failures, the HV doesn't become excessive but the sense voltage rises due to leakage with the voltage divider. See the section: Apple/Sony monitor dies after variable length of time.

Low or no high voltage

Most of these problems are due to faults in the horizontal deflection system - shorted HOT, shorted windings or HV rectifiers in the flyback, defective tripler, or other bad parts on the primary side of the flyback.

In addition, with auto-scan monitors, the incorrect voltage or other component could be selected due to a logic fault or a problem with the selection relay or other circuitry.

However, if you discover an inch layer of filth inside the monitor, the HV could simply be shorting out - clean it first.

In most cases, these sorts of faults will put an excessive load on the horizontal output circuits so there may be excessive heating of the HOT or other components. You may hear an audible arcing or sizzling sound from internal shorts in the flyback or tripler. Either of these may bet hot, crack, bulge, or exhibit visible damage if left on with the fault present.

Many modern monitors do not regulate HV directly but rather set it via control of the low voltage power supply to the HOT (B+), by snubber capacitors across the HOT, and the turns ratio of the flyback. The HV is directly related to the B+ so if this is low, the HV will be low as well. Faulty snubber capacitors will generally do the opposite - increase the

HV and the X-ray protection circuits may kick in. However, low HV is also a possibility. The only way the turns ratio of the flyback can change is from a short which will manifest its presence in other ways as well - excessive heating and load on the horizontal output circuits.

While a shorted second anode connection to the CRT is theoretically possible, this is quite unlikely (except, as noted, due to dirt).

Excessive high voltage

Any significant increase in HV should cause the X-ray protection circuits to kick in and either shut down the set or modify the deflection in such a way as to render it harmless.

Symptoms include arcing/sparking of HV, smaller than normal picture, and under certain scenarios, possible excessive brightness.

Causes of the HV being too high are:

1. Excess B+ voltage to the HOT. The likely cause is to a low voltage regulator failure.

2. Open snubber capacitors across the HOT. These are under a lot of stress and are located near hot components so failure is possible.

3. Incorrect excessively long scan drive to HOT caused by failure of horizontal oscillator/sync circuits. However, other things like the HOT will probably blow up first. The picture will definitely be messed up. This is more likely with auto-scan monitors than TVs since what is too long for one scan range may be correct for another and the selection circuitry is confused or broken.

4. Failure of HV regulator. Actual HV regulators are uncommon today but the HV may controlled by a feedback voltage from a divider (focus or screen, or its own) or a secondary winding on the flyback setting the B+ or drive timing. This may result in an underscanned (smaller than normal) picture if only the HV and not the deflection voltages as well are derived from the same supply.

In one example of (4), a arcing of the HV in a Conrac studio monitor resulted in the destruction of the HV switchmode inverter transistor (this used a separate HV supply) and a fusable resistor. The cause was an open HV feedback resistor divider allowing the HV to increase drastically.

Snaps, crackles, and other HV breakdown

Various problems can result in occasional or sustained sparking or arcing sounds from inside the monitor. Note that a static electricity buildup is common on the front of the screen. It is harmless and there iss nothing you can do about it anyhow.

The following may result in occasional or sustained sounds not commonly associated with a properly working TV or monitor. There may or may not be flashes or blanking of the screen at the same time as the audible noise. See the same-named sections that follow for details.

- Arcing, sparking, or corona from CRT HV anode (red wire/suction cup).
- Arcing at CRT sparkgaps.
- Arcing from flyback or vicinity.
- Arcing due to bad connections to or disconnected CRT return.
- Flashovers inside the CRT.

Arcing, sparking, or corona from CRT HV anode (red wire/suction cup)

Symptoms could include a sizzling corona or more likely, an occasional or rapid series of sharp snaps - possibly quite loud and quite visible - from the anode cap on the CRT to the grounded coating on the outside of the CRT or a chassis ground point (or any other conductor nearby). Corona is a high resistance leakage through the air without total breakdown. The snapping is caused by the sudden and nearly complete discharge of the CRT anode capacitance through a low resistance ionized path similar to lightning.

There are two likely causes:

1. Dirt, dust, grime, around and under the suction cup on the CRT are providing a discharge path. This may be more severe in humid weather. Safely discharge the HV and then remove and thoroughly clean the HV suction cup and the area under it and on the CRT for several inches around the HV connection. Make sure there are no loose wires or other possible places for the HV to discharge to in the vicinity.

2. The high voltage has gone through the roof. Usually, the X-ray protection circuitry should kick in but it can fail. If cleaning does not help, this is a likely possibility. See the sections: High voltage shutdown due to X-ray protection circuits and Excessive high voltage.

Arcing at spark gaps and gas discharge tubes on CRT neck board or elsewhere

These are protective devices intended to breakdown and divert excessive voltage away from the CRT (usually).

This is rarely due to a defective sparkgap or gas discharge tube but rather is a safety mechanism like a fuse designed to protect the internal electrodes of the CRT if the focus or screen voltage should become excessive. The sparkgap breaks down first and prevents internal arcing in the CRT. These sparkgaps may be built into the CRT socket as well.

Arcing at a sparkgap or a glowing or flashing discharge tube may be accompanied by total loss of picture or bad focus, brightness or focus fluctuations, or any of a number of similar symptoms. A common cause is a breakdown inside the focus divider (usually part of the flyback or tripler) but could also be due to excessive uncontrolled high voltage due to a failure of the B+ regulator or HOT snubber capacitor, or (ironically) even a short inside the CRT.

- Spark gaps may be actual two or three pin devices with seemingly no insides, part of the CRT socket, or printed on the circuit board itself.

- Gas discharge tubes look like small neon lamps (e.g., NE2) but could be filled with some other gas mixture to provide a controlled higher breakdown voltage.

Therefore, like a fuse, don't just replace or disable these devices, locate and correct underlying problem. The CRT makes an expensive fuse!

Spark gaps and gas discharge bulbs on CRT neck board or elsewhere

These are protective devices intended to breakdown and divert excessive voltage away from the CRT (usually).

- Spark gaps may be actual two or three pin devices with seemingly no insides or printed on the circuit board itself.

- Gas discharge bulbs look like small neon lamps (e.g., NE2) but could be filled with some other gas mixture to provide a controlled higher breakdown voltage.

Arcing at a spark gap or a flashing or glowing gas discharge tube may indicate excessive high voltage, a short in the focus/screen divider network of the flyback, a short in the CRT, or some other fault resulting in abnormally high voltage on its terminals.

Arcing from flyback or vicinity

Arcing may be visible or audible and result in readily detectable levels of ozone. Note that very slight traces of ozone may not indicate anything significant but if the TV smells like an office copier, there is probably some discharge taking place.

WARNING: It is possible for arcing to develop as a result of excessive high voltage. Symptoms might be a smaller than normal excessively bright picture but this may not be able to be confirmed until the flyback is repaired or replaced. See the section: Excessive high voltage.

- On the HV output, it will probably be a loud snapping sound (due to the capacitance of the CRT) with associated blue/white sparks up to an inch or more in length. If the arc length is short enough, this may turn into a nearly continuous sizzling sound with yellow/orange arc and melting/burning plastic.

- Prior to the HV rectifier, it will likely be a continuous sizzle with orange/yellow/white arc and melting/burning plastic or circuit board material.

- Internal arcing in the flyback may be audible and eventually result in a bulging and/or cracked case (if some other component doesn't fail first as this would take some time to develop).

- A corona discharge without actual sparks or a visible well defined arc is also possible. This may be visible in a totally dark room, possibly more likely when the humidity is high. A thorough cleaning to remove all dust and grime may be all that is needed in this case.

- If the arc is coming from a specific point on the flyback - a crack or pinhole - this may be patched well enough to confirm that the rest of the monitor is operational and a new flyback is worth the money. Otherwise, there is no way of knowing if the arcing may have damaged other circuitry until a replacement flyback - possibly money wasted - arrives.

  To attempt a repair, scrape off any dirt or carbon that is present along the path of the arcing and its vicinity. Then, clean the area thoroughly with alcohol and dry completely. Otherwise, the dirt and carbon will just act as a good conductor and the arcing will continue under your repair! Several layers of plastic electrical tape may be adequate for testing. Multiple coats of high voltage sealer or non-corroding RTV silicone (if it smells like vinegar - acetic acid - as it cures, this may get in and affect the windings) would be better if the objective is an actual repair. A thick layer of Epoxy may be even better and affected less by possible HV corona. Either of these may prove to be a permanent fix although starting the search for a source for a new flyback would not hurt just in case. The arc most likely did damage the insulation internally which may or may not be a problem in the future.

  Also see the section: Dave's complete procedure for repair of an arcing flyback.

- In some cases, the pinhole or crack is an indication of a more serious problem - overheating due to shorted windings in the flyback or excessive secondary load.

- If the arc is from one of the sparkgaps around the CRT, the CRT socket, or the plastic 'alignment base' on the CRT itself, this could also be a flyback problem indicating internal shorts in the focus/screen network.

- If the arcing is inside the CRT, this could indicate a bad CRT or a problem with the flyback focus/screen network and no or inadequate sparkgap protection.

Where repair seems possible, first, clean the areas around the arc thoroughly and then try several layers of plastic electrical tape. If the TV works normally for say, an hour, then there is probably nothing else wrong and you can try for a proper sealing job or hope that tape holds out (put a few more layers on - each is good for about 8-10 kV theoretically).

Once I had a TV where the main problem was a cracked flyback arcing but this took out one of the fusable resistors for the power supply to the *vertical* output so the symptoms included a single horizontal line. Don't ask me to explain - replacing that resistor and the flyback (the flyback tested good, but this was for someone else) fixed the TV.

In another case, a pinhole developed in the flyback casing probably due to poor plastic molding at the time of manufacture. This resulted in a most spectacular case of sparking to a nearby bracket. A few layers of electrical tape was all that was needed to affect a permanent repair.

However, replacement is really the best long term solution both for reliability as well as fire risk.

(From: Bert Christensen (rosewood@interlog.com).)

It may well last a long time. The insulation breakdown was probably in the area of the rectifier section rather than the flyback section. I have repaired several units in the same way but I have generally replaced the flyback before sending back to the customer. I am worried that the repair will not hold and that a fire could start. I have no desire whatsoever to be sued by some fire insurance company.

I am always reminded by the experience that Zenith had with its System 3 chassis a few years ago. They burned and caused many house fires including one in the governor's mansion in Texas. Zenith spent mega bucks on that one. They also spent mega-bucks on their 'safety capacitor' mess a few years before that.

Dave's complete procedure for repair of an arcing flyback

(From: Dave Moore (penguin@datastar.net).

First I clean the afflicted area with Electromotive spray from Autozone. It's for cleaning alternators. On Z-line I remove the focus control and wash with the alternator cleaner and a tooth brush until all dirt and carbon deposits are removed. Then I take an xacto knife and carve out the carbonized hole where the arcing broke through. Then take your soldering iron and close the hole by melting adjacent plastic into it. (clean any solder off your iron with solder-wick first). Then cut some plastic off of some other part off the flyback where it wont be needed and use this to plastic weld (with your iron) a hump of a patch into and over the arc hole. Smooth and seal with iron. Next apply as thick a layer of silicone rubber as you can and let dry overnight.

Arcing due to bad connections to or disconnected CRT return

The Aquadag coating on the outside of the CRT is the negative plate of the HV filter capacitor. If this is not solidly connected to the HV return, you will have your 25 kV+ trying to go where it should not be. There should be a wire solidly attached to the CRT neck board or chassis. Without this, voltage will build up until it is able to take some other path - possibly resulting in damage to sensitive solid state components in the process. Therefore, is is important to rectify the situation.

Warning: If you find this disconnected, don't just attach it anywhere. You may instantly kill ICs or other solid state components. It must be connected to the proper return point on the CRT neck board or chassis.

Flashovers inside the CRT

Due to sharp edges on the electron gun electrodes, impurities, and other manufacturing defects, there can be occasional arcing internal to the CRT. Properly designed HV, deflection, and power supply circuits can deal with these without failing but not all monitors are designed well.

There is nothing you can do about flashovers assuming your HV is not excessive (see the section: Excessive high voltage. If these persist and/or become more frequent, a new CRT or new monitor will be needed.

Ozone smell and/or smoke from monitor

Smoking is just as bad for monitors as for people and usually more quickly terminal (no pun....).

White acrid smoke may indicate a failed electrolytic capacitor in the power supply probably in conjunction with a shorted rectifier. Needless to say, pull the plug at once.

A visual inspection should be able to easily confirm the bad capacitor as it will probably be bulging and have condensed residue nearby. Check the rectifier diodes or bridge rectifier with an ohmmeter. Resistance across any pair of leads should be more than a few ohms in at least one direction. Remove from the circuit to confirm. Both the faulty diode(s) and capacitor should be replaced (though the capacitor may work well enough to test with new diode(s).

If a visual inspection fails to identify the smoking part, you can probably plug the monitor in for a few seconds until the source of the smoke is obvious but be prepared to pull the plug in a real hurry.

If the smell/smoke is coming from the flyback, then it has probably gone belly up. You may be able to see a crack or bulge in the case. While the flyback will definitely need to be replaced, it is likely that nothing else is wrong. However, it might be prudent to use a Variac when performing initial testing with the replacement just in case there is a secondary short circuit or excess HV problem.

X-ray and other EM emission from my TV or monitor?

X-ray radiation is produced when a high velocity electron beam strikes a target containing heavy metals. In a modern TV or monitor, this can only take place at the shadow mask/aperture grille and phosphor screen of the CRT.

For X-rays, the amount of radiation (if any) will be proportional to brightness. The energy (determined by the CRT high voltage, called kVP in the medical imaging field) is not affected. This is one reason many monitors and TVs are designed with brightness limiting circuits.

In any case, there will be virtually no X-ray emissions from the front of the CRT as the glass is greater than an inch thick and probably contains some lead for added shielding. Also see the section: Should I be worried about X-ray exposure while servicing a TV or monitor?.

Electromagnetic radiation (EM) is produced mostly from the deflection yoke and to a lesser extent from some of the other magnetic components like transformers and inductors. Depending on monitor design (some are specifically designed to reduce this), EM emissions can vary quite a bit. Frequencies range from the 50/60 Hz of the power line or vertical scan rate to several hundred kHz in the AM broadcast band. The intensity and spectral distribution will vary depending on horizontal and vertical scan rate.

A totally black screen will reduce X-ray emission to zero. It will not affect EM emissions significantly as most of this comes from the magnetic parts, particularly the deflection yoke.

There is no measurable microwave, IR, or UV radiation.

I refuse to get into the discussion of what, if any, health problems result from low level EM emissions. There is simply not enough data.

Should I be worried about X-ray exposure while servicing a TV or monitor?

The only source of X-rays in a modern TV or monitor is from the CRT. X-rays are generated when a high velocity electron beam strikes a heavy metal target. For anything you are likely to encounter, this can only happen in a vacuum - thus inside the CRT. The higher the voltage, the greater the velocity and potential danger. Really old TVs (prior to around 1975) may still have HV rectifier and regulator tubes - other sources of X-rays. However, modern TVs and monitors implement these functions with solid state components.

The thick front CRT faceplate protects users adequately but there may be some emission from the thinner sides. At 25-30 kV (quite low as X-ray energies go) X-rays will be stopped by almost any metal so what you have to worry about is where there are no shields. In addition, the CRT glass usually contains some lead compounds to block X-ray emissions.

Other than lowering the brightness (or high voltage!), there isn't anything you can do to reduce X-ray emission from the front of the monitor. Any sort of add-on screen (grounded or otherwise) unless it is made of thick leaded glass, will have no significant effect on X-rays. If you are still concerned, sit farther away.

However, realistically, there is very little danger. I would not worry about exposure unless you plan to be sitting for hours on the sides, behind, or under the TV or monitor - with a picture (there will be none if the screen is black).

It is interesting that even those 1.5" Watchman and .5" camcorder viewfinder CRTs have X-ray warning labels even though the high voltage used with these isn't anywhere near high enough to be of any concern!

More on radiation from TVs and monitors

(From: Jerry Greenberg (jerryg50@hotmail.com).)

Your standard TV set or monitor should not exceed about 0.2 mR/Hr of radiation from a distance of 5 cm from any part of the cabinet. Most TV monitor equipment is less than half of this amount.

The CRT has a coating on the inner wall of its glass envelope, and also there is a metal shadow mask or aperture grill in the front. There is also a metal shroud around its parameter.

The type of emission from the CRT is known as soft X-Ray emission. This is because it is low power, and is in the lower X-Ray region.

The X-Ray emission is strongest at the rear of the TV set because there is some opened area where the electron gun is located. But, this is very weak as well. The radiation from a TV or monitor is not being focused to one point, and is also below the threshold level of being dangerous.

The long term effect of the total radiation from normal operating TV equipment is not fully known. However, the effect of X-Ray radiation is accumulative over time if there are no breaks in between the exposures. As for standard focused X-Rays like the ones used in a medical or security facility, these and most of their effects are well known.

As for normal working TV equipment, when used normally, the total radiation is less that what you would get when walking on the street. There are many satellites beaming down signals, radio and TV broadcast stations, communications systems, and then cell phones.

The X-Ray radiation in a TV set is emitted from the effect of the High Voltage drive generating the electron beam. If the High Voltage exceeds the designed safety limit for the CRT, then there is concern that the X-Ray radiation may have some effect on anyone that is in close proximity to the CRT. The amount of by which the high voltage exceeds the design specfifications will determine the total X-Ray emission. Since this emission is not focused into a fine area, its immediate danger is also greatly reduced.

All TV sets by law must have in their design some type of protection to shut the TV down if there is excessive High Voltage, excessive High Voltage current drive, and a number of other safety criterias.

There is also the concern about electromagnetic radiation. In fact all radio frequencies are based on electromagnetic radiation (EMR).

There was a great concern about the low frequency EMR. This would come from the power supply, deflection amplifier stages, and then from the deflection yoke and flyback transformer. There different types of EMR from TV sets.

Concerning TV's and monitors, this radiation worry comes up from time to time. If a woman is pregnant it would be wiser for her to not expose the unborn baby by working close to a terminal or monitor. This nonexposure is a good policy to make sure that everyone is safe rather than suffer any type of damage or health risks.

As for a safety concern for a mother to be, or a small baby, they can be in front of a TV set but at least 5 to 7 feet away. From this distance there should not be any danger at all.

The above is from my personal observations and is very general. I have also read various publications over the years that pertain to this subject.

I have a personal concern about the radiation from TV sets and monitors because I do an extensive amount of service on these. I am also doing a lot of picture tube changes in monitor equipment. I am then exposed for a few hours because I must do the purity and convergence setups of these sets. I have some days where I work 10 to 12 hours doing TV and monitor service work.

If you want a TV monitor that will put out near zero X-Ray radiation, and very low electromagnetic radiation, then go for one of the new LCD flatscreen monitors.

Flyback got wet

You put your can of Coke where????

Who says these FAQs cannot be funny?

Needless to say, unplug the monitor immediately. Inspect around the target area for obviously blown or damaged components. Test fuses and fusable resistors. Remove all traces of liquid - especially sugary or corrosive liquid. Use water first and then alcohol to promote drying. Repair burnt solder connections and circuit board traces. Once the monitor is entirely dried out, power it up - preferably through a series light bulb and/or Variac until you are sure nothing else will let loose. Look, listen, and smell for any unusual behavior. If it now works, then consider yourself lucky. If not, there may be damage to transistors, ICs, or other components.

Another cause of this is using spray cleaner or a too wet rag on the front of the CRT (other parts of the monitor, for that matter). Any liquid which drips inside (all too likely) may short out circuitry on the mainboard with very expensive consequences.

Blooming or breathing problems

There are several symptoms that are basically similar:

- Blooming is defined as an expansion of the raster or horizontal sections of the raster with bright material. For example, switching between dark and light picture causes the size of the picture to expand by 10%. A slight change in size is unavoidable but if it is greater than 1 or 2 percent from a totally black image to a full white one, this is either an indication of a defective monitor or one that is badly designed. The cause is poor low or high voltage regulation.

  Check the B+ to the horizontal deflection. This is usually well regulated. If it is varying in sympathy to the size changes, trace back to determine why the low voltage regulator is not doing its job. The reason for the size change is that the high voltage is dropping and reducing the stiffness of the electron beam.

- Expansion of the raster width in areas of bright imagery is an indication of short term regulation problems. The video drive may be interacting with the other power supplies. Check for ripple - this would be at the vertical scan rate - in the various regulated power supplies. The cause may be a dried up electrolytic capacitor - once you locate the offending voltage, test or substitute capacitors in that supply.

In both these cases, if this just started after some work was done to the monitor, the brightness limiter and/or video drive may simply be set so high that the monitor cannot supply enough current to the high voltage. If the brightness is acceptable with these turned down slightly and still have acceptable brightness, then there may be nothing wrong.

- Breathing is defined as a periodic change in the size of the raster which may be independent of what is displayed or its severity or frequency may be related to the brightness or darkness of the image. This is another type of regulation problem and may be caused by bad electrolytic capacitors or other components in the low voltage power supplies.

  If the monitor uses a switchmode power supply or low voltage regulator separate from the horizontal deflection, first check its output(s) for a variation in voltage at the breathing rate. Test with a light bulb or resistor load to confirm that the problem is here and not the deflection or remainder of the monitor.

- A condition with somewhat similar symptoms is bad focus - fuzzy picture - but only with bright (high beam current) scenes. This could be just a matter of adjusting the focus control but may also indicate sub-optimal filament voltage due to bad connections or components in the filament circuit, or a tired worn CRT. You won't get high beam current without some serious spot blooming (a fat beam because too much cathode area is used) and you will get cathode 'poisoning' after prolonged use.

  Visually inspect the neck of the CRT for the normal orange glow of the filaments and check for bad connections and bad parts.

Erratic focus or screen (G2) voltage and/or controls on flyback

Symptoms may include fluctuating focus or brightness. In extreme cases, the result may be a too bright or dark picture or other behavior caused by breakdown in the Focus/Screen(G2) divider network.

Usually, this will require flyback replacement to repair reliably. Sometimes, the section with the controls can be snapped apart and cleaned but this is not common.

First, just try rotating the screen (G2) control back and forth a few times. This may clean up the contacts and eliminate the erratic behavior. Possibly, positioning it a bit to one side of the original location will help. Then, use the individual or other master background/bias adjustments to compensate for the improper brightness.

If pressing in on the erratic control helps to stabilize the setting, you might try adjusting it to the optimal position and then put a dab of hot-melt glue (or Superglue if you can manage not to stick your fingers together) on the shaft to hold it with a little more contact force.

If none of this helps, here is a 'well it's going in the dumpster anyhow' procedure to try:

After discharging the CRT (so you don't get zapped) drill a tiny hole in the plastic cover near the bad control. Be careful you don't damage anything inside - you just want access to the contacts of the controls. Use a hand drill with, say, a 1/16" bit. Don't drill more than about 1/8" deep which should enter the airspace. Then spray some contact cleaner through the hole and work the controls. Wait sufficient time (say, 24 hours) for everything to dry COMPLETELY and see if behavior changes (or it works at all).

This is a 'you have got to be kidding' type of repair so no guarantees :-).

If by some miracle it does work, fill the hole with a drop of RTV or just put a couple of layers of electrical tape over it.

Focus/Screen divider bypass surgery

This is kludge number 41256 but may be the difference between a bit more life and the dumpster.

If the previous extreme measures don't help, then it may be possible to simply substitute a good divider network externally.

Note that if there is evidence of internal breakdown in the divider of the original flyback (hissing, cracks, overheating, bulging case, etc.), this will not work unless you can disconnect it from its HV connection.

There are two issues:

1. Is this a stable situation? Even if you provide an external substitute, the parts inside the flyback may continue to deteriorate eventually resulting in other more total failure of the flyback or worse.

2. If you provide an external focus/screen divider, it must be done is such a manner (including proper mounting and super insulation) such that it cannot be called into question should there be a fire where the monitor is even the slightest bit suspect.

Various size external focus/screen divider networks can be purchased but whether this is truly a cost effective solution is not obvious.

(From: Larry Sabo (sabo@storm.ca).)

I just ordered a 'bleeder resistor' from Data Display Ltd (Canadian sub of CCS) to use as a cure for flybacks with flaky focus/screen pots. It contains focus and screen pots, and costs Cdn$ 16.99, which is a lot less than a complete flyback, that's for sure. I expect it will be compatible with quite a wide range of flybacks.

I have used bleeder resistor assemblies from duff flybacks a couple of times with good success. You connect the HV lead into the HV cap of the original flyback, ground all pins of the sub flyback, and use the focus and screen leads from the sub bleeder assembly in place of the originals.

Looks like hell but works fine. Mounting (and securing) the substitute is a challenge given the limited space available. I only use this approach on what would otherwise be uneconomical to repair, and always advise the owner or customer of the cobbling job. It also enables you to verify whether it is the flyback that needs replacement, versus the CRT.

Decaying or erratic focus or screen (G2) voltages

The following applies to both CRT focus voltage (which should be a few kV) and screen or G2 voltage (which should be several hundred V).

> "The screen voltage will come up to normal after sitting over night, 400 V or so. After approximately 5 minutes or slightly longer, I hear a slight arcing. From that point on, the screen voltage will wander anywhere from 75 V up to maybe 150 V. Adjustment of the screen control on the flyback has only a small effect and is not permanent. Removing the CRT pcb results in the screen voltage returning to normal."

This is very likely a short between electrodes inside the CRT unless there is something on the neck board that is breaking down as a result of some connection to the CRT. The flyback should largely not know the difference with the socket plugged into the CRT. However, on rare occasions, there is contamination within the 'plastic alignment base' on the end of the CRT neck. (It is possible to *carefully* remove the plastic piece and clean the CRT glass/pins. Reinstall the plastic piece if it is still intact or leave it off - just take care in replacing the CRT neck board.)

One possibility is that glue used to hold components down on some circuit boards has deteriorated and turned conductive. Check for tan to brown stuff shorting traces on the CRT neck board. If this is present on the focus or screen traces or wires, it may just be your problem. Scrape off all of the old glue and then clean thoroughly. Repair any damaged traces.

What happens to the HV? A HV breakdown possibly inside the CRT would result in all the voltages being dragged down.

What happens to the picture?

If you connect a charged HV capacitor (guessing a couple hundred volts, a couple microfarads) between G2 and G1 or focus, you **will** know if tapping the neck results in a momentary short! I cannot predict whether this will be a temporary cure or permanent killer. See the section: Rescuing a shorted CRTRescuing a shorted CRT.

Here is another thing to try: put a 100 M ohm or so resistor between SCREEN and the CRT socket. This should not affect the behavior much until the failure occurs. Then, check the voltage on both sides with a high impedance voltmeter (1000 M). If the CRT is arcing, it will be much lower on the CRT side and will probably fluctuate. You can play similar games with focus voltage.

Disconnecting flyback wire(s) from CRT driver board

In some cases, there may be one or more separate wires running to directly to the CRT socket. These are typically for focus which has a relatively high voltage so better insulation is needed but there may be no obvious means of removal should flyback replacement be needed.

One alternative is simply to cut the wire(s) in a location that is well away from any place to short out, solder, and then do a most excellent job of insulating the splice. If there is more than one wire, make sure to label them first if they aren't color coded.

However, you may find that the cap on the CRT socket snaps off using a thin knife blade or screwdriver. The wire may be soldered or just pressed in place in such a way that pulling it out is difficult or impossible without removing the cover. If there is more than one wire, label them before removal unless the locations are clearly marked.

Sometimes the color is stamped on the plastic but there may just be a designation like "A" and "B".

(From: Raymond Carlsen (rrcc@u.washington.edu).)

The last one I worked on puzzled me for a few moments. See if you can see a space between the little cup (where the wire enters the socket) and the socket itself. Pry up on the cap with a knife and it should pop right off. The wire is soldered to a pin under it. Don't apply heat for very long... you may melt the socket.

Focus or screen voltage drifts after warmup only when CRT is connected

> "I have a 3-5 yr old monitor that loses screen voltage. I believe that the problem is specific to the CRT or the flyback, either one is a guess I'd rather be sure of prior to ordering a part.
>
> The screen voltage will come up to normal after sitting over night, 400 V or so. After approximately 5 minutes or slightly longer, I hear a slight arcing. From that point on, the screen voltage will wander anywhere from 75 V up to maybe 150 V. Adjustment of the screen control on the flyback has only a small effect and is not permanent. Removing the CRT pcb results in the screen voltage returning to normal.
>
> I cannot find the source of the arcing, as it happens quickly and I have always been on the other side of the set when it happens. I have replaced the crt socket, thinking the spark gap was arcing. I have checked the CRT for G1 and HK shorts on a sencore crt checker, it checks good, but I am aware that since it is an intermittent problem, that the checker probably will not catch it."

This is very likely a short between electrodes inside the CRT unless there is something on the neck board that is breaking down as a result of some connection to the CRT. The flyback should largely not know the difference with the socket plugged into the CRT. However, on rare occasions, there is contamination within the 'plastic alignment base' on the end of the CRT neck. (It is possible to *carefully* remove the plastic piece and clean the CRT glass/pins. Reinstall the plastic piece if it is still intact or leave it off - just take care in replacing the CRT neck board.)

One possibility is that glue used to hold components down on some circuit boards has deteriorated and turned conductive. Check for tan to brown stuff shorting traces on the CRT neck board. If this is present on the focus or screen traces or wires, it may just be your problem. Scrape off all of the old glue and then clean thoroughly. Repair any damaged traces.

What happens to the HV? A HV breakdown possibly inside the CRT would result in all the voltages being dragged down.

What happens to the picture?

If you connect a charged HV capacitor (guessing a couple hundred volts, a couple microfarads) between G2 and G1 or focus, you **will** know if tapping the neck results in a momentary short! I cannot predict whether this will be a temporary cure or permanent killer.

Here is another thing to try: put a 100 M ohm or so resistor between SCREEN (or FOCUS) and the CRT socket. This should not affect the behavior much until the failure occurs. Then, check the voltage on both sides with a high impedance voltmeter (>1000 M). If the CRT is arcing, it will be much lower on the CRT side.

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Raster, Color, and Video Problems

Blank picture, power light on, digital controls (if any) active

Does 'blank picture' means a totally black screen with the brightness and contrast controls having no effect whatsoever? Or, is there is no picture but there is a raster - light on the screen? The direction in which troubleshooting should proceed differ significantly depending the answer.

Verify that you computer has not simply entered power saving mode and blanked the screen or shut off the monitor video and power circuits entirely.

Confirm that the video source is not defective or blank - try another one.

Here are some questions:

1. Is there any light on the screen at any settings of the brightness and contrast controls, and/or when switching channels. Can you see any raster scanning lines?
2. Can you obtain a raster of any kind by adjusting the screen (G2) control (probably on the flyback) or master background or brightness?
3. Looking in the back of the monitor, can you see the glow of the CRT filaments?
4. Do you get that static on the front of the tube that would indicate that there is high voltage?

If the answer to all of these is 'no', then you have a power supply and/or deflection problem. Refer the the section: No picture but indications of power.

Possible causes of no raster:

- No or low high voltage (low voltage, deflection, or high voltage power supply failure).
- Fault with other voltages like G1 or screen (G2) to CRT.
- Filament to CRT not getting powered.
- Drive to CRT bad/shut off as a result of fault elsewhere. For example, failure of the vertical deflection may disable HV or blank the screem to protect the CRT from burn-in due to the very bright horizontal line that would result. With some monitors, it is possible that the X-ray protection circuitry will blank the screen.

Possible causes of no video: problem in video input, video amplifiers, video output, cutoff due to other fault.

It could be as simple as a bad connection - try gently prodding the boards with an insulated stick while watching the screen. Check for loose connectors and reseat all internal connectors.

Brightness control has no effect

The following assumes that the picture is fine but the brightness is fixed - probably at too high a level. However, there could be several interrelated problems if a common supply voltage were missing, for example.

If it is a knob, then it should be varying the control grid (G1) voltages relative to the cathodes (K) of the CRT. This is not likely to be a very complex circuit. If you do not have a schematic, start by tracing from the control, check continuity and solder connections. Check the control itself for proper operation with an ohmmeter. A power supply going to one side of the control (negative probably) may be missing. Tbe control grid voltage will end up on the little board on the neck of the CRT - check there as well for bad solder connections or open resistors.

If brightness is a digital control, then you will need a schematic unless there is an obvious bad connection.

No color - black and white picture

This means absolutely no color - equivalent to a black and white picture. Not even a hint of color.

If you are using a composite video input, troubleshoot the chroma circuitry like you would a TV - see the document: Notes on the Troubleshooting and Repair of Television Sets.

This is an extremely unlikely failure mode for a computer monitor unless you are using a composite video input. It is most likely to a software driver or program problem. Sometimes, the PC will think that the monitor you have connected is not capable of color and certain programs will then display in B/W no matter what. This may be due to an initialization problem - possibly a race condition during the boot process - especially likely if you are using an older video card with a new fast processor.

First, confirm that the source is actually in color - try the monitor on another computer or vice-versa.

Check the settings of any mode switches - in rare cases there is a color/mono switch or button.

Note that to the average person, the obvious question becomes: is my color picture tube bad? The answer is a definitive NO. It is virtually impossible for a defective CRT to cause a total loss of color. A defective CRT can cause a lack of a primary color - R, G, or, B which will mess up the color but is not likely to result in a black and white picture.

One color is too weak or too strong

If the problem is slight and/or has gradually gotten worse, this may just require an adjustment of the color brightness/background/bias and/or color gain/drive controls inside the monitor. See the section: Brightness and color balance adjustment.

Even if it appears as though there is an excess, this may actually be a reduction in one of the primary colors. For example, a magenta tinge is represents a reduction in the strength of the green signal.

- Too high an intensity for one of the color channels will result in a tint of one of the primaries: red, green or blue.
- Too low an intensity for one of the color channels will result in a tint of the complement of one of the primaries: yellow, cyan, or magenta.
- Problems mainly in the shadows or dark areas of the picture usually represent a fault with brightness/bias/background.
- Problems mainly in the highlights or bright areas of the picture usually represent a fault with the gain/drive.

A color that that is now suddenly brighter or darker than normal resulting in incorrect color balance or a tint in the background could be due to a number of causes:

- Bad cable or pin bent on cable connector.
- Bad connections or bad component in video amplifier or on CRT neck board for that color.
- Weak gun in CRT (reduced color).
- Bad video card or incorrect software color map settings.
- For monitors with sync-on-green capability, the monitor may think you are using sync-on-green when in fact you have separate sync. In particular, this may result in a problem with excessive green:

  (From: Bob Myers (myers@fc.hp.com).)

  Some monitors provide a user-selectable setup option for "sync-on-green" vs. separate syncs. Sometimes, this doesn't really change where the sync itself is coming from. In those cases, it's automatically detected but *does* change where the reference level for the video is expected to be. You might try checking this setting, if you have it, and changing it back and forth to check the effect. It's not likely to be the problem in a separate-sync system like a PC, but weirder things have happened and it's easy and cheap to check out.

Psychodelic color

The means colors that are not normal and that adjustment of the user controls is not able to correct it so that all colors of the picture are properly displayed at the same time. For example, you are unable to get any yellows or blues in picture that should have these colors.

- If you are using a composite video input, troubleshoot the chroma circuitry as you would a TV - see the document: Notes on the Troubleshooting and Repair of Television Sets.
- Confirm that the input is not a weird color video - try another software program or video source. We have a draftsperson who always sets up his Windows color scheme in this manner - we keep wishing it is the monitor as **that** could be fixed!
- Verify that this is not a missing color problem - one of the primary R, G, or B, has disappeared. If so, refer to the section: Intermittent, flickering, or missing colors.
- If this is a monitor with BNC connectors and you are using them, make sure you had the video termination switches set correctly (75 ohms if this is the only monitor or the last monitor in a daisychain; HiZ if an intermediate monitor in a daisychain.) A very common cause of unbalanced or blooming colors assuming the monitor itself is good is incorrect settings of the termination.
- A bad connection, bad component, or short circuit in the video circuitry or CRT neck board could also result in strange colors.

Monitor manufacturing quality and cold solder joints

Any intermittent problems with monitors that cause random sudden changes in the picture brightness, color, size, or position are often a result of bad connections. Strategically placed bad connections can also cause parts to blow. For example, a bad connection to the SCR anode in a phase controlled power supply can result in all the current passing through the startup resistor, blowing it as well as other components. I had a TV like this - the real problem was a bad solder joint at a pin on the flyback. Thus, erratic problems, especially where they are power or deflection related, should not be ignored!

Bad solder joints are very common in monitors due both to poor quality manufacturing as well as to deterioration of the solder bond after numerous thermal cycles and components running at high temperature. Without knowing anything about the circuitry, it is usually possible to cure these problems by locating all bad solder connections and cleaning and reseating internal connectors. The term 'cold solder joint' strictly refers to a solder connection that was either not heated enough during manufacturing, was cooled too quickly, or where part pins were moved before the solder had a chance to solidify. A similar situation can develop over time with thermal cycling where parts are not properly fastened and are essentially being held in by the solder alone. Both situations are most common with the pins of large components like transformers, power transistors and power resistors, and large connectors. The pins of the components have a large thermal mass and may not get hot enough during manufacturing. Also, they are relatively massive and may flex the connection due to vibration or thermal expansion and contraction.

These problems are particularly common with TVs and monitors - especially cheaper monitors.

To locate cold solder joints, use a strong light and magnifier and examine the pins of large components for hairline cracks in the solder around the pin. Gently wiggle the component if possible (with the power off). Any detectable movement at the joint indicates a problem. With the power on, gently prod the circuit board and suspect components with an insulated tool to see if the problem can be effected.

When in doubt, resolder any suspicious connections. Some monitors may use double sided circuit boards which do not have plated through holes. In these cases, solder both top and bottom to be sure that the connections are solid. Use a large enough soldering iron to assure that your solder connection is solid. Put a bit of new solder with flux on every connection you touch up even if there was plenty of solder there before. However, remove any obvious excess. Inspect for solder bridges, sliver, splashes, etc. before applying power.

Why can't monitor manufacturers learn to solder properly?

I can think of several potential reasons - all solvable but at higher manufacturing cost.

1. Mass of large component leads (like shields) does not get adequately heated during manufacture leading to latent cold solder joints. While they may look ok, the solder never actually 'wetted' the heavy pins and therefore did not form a good mechanical or electrical bond.

2. Thermal cycles and differential thermal coefficients of circuit boards, traces, and solder. While it is not easy to do anything about the material properties, using plated through-holes or a similar mechanical via would greatly increase the surface area of the joint and prevent the formation of cracks.

3. Vibration. This is also directly related to the single sided circuit boards without plated through-holes to strengthen the joints.

4. Lack of adquate mechanical support (single sided circuit boards without plated through-holes (vias).

I believe that the single most significantimprovement would come about by using plated trhough-holes but this would add to the cost and apparently the consumer is not willing to pay more for better quality and reliability! Some designs have used rivlets - mechanical vias instead of plated ones. While this is good in principle, the execution has often been flawed where cold solder joints resulted between the rivlets and the circuit board traces due to lack of adequate process control.

Monitors, due to their generally higher cost compared to TV sets, should be better constructed but not always.

Intermittent, flickering, or missing colors

This is a catch-all for some of the most common monitor problems. Most of the causes boil down to bad connections of one form or another. However, defective components like bias resistors on the CRT driver board or in the video circuitry could also be at fault.

Note that due to the additive color scheme used in all emissive color displays like CRT or flat panel TV sets and video monitors, a single missing primary color (red, green, or blue) will result in the following appearance (for a white screen):

```
  Missing Color        Appearance
------------------------------------------------
     Red               Cyan (blue-green)
     Green             Magenta (reddish-purple)
     Blue              Yellow
```

This may best be observed with a test pattern a color on-screen display for which you recall the proper colors.

- Does whacking the monitor have any effect? If so, then bad connections are confirmed. If the color(s) come and go suddenly, then it is most likely *not* a CRT problem. The bad connections could be at the VGA cable, video driver board on the neck of the CRT, or elsewhere (see below).

- If the color fades in and out with a delay of about 10-15 seconds, it is probably intermittent power to the CRT filament for that color and probably means a bad CRT since the three filaments are wired in parallel inside the CRT. One of the internal connections has come loose.

  Look in the neck of the CRT to make sure all three filaments are glowing orange. If one is out or goes on and off, toss the monitor. Replacing the CRT is probably not worth it. However, if they all go on and off together (all colors would be fading in and out though perhaps not quite in unison), then bad connections for the CRT filaments on the CRT neck board are indicated.

Possible causes of intermittent or missing colors:

- VGA or other video input cable. Sometimes these develop intermittent problems at the connector to the VGA board. These may be internal to the cable in which case it will need to be replaced or if you are handy and have infinite patience, you can replace just the VGA connector.

  Alternatively, the male pins of the cable may not be making good contact with the female VGA socket. First try contact cleaner. If this does not work, gently squishing the male pins with a pair of needlenose pliers may provide temporary or permanent relief if the pins are a tad too small. However, if you go too far, you can damage or break the pins or cause the female socket to become enlarged and loose fitting for any other monitor you may use.

  If this just happened after reconfiguring your system and reconnecting the monitor or installing a new monitor, check your video connector - you may have bent over or pushed in pins 1, 2, or 3 - the R, G, and B video signals respectively.

  If you find a bent pin, ***carefully*** straighten it with a pair of needlenose pliers. If it is pushed in, try to grab onto it and pull it out - then put a drop of Epoxy or other adhesive at its base (don't get any on the part of the pin that makes contact) to prevent it from being pushed in again.

  There may be cold solder joints on the VGA board itself at the VGA connector. These can be resoldered.

- Printed circuit board on the CRT neck. This is a common location for cold solder joints. Check with a bright light and magnifying glass for hairline cracks around the pins of larger parts. Prod and tap with an insulated tool to see if the problem is effected. Resolder if necessary.

- Cold solder joints elsewhere in monitor usually around the pins of large parts such as transformers, power transistors and resistors, and internal connectors. Inspect with a strong light and magnifier if necessary.

- Internal connectors that need to be cleaned and reseated. Remove, clean with contact cleaner, burnish, and replace.

- Bad filament connections inside the CRT (gradual fade in and out or one filament not lit). Replace CRT or monitor.

To narrow down the problem:

- Locate the output for the bad color on the video driver board on the neck of the CRT. This will probably read a significantly higher voltage than the corresponding pins for the good colors. A circuit problem is likely - probably on this board but it could be in other parts of the video circuitry.

- Test components on this board for the good and bad color channels. A shorted transistor or open resistor can kill one channel. Swap parts between good and bad colors to confirm.

- Gently pull the CRT neck board off of the CRT and replace it. This will tend to clean the contacts.

- Connect an output of the video circuit/chip that is working (i.e., a color that appears on the screen) to *all* three color drivers on the CRT neck board.

  - If you now get a more-or-less black and white picture (there may be a moderate color tint as the relative intensities of R,G,B may not be balanced), the problem is likely with the circuitry on the mainboard.

    Note: the picture will be the intensity of only one color channel so it will not be quite *normal* in any case.

  - If you still have missing or messed up colors, the problem is on the CRT neck board or with the CRT.

Some commentary on monitor and TV whacking

Anytime that intermittent symptoms are experienced, I recommend gently whacking the patient to determine if mechanical shock or vibration affects the behavior. Here are a couple of responses to this suggestion.

(From Marc Gelfond (71363.1700@CompuServe.COM).)

I just love the bit about "whacking it". It brings to mind an episode from the old Andy Griffith show, where a new fangled piece of electronics gear, was broght into Emmets repair shop. After many long hours of fruitless troubleshooting, out of frustration Emmet gave the thing a whack, and sure enough it fixed the problem.

As we say in the Telephony business, it "CCWT" or Came Clear While Testing. Another saying is that it "CCBFM" Came Clear By F------ Magic!!

(To which Gavin Adams (gaa@hopi.com) comments):

In the video industry we had a saying concerning malfunctioning gear:

> "If it's broke, hit it with a hammer"
> "If that doesn't fix it, paint it and sell it"

My DEC 16" monitor is case in point. Evey once in a while it would lose sync, and smacking it would bring it back (sometimes a few smacks). Recently it gave up the ghost completely, and after the local DEC office gave me a quote of $900 to fix it (Bermuda), I ordered a new Viewsonic 17" for the same price.

I ripped the guts out of the DEC beast, painted it with a marble finish, put plants in it, and sold it! :>

Ghosts, shadows, or streaks in picture adjacent to vertical edges

Complaints about these kinds of problems are very common especially as the screen resolution and necessary video bandwidth keeps increasing. Most are due to cable and video termination deficiencies and not actual monitor defects.

The video signals for red, green, and blue (or just a single signal for monochrome) are sent over cables which are generally 75 ohm transmission lines. These are coaxial cables that may be combined inside a single sheath for VGA, SVGA, MACs, and many workstations but may be separate coaxes with BNC (or other) connectors for other video applications.

Without going into transmission line theory, suffice it to say that to obtain good quality video, the following conditions must be met:

- A good quality of cable must be used. This means one in which the characteristic impedance is close to the optimum 75 ohms, one which has low losses, and one which has good shielding. For installations using BNC connectors, a good quality of 100% shielded RG59U is often used. The BNC connectors must be properly installed or they will contribute to mismatch problems.

- Where multiple monitors are to be connected to a single video source, all wiring is done in a daisy chain fashion. The only taps permitted are the minimum necessary to connect each monitor to the chain. This usually means a BNC-T connector or a pair of connectors on the monitor for each video signal. T connections with cable must be avoided. (BNC cables only - SVGA monitors cannot be daisy chained without additional hardware.)

- Only the last monitor in the chain should be terminated in 75 ohms. All of the others must be set to Hi-Z. Monitors with BNC connectors will usually have one switch or a switch for each color to select termination.

Monitors for PCs, MACs, and many workstations usually have built in termination and do not offer the choice of Hi-Z. This means that without a video distribution amplifier, it is not possible to connect multiple monitors of this type to a single video source with any expectation of a good quality display.

Even adding a short extension cable or using an A-B monitor select box may result in unacceptable image degradation especially at higher scan rates.

Failure to follow these rules will result in video ringing, ghosts, shadows, and other unsightly blemishes in the picture. It is often not possible to control all aspects of the video setup. The cable is often a part of the monitor and cannot easily be substituted for a better one. The monitor may not have properly designed circuitry such that it degrades the video regardless of the cable and display board quality. The display card itself may not have proper drivers or source termination.

Ironically, the better the video card, the more likely that there will be visible problems due to termination. This is due to the very high bandwidth and associated signal edge rates.

Some examples of common termination problems:

- Overly bright picture with trails following vertical edges, perhaps with periodic ringing. This is due to a missing termination. Check if the monitor is set for Hi-Z instead of 75 ohms. If there is no switch, then the termination may be faulty or the monitor may need an external resistor. For BNC connectors, plug-on terminations are available.

- Bright ghost images adjacent to vertical lines. This may indicate that the terminating resistor is greater than the impedance of the cable. You may be using Ethernet Thinnet cable by accident which is RG58 with an impedance of 50 ohms.

- Dark picture and ghost images adjacent to vertical lines. This may indicate that the terminating resistor is too low - multiple monitors on a chain all set for 75 ohms instead of just the last one. Or, an improper type of cable such as audio patch cord.

- Fuzzy vertical edges. This may indicate a poor quality cable or a run which is just too long. For high resolutions such as 1280x1024, the maximum cable length may be as short as 25 feet or less for poor quality cable. Better cable or fiber-optic repeaters may be necessary.

- Other similar problems - check cables for defective or improperly installed connectors. This is especially applicable to cables with BNC or UHF type connectors which require a kind of artistic talent to assembly properly and consistently. Throw out those extension cables and switch boxes!

If only 1 or 2 colors (of the R, G, and B) are effected, then look for improper switch settings or bad connections (bad cable connectors are really common) on the problem color cables.

General streaks or lines to the right of bright or dark areas

The problem is that on a white background the various objects leave a shadow to their right. Not a duplicate image but more like horizontal dark streaks on the white background. Also it seems that high intensity colors display very bright but low intensity colors are overly dark (almost black). The contrast and brightness adjustments may make no difference.

This could be a number of things but they are all in the video amplifier and probably not the CRT driver board though this is possible. Dried up filter capacitors could result in video dependent ripple on the power supply lines. Bad coupling capacitors could result in similar symptoms but probably for only one color, not all of them.

Since all colors are effected, look for something common like a bad power supply. With a scope, this would probably be rather easy even without schematics. If the brightness and contrast controls do nothing, this would suggest some fault in their general area or the IC or transistors they control in the video amps - and that this is not a CRT problem. Locate the video amp IC if it uses one and locate a pinout - this should be enough to determine which signals are faulty.

First, do check carefully for bad connections and other obvious failures.

This could also be a symptom of a bad CRT but this would be unusual with a not-ancient monitor (and not if the brightness and contrast controls have no effect).

Washed out picture

If you can obtain a full intensity raster by varying the brightness or screen control, then your problem is most likely in the video amplifiers or power for the video amplifiers.

If, however, the screen control varies the brightness but will not get a bright raster, you probably have problems either with the HV power supply or the filament supply for the CRT - is there the normal bright orange glow at the base of the CRT? If it is dim or very reddish, there may be a marginal connection or bad component in the filament circuitry.

Retrace lines in picture

During the time the electron beam is returning from right to left at the end of a line and bottom to top (over the course of multiple lines), it is supposed to be result in no visible light on the screen. However, a number of faults can result in visible retrace lines.

The appearance will likely be a general reduction in contrast from the visible horizontal retrace on every scan line and two dozen or so diagonal lines lines (lower left to upper right) resulting from the vertical retrace.

The retrace lines may be either white or gray (possibly with a slight color tint due to unequal settings of the color adjustments) or a primary color - red, green, or blue. Anything in between is also possible but less likely.

White/gray retrace lines

Where all colors are involved - the lines are essentially white or gray (or with a slight tint due to slight unequal settings of the color adjustments), look for something common like an incorrectly adjusted screen (G2) or master brightness/background/bias control or a problem in one of these circuits, a defective power supply or a problem in the blanking circuitry:

- Screen (G2) or master brightness/background/bias control - mark setting and then see if a slight adjustment removes the retrace lines. See the chapter: "Monitor Adjustments". Of course, if this happened suddenly, the problem is not due to a misadjusted control though a dirty pot is possible - turn it back and forth - this might clean it and restore normal operation.

- Power supply or connection to CRT neck board - insufficient voltage will result in the CRT never totally blanking. Check (usually scan derived) power supply components (from flyback).

- General power supply - check B+ for correct value and ripple. A main power supply fault might result in these symptoms (and usually many others).

- Blanking circuit - this may be a part of the video/chroma chip or separate. Check waveforms to determine if the blanking pulses are making it to the video output.

Red, green, or blue retrace lines

Where only one color is showing, suspect an incorrectly adjusted individual background/bias control or bad part on the CRT neck board for that color.

- Individual brightness/background/bias control(s) - mark setting of pot for the problem color and then see if a slight adjustment removes the retrace lines. See the chapter: "Monitor Adjustments". Of course, if this happened suddenly, the problem is not due to a misadjusted control though a dirty pot is possible - turn it back and forth - this might clean it and restore normal operation.

- Component or connection on CRT neck board - insufficient voltage to or incorrect biasing of the video driver for this color can result in the CRT never totally blanking. Compare voltages and signals, and swap components between good and bad channels to confirm.

- Blanking circuit - this may be a part of the video/chroma chip or separate. Check and compare waveforms of good and bad colors to determine if the blanking pulses are making it to the video output.

There is a slight possibility that a bad CRT may result in visible retrace lines. To eliminate this possibility:

- Disconnect the filament - all evidence of a picture, raster, and retrace lines should disappear once the filaments/cathodes have cooled (15 seconds or so. If there are still visible retrace lines, the CRT is suffering from cold or field emission from someplace (may not even be the cathode).

- Turn down the screen (G2) control on the flyback (usually). If one color remains no matter how you set the control, again there is some kind of weird emission from the CRT. However, if white/gray retrace lines remain, the problem may be in the screen supply.

See the section: Bad CRT causing retrace lines.

Bad CRT causing retrace lines

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The TV which I bought last started developing retrace lines after a month or so of use. I took it back to the lab for warranty (special deal) and had it examined by the real experts. They found that even with the filament supply disconnected and VG2 at 0V the screen would still light up. They could even see that the electrons weren't even coming from the cathode. That was with only the picture tube in a test rig. So in this case the obvious conclusion had to be that the tube was bad, and it was replaced (32" 16:9 SF, very $$). It had something to do with processing problems during manufacturing of the electron guns.

So even if this was a rare case, it *can* happen that retrace lines are due to a bad picture tube. It's more usual to suspect the VG2 (screen voltage) or a defect somewhere in the RGB video path.

Red, green, or blue full on - fog over picture

This could be a heater-cathode (H-K) short in the CRT, a failure of a component in the chroma circuits or video output (driver board), or bad connections there or elsewhere.

Don't panic - heater-cathode shorts in CRTs can often be worked around.

Note: before proceeding, it is a good idea to make sure that the screen is degaussed - else you could be attempting to track down problems with the wrong color!

Some simple tests can confirm or rule out other possibilities.

- Compare the voltages for the video drive signals to the CRT on the little board on the neck of the CRT with the CRT both connected and unplugged. A schematic will help greatly in locating these signals.

    - If there is a significant difference especially on the bad color, then the CRT is a likely candidate. Try tapping the neck of the CRT GENTLY (with it plugged in and while viewing a picture) to see if it is an intermittent problem.

    - If there is no significant difference, you may have a bad driver or a problem in the chroma circuits.

- Look for bad connection/cold solder joints, probably on the little board on the neck of the CRT. Use an insulated stick to gently prod the board and its components in an effort to induce/cure the problem. Look carefully for hairline cracks around the component leads.

- You can swap components between two colors and/or test with an ohmmeter on that driver board to determine what is bad. The nice thing about color monitors and TVs is that there three copies of each of these components. Swapping and/or comparisons between these is an excellent diagnostic technique.

- Another simple test: Disconnect the cathode for the full-on color from its drive. If it is still full-on, there is probably an H-K short in the CRT since the only way to get each color on the screen is via the cathode connection to the CRT neck board. If it is removed and there is still that color, the current must be taking another path inside the CRT.

- Alternatively, interchange the outputs of the bad color with a good one by jumpering on the video driver board (on the CRT neck). If the bad color changes, then the problem is in the circuitry and not the CRT.

  Here is the procedure in more detail (example for red full on):

  (From: J. K. Emerine (jkemerine@aol.com).)

  To identify if the fault is in the crt or a control problem try this (WITH SET OFF):

  On the CRT board, lift the output end of the green cathode final resistor. Do the same with the offending red cathode's resistor. Use short insulated jumpers to 'swap' drive signals - drive the red cathode with the green drive and the green cathode with red drive. (Note that if this problem only occurs after a warmup period, color at turn on will be - well - wierd, but it is just a test.)

    - If the symptom returns = 'goes red' the CRT is shorting. (See the section: Providing isolation for a CRT H-K short. --- Sam.)

    - If instead the symptom becomes 'goes green' then the red drive leg has the fault and the CRT is probably good. (In this case, there may be bad connections or a bad component on the CRT drive board or further back in the chroma circuitry. --- sam)

Totally white screen (probably with retrace lines)

There may or may not be any indication of a picture. This may be a problem in the high voltage power supply (SCREEN, G2), loss of power or a fault in the video output drivers, other video amp problems, or a bad (shorted) CRT.

Is focus still reasonably sharp? If not, try adjusting it (usually on the flyback or a separate little panel). If changing focus affects brightness significantly, there is a short between the two supplies - either in the HV power supply or CRT. See the section: Bad focus and adjustment changes brightness. In this case, changing SCREEN (G2, also on the flyback) may also affect focus or may not do anything.

Try adjusting SCREEN. If it has no affect, a problem in its power supply from the flyback is possible. If you have a high impedance voltmeter (not just a DMM, the resistance of the voltage divider supplying SCREEN is hundreds of M ohms), check it while changing the SCREEN control. If it does not change, you have found a definite problem.

Assuming that adjusting FOCUS and SCREEN result in normal behavior and do not strongly interact, the problem is likely in the video circuitry or output drivers.

Check the power to the CRT video output drivers on the little board on the neck of the CRT. If this failed, all three video outputs will be full on. If you have a scope, look at the video outputs - they should be varying between over 100 V and a low value. If they are missing or very low all the time, there is a problem further back in the video chain.

See the other sections relating to brightness and high voltage problems as well.

Shorts in a CRT

Occasionally, small conductive flakes or whiskers present since the day of manufacture manage to make their way into a location where they short out adjacent elements in the CRT electron guns. Symptoms may be intermittent or only show up when the TV or monitor is cold or warm or in-between. Some possible locations are listed below:

- Heater to cathode (H-K). The cathode for the affected gun will be pulled to the heater (filament) bias voltage - most often 0 V (signal ground). In this case, one color will be full on with retrace lines. Where the heater is biased at some other voltage, other symptoms are possible like reduced brightness and/or contrast for that color. This is probably the most common location for a short to occur.

- Cathode to control grid (K-G1). Since the G1 electrodes for all the guns are connected together, this will affect not only the color of the guilty cathode but the others as well. The result may be a very bright overloaded *negative* picture with little, none, or messed up colors.

- Control grid to screen (G1-G2). Depending on circuitry can result in any degree of washed out or dark picture.

- Screen to focus (G2-F). Screen (G2) and focus voltage will be the same and the controls on the flyback will interact. Result will be a fuzzy white raster with retrace lines and little or very low contrast picture. Symptoms will be similar to those of a flyback with breakdown in the focus/screen divider network.

- Focus to high voltage (F-HV). High voltage will be pulled down - probably arcing at the focus spark gaps/other protective devices. Line fuse and/or HOT may blow. A high impedance short may only result in increased focus voltage but this is probably unusual.

- Other locations between electron gun elements as feed wires.

Except for the high voltage to other places, the short may actually be located in the CRT *socket* or even on the CRT neck board, probably in the spark gap(s) for the problem pins. Remove the socket and test between the suspect pins on the CRT itself. If the CRT itself is fine, the spark gaps should be inspected and cleaned/repaired and/or components replaced. At this point, the cause may still be present - a short inside the flyback for example resulting in excessive voltage on one or more pins.

Assuming this is not the case, replacing the CRT may be the best solution but there are a variety of 'techniques' that can often be used to salvage a monitor that would otherwise end up in the dump since replacing a CRT is rarely cost effective:

1. Isolation - this will usually work for H-K shorts as long as only one gun is involved. However, with high video bandwidth monitors, there may be some smearing of the affected color due to the added capacitance of the transformer and filaments now connected to its video signal.

2. Blowing out the short with a capacitor - depending on what is causing the short, this may be successful but will require some experimentation.

3. Placing the CRT (TV or monitor) face down on a soft blanket and *gently* tapping the neck to dislodge the contamination. Depending on the location of the short, one side or the other might be better as well. Sometimes, this can be done in-place while watching the picture.

A combination of (2) and (3) may be required for intermittent shorts which don't appear until under power. See the sections below for additional details. However, for shorts involving the focus and high voltage elements, even a sharp edge can result in arcing even if there is no actual short. There is no remedy for these types of faults.

Providing isolation for a CRT H-K short

This procedure will substitute a winding of your own for the one that is built in to the flyback to isolate the shorted filament from the ground or voltage reference. Note that if you have a schematic and can determine where to disconnect the ground or voltage reference connection to the filament winding, try that instead.

The flyback is the thing with the fat red wire coming out of it (and perhaps a couple of others going to the CRT board or it is near this component if your set has a separate tripler) and may have a couple of controls for focus and screen. It should have some exposed parts with a ferrite core about 1/2-3/4" diameter.

The filament of the CRT is the internal heater for each gun - it is what glows orange when the set is on. What has happened is that a part of the fine wire of the bad color's filament (assuming this is indeed your problem) has shorted to the cathode - the part that actually emits the electrons. Normally, the heater circuit is grounded or tied to a reference voltage so when it shorts to the cathode, the cathode voltage level is pulled to ground or this reference.

You will need some well insulated wire, fairly thick (say #18-22). Find a spot on the flyback where you can stick this around the core. Wrap two turns around the core and solder to the CRT filament pins after cutting the connections to the original filament source (scribe the traces on the board to break them). Make sure you do not accidentally disconnect anything else.

This winding should cause the filaments to glow at about the same brightness as before but now isolated from ground. If they are too dim, put another turn on the flyback to boost the voltage as low filament temperature will result in reduced emission, blooming, and possible damage to the cathodes after awhile. (Don't go overboard as you may blow the filament totally if you put too many turns on the core - you then toss the monitor.)

Route the wires so that there is no chance of them getting near the high voltage or any sharp metal edges etc. Your picture quality may be a tad lower than it was before because of the added stray capacitance of the filament wiring being attached to the the (formerly bad) video signal, but hey, something is better than nothing.

Rescuing a shorted CRT

If the short is filament-cathode (H-K), you don't want to use the following approach since you may blow out the filament in the process. If this is the case, you may be able to float the filament and live with the short (see the section on: "Red, green, or blue full on - fog over picture".

Shorts in the CRT that are between directly accessible electrodes can be dealt with in a more direct way than for H-K shorts. At this point you have nothing to loose. A shorted CRT is not terribly useful.

If the short is between two directly accessible electrodes like cathode-grid, then as a last resort, you might try zapping it with a charged capacitor.

Unplug the CRT socket!

Start with a relatively small capacitor - say a few uF at a couple hundred volts. Check to see if the short is blown after each zap - few may be needed. Increase the capacitance if you feel lucky but have had little success with the small capacitor.

If the fault is intermittent, you will, of course, need to catch the CRT with the socket disconnected and the short still present. Try some gentle tapping if necessary. If you do this with the charged capacitor across the suspect electrode, you **will** know when the short occurs!

Also see the section: High voltage to focus short.

High voltage to focus short

Symptoms would be (with the unit powered and high voltage present):

- With the CRT neck board plugged into the CRT, the focus spark gap is likely arcing.

- With the socket unplugged, putting anything connected to ground (or any other circuitry) near the focus pin would result in a juicy spark or arc. WARNING: Removing the CRT socket and powering the unit may destroy the CRT on some models. See the section: Warning about disconnecting CRT neck board.

If the CRT is gassy or up to air, forget it - it might make a decent fish tank :-). In this case, there would be visible arcing INSIDE the CRT probably not confined to a single location.

However, if there is just a metal whisker between the F and HV, that might be able to be cleared by careful tapping or a charged capacitor. You may even be able to see it if you were to remove the yoke - the gap is pretty large, about 1-2 mm - the last gap between electrodes before the start of the internal (Dag) coating.

See the section: Rescuing a shorted CRT.

Note that other damage may have been done as

Other components including the flyback, HOT, and parts on the CRT neck board and beyond, may have been damaged as a result of the short. Zapping the CRT may be just the beginning of what is required to repair it all.

Dark picture

A monitor with a picture that is too dark may have a fault or the CRT may just be near the end of its useful life.

First, confirm that your video source - computer, camera, etc. - is producing a proper signal.

Is the brightness at all erratic? Does whacking the monitor have any effect? If so, then you may have bad connections on the CRT driver card or elsewhere. If the brightness tends to fade in and out over a 10 to 20 second period, a bad filament connection is likely. Check for the normal orange glow of the filaments in the neck of the CRT. There should be 3 orange glows. If they are excessively reddish, very dim, or fade in and out, you have located a problem. See the section: Picture fades in and out.

Common causes of brightness problems:

1. Dirty CRT faceplate or safety glass. Don't laugh. It sounds obvious, but have you tried cleaning the screen with suitable screen cleaner? It is amazing how dirty screens can get after a few years - especially around smokers!

   (From: A. R. Duell (ard12@eng.cam.ac.uk).)

"I once spent a morning battling with a DEC VT105 terminal with a very dim and washed out picture, and only after checking everything on the video board did I wipe over the screen. That cured it. It's amazing how dirty screens can get after a few years use."

Wipe gently with a slightly dampened cloth - not soaking or you may end up with real problems when the water drips down inside and hits the electronics!

2. Old CRT. The brightness of the CRT deteriorates with filament on-time. It doesn't matter much what you are doing or if you use a screen saver.

   An indication of a weak CRT would be that turning up the SCREEN (G2) or master brightness control only results in a not terribly bright gray raster before the retrace lines show up. There may be indications of poor focus and silvery highlights as well. A CRT brightener may help. See the sections: Brightening a old CRT and Monitor life, energy conservation, and laziness.

3. Bad component in filament circuit or bad connection reducing filament voltage. This should be easy to check - there are only a few parts involved. If it is erratic, bad connections are likely.

4. Brightness control faulty - bad pot, bad connections, or problem with its power supply. Depending on specific problem, control may or may not have any effect. If digitally adjusted, there could be a problem with the logic or control chip. If the button or menu item has no effect at all, then a logic or control problem is likely.

5. Improperly set SCREEN (G2) voltage (usually on flyback) or faulty divider network. See the section: Brightness and color balance adjustment.

6. Improperly set video bias (background) levels or fault in video drive circuitry. See the sections starting with: "Optimal procedure for setting brightness/background and screen adjustments".

7. Fault in video amplifiers. With all three color affected equally, this would most likely be a power supply problem. A video amplifier problem is likely if turning up the SCREEN (G2) or master brightness control results in a very bright raster before the retrace lines appear. Cheack signals out of the video/chroma IC.

8. Fault in beam or brightness limiter. Many TVs and monitors measure the beam current (possibly indirectly) and limit the maximum to a safe value. The purpose of this may be to protect the CRT phosphors, and/or to assure that the power supply does not go out of regulation, and/or to limit X-ray emission. If this circuit screws up, a dark picture may result. Checking the signals and voltages at the CRT socket should determine if this is the problem.

9. High voltage is low. However, this would likely result in other symptoms as well with focus, size, and geometry.

Brightening an old CRT

If performing adjustments of the internal background and/or screen controls still results in a dark picture even after a long warmup period (and the controls are having an effect - they are not faulty), the CRT may simply be near the end of its useful life. In the old days of TVs with short lived CRTs, the CRT brightener was a common item (sold in every corner drugstore, it seemed!).

First confirm that the filaments are running at the correct voltage - there could be a marginal connection or bad resistor or capacitor in the filament power supply. Since this is usually derived from the flyback, it may not be possible to measure the (pulsed high frequency) voltage with a DMM but a service manual will probably have a waveform or other test. A visual examination is not a bad way to determine if the filaments are hot enough. They should be a fairly bright orange to yellow color. A dim red or almost dark filament is probably not getting its quota of electrons. It is not be the CRT since all three filaments are wired in parallel and for all three to be defective is very unlikely.

If possible, confirm that the video output levels are correct. For cathode driven CRTs, too high a bias voltage will result in a darker than normal picture.

CRT brighteners are available from parts suppliers like MCM Electronics. Some of these are designed as isolation transformers as well to deal with heater-to-cathode shorts.

You can try a making a brightener. Caution: this may shorten the life of the CRT - possibly quite dramatically (like it will blow in a couple of seconds or minutes). However, if the monitor or TV is otherwise destined for the scrap heap, it is worth a try.

The approach is simple: you are going to increase the voltage to the filaments of the electron guns making them run hotter. Hopefully, just hotter enough to increase the brightness without blowing them out.

Voltage for the CRT filament is usually obtained from a couple of turns on the flyback transformer. Adding an extra turn will increase the voltage and thus the current making the filaments run hotter. This will also shorten the CRT life - perhaps rather drastically. However, if the monitor was headed for the dumpster anyhow, you have nothing to lose. You can just add a turn to an existing winding or make your own separate filament winding as outlined in the section: Providing isolation for a CRT H-K short.

In some monitors, there is a separate filament supply on the mainboard - this should be obvious once you trace the filament wires from the video driver board). In this case, it still may be possible to increase this output or substitute another supply but a schematic will be required.

There are also commercial CRT rejuvenators that supposedly zap the cathodes of the electron guns. A TV or monitor service center may be able to provide this service, though it is, at best, a short term fix.

Color balance changes across screen from left to right

The characteristics are that a solid white screen will tend to be blue tinted on one side and red tinted on the other. This is usually a subtle effect and may be unavoidable with some designs.

There are several possibilities:

1. Purity - this means the beams are landing on the wrong phosphor dots. This is what would be affected by moving from one location to another or even rotating the TV on its base without degaussing. If the problem just appeared, degaussing may be needed.

   What do you have near the TV or monitor? Loudspeakers or other devices which generate magnetic fields can easily cause all sorts of color purity problems. Relocate the offending device(s) or the TV or monitor and then degauss it.

   See the section: Degaussing (demagnetizing) a CRT.

   If the problem still persists, purity adjustment may be needed. However, this isn't likely to have changed so look for other causes before tackling these adjustments.

2. Unequal electron gun to shadowmask/screen distance - the electron beams for the red and blue video travel

slightly different distances on the left and right sides of the screen so their intensity (due to focus not being optimal and other factors) in each case may differ slightly affecting color balance.

3. Doming - This would only happen in very bright areas and causes the shadow mask to expand and distort. (Doming should not be a problem with Trinitron CRTs which use tensioned wires in their aperture grill.) This would also not really affect left-right color balance in particular.

I don't really know how much of a problem (2) is in practice or whether some manufacturers compensate for it.

Bleeding highlights

On very bright areas of the picture, one or more colors may bleed to the right resulting in a trail of those colors. The difference between this problem and the section: Trailing lines in one or more colors is that in this case, only highlights are affected.

One cause of this is that the color gain, contrast, or intensity controls (whatever they are called on your monitor) are set too high. See the section on: "Brightness and color balance adjustment". Check the settings of any brightness limiter controls as well.

Trailing lines in one or more colors

Assuming this is not a form of ghosting resulting from cabling and/or use of switchboxes, etc, then it could be any of the following:

- Poor decoupling in the power supplies for the video drive circuits - probably on the CRT neck board. Check for bad (low uF or high ESR) filter capacitors (electrolytic mostly) on this board or the power supplies feeding it.

- Insufficient CRT filament voltage. This could be a result of bad connections or a bad component in the filament power supply (probably from the flyback). Check to see if the filaments are glowing bright orange and check the voltage if possible (though this can be tricky since it is often fed from a winding on the flyback and is a pulse waveform, not DC or a sinusoid. The service manual will probably have info and waveforms.

- Bad CRT (more likely if only one color is affected). A weak electron gun can result in this behavior. Swap it with one that work properly. If the same color is still bad, that CRT gun is weak. The CRT will need rejuvenation or need to be replaced (more likely, the entire monitor will be tossed into the dumpster).

Purity problems with bright pictures

Setting the brightness excessively high may result in enough heating of the shadow mask to distort it. IF severe enough, the positions of the holes will shift enough to result in visible purity problems. This is less of a problem with tubes using an InVar shadow/slot mask. It should also be less of a problem for Trinitron aperture grille CRTs.

The only solution is to reduce the brightness.

Why does the intensity appear so non-uniform in bright areas?

Actually, the intensity variation is likely to be even worse than you might think - possibly as much as 2:1 from the center to the corners. In most cases you do not notice it. With large deflection angle tubes, fewer electrons make it to phosphor dots near the edge of the screen. It is simple geometry.

(From: Bob Myers (myers@fc.hp.com).)

It is extremely difficult for any CRT display to maintain perfect brightness and color uniformity across the entire image. Just the geometry of the thing - the change distance from the gun to the screen as the beam is scanned, the changing spot size and shape, etc. - makes this nearly impossible, and there can also be variations in the phosphor screen, the thickness of the faceplate, etc.. Typical brightness-uniformity specs are that the brightness won't drop to less than 70% or so of the center value (usually the brightest spot on the screen).

On color tubes, the lack of perfect brightness uniformity is aggravated by the lack of perfect COLOR uniformity and purity. What appear to be "dark spots" on a solid gray image may actually be beam mislanding (color purity) problems, which may to some degree be remedied by degaussing the monitor.

Again, *some* variation is normal; if you think you're seeing too much, you can try degaussing the thing and seeing if that helps. If it doesn't, then the question is whether or not the product meets its published specs, and that 's something you'll have to discuss with the manufacturer or distributor.

Brightness changes from left-to-right across screen

Slight variations in brightness across the face of the CRT are not unusual. In fact, if you used a photometer to actually measure the brightness, you might be amazed at the actual variance even with the best monitor or TV - you just don't notice it. However, a major variation - usually a decay from left to right but could be the other way indicate a component failure. Of course, make sure the face of the screen is clean!

- A fault in the power supplies to the video amplifier and/or video output circuits. Most likely, an electrolytic capacitor has dried up and is not adequately filtering the power derived from the flyback which then has ripple at the horizontal scan rate and thus locked to the screen. The voltage decays from left-to-right between horizontal flyback pulses.

  The most likely location for these capacitors is in the vicinity of the flyback transformer on the mainboard or on the CRT neck board. Check the capacitors with capacitor tester or ESR meter and/or take a look at the power right at the video amplifier and video output drivers.

- Horizontal linearity is bad - this may actually be a horizontal geometry problem and not a brightness problem.

  See if objects on left side of the screen are stretched compared to those on the right (or vice-versa). If they are, the problem is in the horizontal deflection circuits - possibly a bad (or in the case of a multiscan monitor, correctly selected) S correction capacitor or linearity coil.

- Inoperative degauss circuit, monitor moved or rotated without degaussing, or magnetic field from some other device (like a permanent magnet) is affecting CRT - slight amounts of magnetization may reduce brightness (by moving the beams into the black space between phosphor dots) before affecting color purity (where the beams land on the wrong phosphor dots).

  See if the degauss button, if present, does anything. Try deguassing manually. See the section: Degaussing (demagnetizing) a CRT.

Picture fades in and out

If the picture faded away on the order of 10-20 seconds (and if it comes back, also comes up to full brightness in same time frame - possibly with the persuasion of some careful whacking) AND with NO other significant changes such as size, focus, etc., then take a look in the back of the tube for the filaments to be lit - the orange glow near the CRT socket. If the glow is coming and going as well, then you probably have a bad solder connection on the circuit board on the neck of the CRT. Look for fine cracks around pins on that board. Try prodding it with an insulating stick to see if the picture comes back. Resolder if necessary. It is probably not a bad CRT as the filaments are usually wired in parallel and all would not go bad at the same time.

However, if only a single color fades in and out, then a bad connection inside the CRT is a distinct possibility - look for only one of the filament's glow to be coming and going. This is probably not worth fixing since it will require CRT replacement.

If the picture faded away with other symptoms, then there is probably a fault in the video amplifier/output one of its power supplies - still probably a loose connection if you are able to get it back by whacking.

Occasional brightness flashes

These may last only a fraction of a scan line or much much longer.

Make sure it is not the video source - try another one.

This could mean an intermittent fault in a variety of places including the video circuitry and SCREEN power supply:

- Brightness circuitry - SCREEN, master background or its power supply. Could be in or around flyback or focus/screen divider. Could perhaps be in the CRT, but probably less likely.

- Video amp before or at chroma demodulator (if composite input) - since after this point, you would most likely get colored flashes since only one of the RGB signals would likely be effected. However, a bad power connection to the video circuitry could cause all the colors to be affected.

If you still get flashes, it should be quite easy to monitor either the video outputs or SCREEN supply (with a HV divider on your scope) for noise. Then trace back to power or noise source.

Occasional static, lines, spots, or other unsightly blemishes

First, confirm that these are not video source - PC - related. Try the monitor on another computer. This may be a problem with the hardware or driver (software) for the video card, the O/S, or memory or bus speed.

If it is not computer related, then it could be arcing, corona, bad connections, or some electronic component breaking down. See the appropriate sections for these problems.

Note that problems in absolutely fixed locations or with an extent related to pixel sizes in the video card are nearly always computer/video card related and not due to a faulty monitor.

Flickering monitor

First, make sure your scan rate is set high enough (but not beyond the capabilities of the monitor). A scan rate less than 60 Hz is likely to result in annoying flicker especially at high brightness levels.

See if the flickering correlates with any processor or disk activity indicating a software driver or video card problem.

Assuming neither of these applies and you are not doing your work by candlelight, a flickering image is probably due to an intermittent arc or short, probably in the high voltage section near or at the flyback transformer. However, it is also possible that it is due to a simple bad connection elsewhere.

So the first thing to do will be to remove the cover and without touching anything, carefully examine for any obvious signs of bad connections, arcing, or burned areas. In particular look for:

- hairline cracks around the pins of large components like power transistors, power resistors, transformers, and connectors.

- any discoloration, cracking, other unusual signs on the flyback. The flyback also provides, via a high resistance divider network, the several kV for focus and several hundred V for the G2 (screen) CRT electrode. These are the voltages that may be intermittently changing and resulting in flicker.

Now, with the monitor powered in a darkened room with a normal picture (use the highest resolution at which your monitor will work as this should put the most stress on it, maybe).

- Look for any arcing or corona around the area of the flyback or the neck of the CRT first, then just anywhere.

- Use a well insulated stick (wood or plastic) to gently prod the circuits board, components, wires, etc. to see if you can induce the problem.

There will probably be a pair of adjustments on the flyback itself. One of these is FOCUS and the other is SCREEN - essentially a master brightness.

- Now, with one hand in your back pocket, try turning each of these a fraction of a turn in each direction. Don't worry, you cannot hurt anything by doing this. The FOCUS should only change the sharpness of the picture. The SCREEN should only change the brightness. In both cases, this should be a smooth effect. Sometimes, these controls will simply get dirty and cause the problems you have seen. In this case, just moving them back and forth may clean them. If one affects the other - if turning focus alters brightness or vice-versa, there is a short between the focus and screen voltages, probably inside the flyback but it could be elsewhere.

It is likely that all of the above tests will come out negative as you may have an intermittent short internal to the flyback which can only be fixed by replacement. However, eliminate the easy fixes first.

Excessive brightness and/or washed out picture

There are a number of possibilities including incorrect screen (G2) or bias (G1) voltages, or a problem in the video or blanking circuitry. Any of these could be the result of bad connections as well. A short in the CRT can also result in these symptoms.

- Excessive brightness/washed out picture is often an indication of a problem with the screen (G2) supply to the CRT. May be a bad capacitor or resistor divider often in the flyback transformer assembly or on the board on the neck of the CRT.

- If the excessive brightness just developed over time, then a simple adjustment of the screen or background brightness controls may keep it (and you) happy for a long time.

  When good, a typical value would be in the 200 to 600 VDC at the CRT. The screen (it may also be called master brightness, bias, or background) control should vary this voltage. However, it may be difficult to measure as the resistors in the voltage divider network may be quite large - hundreds of M ohms. If your unit has an external screen control (less likely these days) and it has no effect, trace out the circuitry in the immediate vicinity and check the resistors and potentiometer for opens, look for bad connections, etc. If it is built into the flyback transformer and is sealed, the entire flyback will need to be replaced unless the actual problem turns out to be a bad connection or bad component external to the flyback.

- Where the brightness control has no effect, suspect a missing bias supply to the G1 (control grid) electrodes of the CRT. This is usually derived from the flyback with a simple rectifier/filter capacitor power supply. Parts may have failed (though not likely the flyback itself). Adjusting the user brightness control should vary this voltage over a typical range of 0 to -50 V with respect to signal ground.

- It could also be a problem with biasing of the video output transistors. There may individual controls for background brightness on the little board on the neck of the CRT. However, we are looking for a common problem since all colors are wrong in the same way. This is likely to be a missing voltage from a secondary supply from the flyback.

- A short between electrodes inside the CRT can result in brightness problems. It may be possible to check this with an ohmmeter with the power off and the CRT socket removed. Test between G1, G2, and F where all colors are affected though a short between F and G2 will result in the focus control changing brightness and vice-versa - a classic symptom.

  However, in some cases, it only shows up when operating and one must deduce the presense and location of the short from its affect on voltages and bias levels.

  See the section: Rescuing a shorted CRT and other related topics.

First, check for bad connections/cold solder joints by gently prodding with an insulating stick. Check voltages and bias levels.

Focus problems

Slight deterioration in focus can be corrected by adjusting the focus control usually located on the flyback transformer. Sometimes, this is accessible externally but usually not. On monochrome monitors, the focus control, if any, may be located on the main board.

Don't expect to have perfect focus everywhere on the screen. Usually there will be some degradation in the corners. A compromise can generally be struck between perfect focus in the center and acceptable focus in the corners.

If the adjustments have no effect, then there is probably a fault in the focus power supply.

For most color TVs and monitors, the correct focus voltage will be in the 4 to 8 kVDC range so you will need a meter that can go that high or some big resistors to extend its range or a HV probe. You must use a high impedance meter as the current availability from the focus power supply is very low.

The pots in the flyback are sometimes accessible by removing their cover, which may snap on. However, a typical focus circuit will have a large value resistor potted inside the flyback (like 200 Megohms).

Try to measure the focus in-circuit. If the value you read is very low (assuming your meter has a high enough impedance not to load the circuit appreciably), then disconnect the wire (from the PCB on the neck of the CRT or wherever) and measure again and observe any change in picture.

- If still low, then almost certainly there is a problem with the pot or the flyback. See if you can open it enough to measure and/or disconnect the pot. If the problem is inside the potted part of the flyback, the only alternative is a new flyback or an external divider if you are so inclined. However, once the focus network goes bad inside the flyback, there is an increased chance other parts will fail at some point in the future.

- If the voltages check out with the CRT disconnected, there is a chance of a bad CRT or of a shorted component on the PCB on the neck of the CRT. Look for shorted capacitors or burnt or damaged traces.

Measure the voltage on the focus pin of the CRT. WARNING: If there is an internal short, you could have the full 25kV+ at this location! If you get a reading, this would be an indication of an internal short in the CRT. See the section "Shorts in a CRT".

Bad focus (fuzzy picture)

Focus voltage on the CRT is usually in the range of 2-8 kV DC and should be controllable over a fairly wide range by the focus pot - usually located on the flyback or a little panel in its vicinity:

- If adjusting the pot results in a position of acceptable focus, you may be done. It is not unusual for the focus setting to drift a over time.
- If the setting is already as good as possible but not really good enough, the CRT may be tired. Alternatively, the filament voltage may be too low. Check for bad connections in the filament circuit.
- If the optimal setting is out of range of the focus pot, the problem is likely leakage in the focus divider in the flyback or one of the components on the CRT neck board.

Also see the sections: Focus adjustment and Focus drifts with warmup.

The focus wire usually comes from the flyback or if the general area or from a terminal on a voltage multiplier module in some cases. It is usually a wire by itself going to the little board on the neck of the CRT.

If a sparkgap (a little 2 terminal device with a 1/8" gap in the middle) is arcing with power on, then the resistive divider has shorted inside the flyback, focus board, or HV multiplier - whatever you TV has - and the this unit will need to be replaced. Ditto if the SCREEN control affects focus and/or vice-versa.

Using a suitable high voltage meter (range at least 10 kVDC, 1000 M ohm or greater input impedance), you should be able to measure it connected and disconnected. The ground return will be the outside coating of the CRT which may or may not be the same as the metal chassis parts. If the voltage is very low (less than 2 kV) and the pot has little effect:

- When measured right off of the source disconnected from the CRT neck board, then the problem is probably in the focus network in the flyback (or wherever it originates). Sometimes these can be disassembled and cleaned or repaired but usually requires replacement of the entire flyback or voltage multiplier. Note: you may need to add a HV (10 kV) capacitor between the focus wire and DAG ground to provide filtering so you get a DC level for your meter.
- When measured with the focus wire attached to the CRT neck board with the CRT connected but reasonable with the CRT unplugged, there is probably a short between the focus and another electrode inside the CRT. See the section: Rescuing a shorted CRT.
- When measured with the focus wire attached to the CRT neck board with the CRT unplugged, there is likely a component on the CRT neck board that is leaky or breaking down. Also, check for decayed (tan or brown) glue which may turn leaky with age.

Focus drift with warmup

This could be due to a problem with the focus voltage power supply, components on the CRT neck board, or a tired worn CRT.

Focus is controlled by a voltage of 2-8 kV DC usually derived from the flyback transformer and includes some resistors and capacitors. One of these could be changing value as it warms up. (assuming nothing else changes significantly as the unit warms up - e.g., the brightness does not decrease.)

Focus voltage is derived from a subset of the high voltage winding on the flyback using a resistive voltage divider which includes the focus pot. These are extremely high value resistors - 200 M ohm is common - and so leakage of any kind can reduce or increase the focus voltage. All other things being OK - i.e., the picture is otherwise fine - I would suspect this type of failure rather than the CRT.

The connection to the CRT is usually a separate wire running from the flyback or its neighborhood to the CRT neck board. Look for components in this general area. Use cold spray or a heat gun to isolate the one that is drifting. If you have access to a high voltage meter, you should be able to see the voltage change as the TV or monitor warms up - and when you cool the faulty part. If it is in the flyback, then sometimes the part with the adjustments clips off and can be repaired or cleaned. Most often, you will need to replace the flyback as a unit.

- If the optimal adjustment point of the focus control doesn't change that much but the best focus is simply not as good as it should be, the CRT is probably the problem. However, if the optimal point produces acceptable focus but it changes (and possibly moves off of one end of the adjustment knob range) as the unit warms up, the flyback or one of the components on the CRT neck board are likely drifting.

- If you have a high voltage meter, you can measure the focus voltage to determine if it is being changed by the focus pot and if it is in the ball park (2-8 kV typical). Sometimes, the part of the flyback with the focus pot can be snapped off and cleaned or parts replaced but usually you need to replace the whole unit. There may a capacitor or two on the PCB on the neck of the CRT that could have increased leakage as well thus reducing the focus voltage.

- To determine if the CRT is the problem, for sharp focus after the unit has warmed up. Power-off for an hour or so and carefully pull the CRT neck board off of the CRT. Then, power up the unit. Let it run long enough such that there would have been a detectable focus drift. Now, power-down, plug the CRT neck board back in, and power-up. Watch the image as it appears on the screen:

    - If the focus starts out fuzzy and sharpens up as the image appears and gradually becomes sharper as the CRT warms up the CRT is likely tired.

      The only catch here is that plugging the CRT neck board into the CRT results in an additional load on the flyback due to the picture beam current which heats it more as well. Thus, if the problem takes a few minutes to appear, keep the brightness turned down except to check the appearance of the picture from time to time.

      You can set the focus control for optimum when warmed up and just turn the monitor on in advance of when you will be needing it or add a user focus adjustment by drilling a hole in the plastic case for an *insulated* screwdriver or flyback focus knob extender :-). The CRT may continue to function for quite a while so this is not impending doom.

    - If the focus is relatively stable as the image appears and increases in brightness *and* is about as sharp as it would be with the monitor warmed up, the problem is most likely in the flyback. However, also check for bad components or decayed (tan or brown) glue on the CRT neck board. A drifting flyback will need to be replaced as it will probably get worse and fail completely. Clean the surface of the circuit board and CRT socket in the vicinity of the focus and screen terminals and traces. Contamination or just dirt and grime can easily cause problems especially on humid days since the resistance of these circuits is extremely high (100s of M ohms).

    - If the focus is relatively stable as the image appears and increases in brightness *and* is similar to what it would be with the monitor cold, you have a very strange situation where some load on the high voltage power supply, perhaps, is causing a thermal problem. This would be rare.

About the quality of monitor focus

Question: I have 2 identical monitors. One is razor sharp from edge to edge. The other is blurred at the corners- not from convergence problems, but just plain out of focus. In this monitor, the focus adjustment on the flyback can improve the focus at the edges, but then the center of the screen becomes worse..My question is : Is this a problem in the electronics and presumably a fixable flaw or is it caused by variance in the picture tube itself and not correctable ? Or is it some other issue?

(From: Bob Myers (myers@fc.hp.com).)

The adjustment on the flyback sets the "static" focus voltage, which is a DC voltage applied to the focus electrode in the CRT. However, a single fixed focus voltage will not give you the best focus across the whole CRT screen, for the simple reason that the distance from the gun to the screen is different at the screen center than it is in the corners. (The beam SHAPE is basically different in the corners, too, since the beam strikes the screen at an angle there, but that's another story.) To compensate for this, most monitors include at least some form of "dynamic" focus, which varies the focus voltage as the image is scanned. The controls for the dynamic focus adjustment will be located elsewhere in the monitor, and will probably have at LEAST three adjustments which may to some degree interact with one another. Your best bet, short of having a service tech adjust it for you, would be to get the service manual for the unit in question.

It is also possible that the dynamic focus circuitry has failed, leaving only the static focus adjust.

As always, DO NOT attempt any servicing of a CRT display unless you are familiar with the correct procedures for SAFELY working on high-voltage equipment. The voltages in even the smallest CRT monitor can be lethal.

Bad focus and adjustment changes brightness

This is the classic symptom of a short between the focus and screen supplies - probably in focus/screen divider which is part of the flyback or tripler. However, it could also be in the CRT. If you have a high voltage meter, measuring the focus voltage will show that (1) it is low and (2) it is affected by the SCREEN control Similarly, the SCREEN voltage will be affected by the FOCUS control (which is what is changing the brightness.

To determine if the problem is in the CRT, measure the FOCUS and SCREEN voltage with a high voltage meter. If they are identical pull the plug on the CRT. If they are now their normal values, then a shorted CRT is a distinct possibility - see the section: Rescuing a shorted CRT.

Charlie's comments on focus problems

(From: Charles Godard (cgodard@iamerica.net).)

Most true focus problems that I have encountered (when the IHVT is ok) are related to leaks or resistance on the focus output. The diming of the screen when the focus pot is adjusted leads me to think in terms of a leaky socket. I'd remove the ground from the crt socket to the tube dag and see if it sparks. If so there may be a leak in the socket to ground. It could also be leaking to another pin, such as the screen grid. A rhetorical question: What happens to the screen voltage when the focus pot is adjusted?

I have seen sockets that had no arching or other telltale signs, leak through the plastic housing to ground out the focus voltage.

Look closely at the screen. If the blurring is in the form of small circles, then you have an open or hi-resistance focus electrode inside the tube. The circles may vary in visibility with brightness.

If you still haven't found the problem, try to confirm that this is truly a focus problem. Remove the crt socket and observe the hi-voltage. If it climbs more than about 1k, say all the way up to 25kv, then you may have a beam current problem rather than a focus problem. In that case re-check all crt board voltages. WARNING: Removing the CRT socket and powering the unit may destroy the CRT on some models. See the section: Warning about disconnecting CRT neck board.

If you have done all of the above and removing the socket makes no change in the hi-voltage, then try to determine why the hi-voltage is low.

Watch the screen as the brightness, contrast, or screen control are adjusted. See if you can observe any signs of blooming. When the IHVT doesn't provide enough current to satisfy the demands of the tube for current, the the picture tends to appear to expand like a balloon. i.e., bloom. This can be caused by not enough drive to the IHVT. Carefully monitor the b+ to the horizontal drive stages to see that is is stable and correct.

Purple blob - or worse

Have you tried demagnetizing it? Try powering it off for a half hour, then on. Repeat a couple of times. This should activate the internal degausser. See the section: Degaussing (demagnetizing) a CRT.

Is there any chance that someone waved a magnet hear the tube? Remove it and/or move any items like monster speakers away from the set.

Was your kid experimenting with nuclear explosives - an EMP would magnetize the CRT. Nearby lightning strikes may have a similar effect.

If demagnetizing does not help, then it is possible that something shifted on the CRT - there are a variety of little magnets that are stuck on at the time of manufacture to adjust purity. There are also service adjustments but it is unlikely (though not impossible) that these would have shifted suddenly. This may be a task for a service shop but you can try your hand at it if you get the service manual - don't attempt purity adjustments without one.

If the monitor was dropped, then it is even possible that the internal shadow mask of the CRT has become distorted and you now have a seventy-five pound boat anchor. See the "Sony1" and "Sony2" photos in James Sweet's Sony/Trinitron Directory for some screen shots showing the symptoms resulting from a monitor falling on its face. :(If the discoloration is slight, some carefully placed 'refrigerator' magnets around the periphery of the tube might help. See the section: Magnet fix for purity problems - if duct tape works, use it!

It is even possible that this is a 'feature' complements of the manufacturer. If certain components like transformers are of inferior design and/or are located too close to the CRT, they could have an effect on purity. Even if you did not notice the problem when the monitor was new, it might always have been marginal and now a discoloration is visible due to slight changes or movement of components over time.

Color rings - bullseye pattern

This probably means the degaussing circuitry is terminating suddenly instead of gradually as it should. The most likely cause is a bad solder connection to the degauss thermistor or posistor or something feeding it.

You can confirm this by manually degaussing the screen with the TV or monitor turned on. If the problem disappears, the above diagnosis is probably valid. Check for bad solder connections in the vicinity of the degauss components and

AC line input.

Magnet fix for purity problems - if duct tape works, use it!

The approach below will work for slight discoloration that cannot be eliminated through degaussing. However, performing the standard purity adjustments would be the preferred solution. On the other hand, the magnets may be quick and easy. And, where CRT has suffered internal distortion or dislocation of the shadowmask, adjustments may not be enough.

In any case, first, relocate those megablaster loudspeakers and that MRI scanner with the superconducting magnets.

The addition of some moderate strength magnets carefully placed to reduce or eliminate purity problems due to a distorted or dislocated shadowmask may be enough to make the monitor usable - though it will probably not be perfect. The type of magnets you want are sold as 'refrigerator magnets' and the like for sticking up notes on steel surfaces. These will be made of ferrite material (without any steel) and will be disks or rectangles. Experiment with placement using masking tape to hold them in place temporarily. Degauss periodically to evaluate the status of your efforts. Then, make the 'repair' permanent using duct tape or silicone sealer or other household adhesive.

Depending on the severity of the purity problem, you may need quite a few magnets! However, don't get carried away and use BIG speaker or magnetron magnets - you will make the problems worse.

Also note that unless the magnets are placed near the front of the CRT, very significant geometric distortion of the picture will occur - which may be a cure worse than the disease.

WARNING: Don't get carried away while positioning the magnets - you will be near some pretty nasty voltages!

(From: Mr. Caldwell (jcaldwel@iquest.net).)

I ended up with the old 'stuck on a desert island trick':

I duck taped 2 Radio Shack magnets on the case, in such a way as to pull the beam back.!!!!

A $2 solution to a $200 problem. My friend is happy as heck.

RCA sells magnets to correct corner convergence, they are shaped like chevrons and you stick them in the 'right' spot on the rear of the CRT.

(From: Tom Sedlemyer (wesvid@gte.net).)

First set purity as best you can.

Obtain some pieces of refrigerator door magnet strips from an appliance repair shop (they usually have some lying around).

Cut the strips into 1 inch pieces. Place a strip as on the bell of the picture tube as close to the yoke as possible and in line with the corner that has the purity error. Rotate the magnet until you correct the purity error and tape it in place. Multiple magnet strips can be used and you may experiment with the size of the strips for best effect. It is very important that the strips are positioned close to the yoke or the effect will not hold. The only drawback to this method is some very slight distortion of the geometry of the raster, but it beats hell out of paying for a new CRT.

Color monitor only displays one color

I assume that now you have no other colors at all - no picture and no raster. Let us say it is red - R.

It is probably not the CRT. Do you have a scope? Check for the R, G, and B video signals at the CRT. You will probably find no signals for the defective colors.

This is almost certainly a chroma circuit problem as any failure of the CRT or a video driver would cause it to lose a single color - the other two would be ok. Therefore, it is probably NOT the CRT or a driver on the little board on the neck of the CRT.

Try turning up the SCREEN control to see if you can get a G and B raster just to confirm that the CRT is ok.

Locate the video drive from the mainboard for the good and a bad color. Interchange them and see if the problem moves. If so, then there is a video signal problem. If not, it is on the little CRT board.

It could be a defective chroma IC or something else in the chroma decoder.

Disappearing Red (or other color)

Problem: I have been given an old colour TV. The reception is good, but very often, when the contrast and brightness of the TV image is low (e.g. when a night scene is shown), the red colour slowly disappears, leaving behind the green and blue image and many red lines.

The remaining red retrace are the giveaway that this is most likely not a CRT problem.

(If there were no red lines, it could be the filament for the red gun of the CRT going on and off due to a bad connection inside the CRT - bad news.)

How is a black and white picture? (Turn down the color control).

If B/W picture is good, then the problem is somewhere back in the chroma decoder circuitry.

Check the video input to the CRT video driver board and signals on that board. If B/W picture is also bad, then you can compare red and green signals to determine where they are becoming different. The red lines in your description sounds like the red video output circuit is drifting and messing up the background level, blanking, screen, or other setting. Could be a capacitor or other component.

Interference resulting in jiggling or wiggling

Note: similar symptoms can be the result of a monitor defect or running the monitor at scan rate beyonds its capabilities. However, magnetic interference from electrical wiring, other equipment is very common and sometimes overlooked when looking for a complex, expensive, and obscure explanation for a misbehaving monitor (or TV).

Also, if your outlet is not grounded, I have heard of similar symptoms under certain conditions. Grounding IS essential for safety should a short circuit fault develop in the PC as well as to get the most benefit from a surge suppressor so now is a good time to upgrade!

Interference from electrical wiring

If the wiring of normal outlets is done correctly even without a safety ground, the currents should be balanced and you will not experience a problem. However, many circuits, particularly those involving setups like 3-way switches or switched outlets and wiring in older buildings can have unbalanced currents when active. If your monitors are close enough to the wiring, there can be interference which will take the form of a flickering or pulsating display.

Other than recommending moving the monitors, there is no easy solution. They can be shielded with Mu Metal but that is expensive. Or you could run all displays at a 60 Hz vertical rate (or 50 Hz depending on where you live). However, this is inconvenient and will never be quite perfect.

If you have flexibility during construction or renovation, there are ways to minimize the chance of unexpected behavior later:

Think of it this way: If the sum of the currents in the cable are zero, there will be no magnetic field to worry about. This will be the case for normal 110 VAC branch circuits.

Some sources for magnetic interference:

- Three (or more) way circuits - lamps or fixtures controlled from more than one location which use a 'traveler'. In this case, a single energized wire runs between switches and/or the switches and the load.
- Circuits which do not have their return in the same cable. For example, ceiling fixtures controlled from a wall switch but where the Hot comes from another location. Or, a string of baseboard heaters fed from opposite ends.
- Circuits which share a Neutral but where one or more of the Hots are not in the same cable. This is more likely to be found in old construction using knob-and-tube wiring where circuits were just connected in the most convenient way.
- Loops in Neutral and Ground conductors. The way circuits are supposed to be wired (U.S.A. at least) is nearly always in a star sort of configuration where the Neutral and Ground conductors never connect at the ends of the 'star'. However, due to poor wiring practices, it is quite possible for Neutrals to be connected to other Neutrals or Grounds to be connected to other Grounds or for them to be cross connected at various locations - all without any other symptoms. This can even happen between buildings. See the section: Interference from cross-connected buildings. However, the likelihood of this sort of fault isn't that great.

First confirm that the problem is due to inside wiring - shut off all power to the building (if possible) or at least switch off each circuit in turn to see if the problem disappears (run the monitor from a UPS or a remote outlet).

- If the symptoms persist, check for external sources of interference (although there could still be a Ground-Neutral loop formed by the connection between G and N at the service panel or to other buildings. In this case, the effect would likely be strongest near the service panel.). See the section: Interference from power lines.
- If the symptoms are gone, try to narrow down the circuit or circuits that are responsible by switching each one on individually.

In all cases, running the Hots and Neutrals for the circuit in the same cable (or at least in close proximity) will avoid this problem as the total current will sum to zero.

Realistically, you would have to be very unlucky to have a noticeable problem in residential wiring except near the service panel or high power appliances like baseboard heaters, equipment with large motors or transformers, etc.

Interference from power lines

Power lines (any size from local distribution to large intercontinental transmission lines) nearby can result in noticeable effects to monitors as a result of the magnetic fields surrounding the individual wires - similar to that from unbalanced inside wiring (see the section: Interference from electrical wiring. TVs may not be affected, at least not as much, since they will be running at a vertical rate almost the same as the power line frequency).

The severity of the effects will vary depending on the load distribution on the three (probably) phases, distance, orientation with respect to the monitor, etc. Moving the monitor as far from the offending power lines as possible, experimenting with its orientation, and seeing if you can live with a vertical scan rate equal to the power line frequency, are the only realistic options other than constructing an expensive mu-metal box for it. Check out MuShield specifically under "Monitor Enclosures" if you're curious. Less EMF, Inc. sells Mu-metal foil by the foot but what they have listed is rather thin - I don't know how well it would work for monitor CRT shielding.

Interference from cross-connected buildings

Here is a rare case where the neighbor was really at fault (in a historical sort of way).

(From: Tuyen Tran (ttran@ziplink.net).)

Get this: my house and my neighbor's house were grounded together, so we connected to the power company's neutral in two places. The way I understand it, this caused a ground loop between our two panels. My neighbors used to own this place. When they built a small house next door, instead of digging a separate well, they just ran a 3/4 inch copper pipe between my water tank and their new place. (This place used to be a dairy farm, so it had plenty of water capacity.) When they installed their panel, the electrician of course bonded their water pipes to the panel, which then connected our two grounds together. When they sold the place, they put in their own well, but nobody bother to cut the original pipe linking the two houses together. It's been like this for at least 40 years; I'm the third owner!

So I took a pipe cutter to the thing, and no more interference.

Interference from other equipment

Any type of equipment which uses or generates strong magnetic fields can interfere with a monitor. Other computer monitors or TVs, equipment with power transformers, and electric motors will cause a pulsating or flickering display. Loudspeakers or other equipment with static magnetic fields will cause color purity and/or geometric distortion problems which degauss will not cure.

The easiest way to confirm that interference is your problem is to move the monitor or suspect equipment to a different location. The only real solution is to separate the monitor and interfering device.

Note that with scan rates that are not even near the power line frequency any more, a variety of symptoms are possible including shimmering, wiggling, undulating (how many more adjectives can you come up with?). The rate of the movement will be related to the difference between the monitor scan rate and the frequency of interference.

My monitor is possessed!

Problems are that all graphics applications fade to black, lose their color on parts of the screen, and there are strange pincushion problems on the right side of the monitor? This all came up suddenly, with no apparent changes your my part.

You tried changing video drivers, modes, cleaning connections on cables and video card, even pulled the card and cleaned the edge connector.

After cleaning up, things seemed to work (still had pincushion problem), but next time it was powered on, same weird problems.

Voodoo might be required but more down-to-earth causes are likely:

Are you sure nothing changed in the building (like you installed a medical MRI unit with a 2T magnet in the same room)?

All monitors have a built in degauss circuit which operates when power is turned on after being off for at least 15 minutes or so. This could have failed - it is switching off suddenly instead of ramping down as it should - and is making the problem worse or you could have a power supply failure inside the monitor.

Gradual variations in color or brightness on the screen or over time are almost always monitor problems, not video card, software, or cables.

It won't hurt to try manual degauss with the monitor powered, see below. If this clears it up - possibly until you turn the power off and on again, then it may be the internal degauss circuitry.

Shimmering image due to vibrations

If your monitor uses a Trinitron or clone CRT, then this may be normal. Even with the 1-3 unsightly stabilizing wires running across the screen, the vertical aperture grille wires in a Trinitron type CRT can wiggle as a result of mechanical shocks or vibration. Any movement results in momentary changes in color purity, color balance, brightness. Gently tap on the side of the monitor and you may see the same effect.

Wiring transmitted interference

The power that comes from the wall outlet is supposed to be a nice sinusoid at 60 Hz (in the U.S.) and it probably is coming out of the power plant. However, equipment using electric motors (e.g., vacuum cleaners), fluorescent lamps, lamp dimmers or motor speed controls (shop tools), and other high power devices, may result in a variety of effects.

While monitors normally include some line filtering, the noise immunity varies. Therefore, if the waveform is distorted enough, some effects may show up even on a high quality monitor.

Symptoms might include bars of noise or distortion moving slowly or rapidly up or down the screen or diagonally. This noise may be barely visible as a couple of jiggling scan lines or be broad bars of salt and pepper noise, snow, or distorted video.

The source is probably local - in your house and probably on the same branch circuit - but could also be several miles away.

- One way to determine if the problem is likely to be related to AC power is to switch your vertical scan rate to match the power line frequency: 60 Hz in the U.S., 50 Hz in most European countries, etc. If the pattern of noise or distortion is now stationary (or at most slowly drifting up or down the screen), the interference is likely power line related:

  - A single bar would indicate interference at the power line frequency.

  - A pair of bars would indicate interference at twice the power line frequency.

  Either of these are possible.

- Try to locate the problem device by turning off all suspect equipment to see if the problem disappears.

- The best solution is to replace or repair the offending device. In the case of a light dimmer, for example, models are available that do a better job of suppressing interference than the typical $3 home center special. Appliances are supposed to include adequate noise suppression but this is not always the case.

  If the source is in the next county, this option presents some significant difficulties :-).

- Plugging the monitor into another outlet may isolate it from the offending device enough to eliminate or greatly reduce the interference.

- The use of a line filter may help. A surge suppressor is NOT a line filter.

- Similar symptoms could also be produced by a defective power supply in the monitor or other fault. The surest way of eliminating this possibility is to try the monitor at another location.

Jittering or flickering due to problems with AC power

If you have eliminated other possibilities such as electromagnetic interference from nearby equipment or electric wiring or a faulty video card or cable - or software - then noisy or fluctuating AC power may be a possibility. However, modern monitors usually have well regulated power supplies so this is less common than it used to be. Then again, your monitor may just be overly sensitive. It is also possible that some fault in its power supply regulator has resulted in it becoming more sensitive to minor power line fluctuations that are unavoidable.

One way to determine if the problem is likely to be related to AC power is to run the monitor on clean power in the same location on the same computer. For example, running it on an Uninterruptible Power Source (UPS) with the line cord pulled from the wall socket would be an excellent test. The output of the UPS's inverter should be free of any power line noise. If the monitor's image has now settled down:

1. Large appliances like air conditioners, refrigerator, or washing machines on the same circuit might cause significant power dips and spikes as they cycle.

   Plugging a table lamp into the same outlet may permit you to see any obvious fluctuations in power. What else is on the same circuit? Depending on how your house or apartment is wired, the same feed from the service panel may be supplying power to widely separated areas.

2. For some unfathomable reason, your monitor may just be more sensitive to something about the power from the circuit in that room. There may be nothing actually wrong, just different. While unlikely, a light dimmer on the same circuit could be producing line-conducted interference.

   If you have a multimeter, you could at least compare the voltages between the location where it has problems and the one where it is happy. Perhaps, the monitor is sensitive to being on a slightly different voltage. This might only be a problem if some circuitry in the monitor is marginal in some respect to begin with, however.

3. There could be a bad connection somewhere on the circuit. If your house has Aluminum wiring, this is a definite possibility.

   Try a table lamp since its brightness should fluctuate as well. This should be checked out by a competent electrician as it represents a real fire hazard.

An electrician may be able to pinpoint the cause but many do not have the training or experience to deal with problems of this sort. Certainly, if you find any power line fluctuations not accounted for by major appliances, on the same circuit this should be checked by an electrician.

My monitor has the shakes

You turn on your monitor and 5-10 seconds later, the display is shaking or vibrating for a second or so. It used to only occur when first turned on, but now, the problem occurs 3 times in 30 seconds. Of course, many variations on this general theme are possible.

Some possibilities:

1. Defective degauss circuit - this would normally cause a shaking or vibration when you first turn it on but you normally do not notice it since the CRT is not warmed up. The degauss circuit may have developed a mind of its own.

2. Other defective circuitry in monitor - power supply regulation, deflection, or bad internal connections.

3. External interference - did you change anything or move your setup recently? See the sections on: "Interference from other equipment", "Interference from electrical wiring", and "Interference from power lines".

4. Defective video cable (unlikely). Wiggle the VGA cable to be see if you can induce the problem.

5. Loose trim magnets of other magnetic components on or near deflection yoke. This is somewhat rare but if the adhesive comes apart, the magnetic fields from the deflection current can cause the parts to vibrate which will result in a jitter or movement of the picture. There may even be audible crackling or snapping sounds associated with this vibration.

Fred's comments on monitor interference problems

(From: Fred Noble) Fred_Noble@msn.com).)

Monitors are very susceptible to electromagnetic fields. If any of the following is "yes" it may point to an 'electrical' cause of the Monitor problem.

- Do you have a ceiling fan in the same room turned on?
- Do you have a wireless telephone in the room?
- Do you get similar effects on your TV?
- Are you near a large transformer, substation, or high voltage overhead wires?
- Is your computer located close to the meter on the other side of the wall?
- Do you have speakers next to the monitor? Are they shielded?
- Do you have a phone or other device with a magnet in it near the monitor?
- Is the cabling routed too near a printer cable?
- Do you have a surge/power strip or UPS near your monitor?

Reposition the monitor or move it to a different location. Also make sure that you are turning the monitor on first and then the system to ensure that the video card is properly recognizing the monitor.

Check cable connections (make sure no other cables are crossing the monitor cable. If you have an extension on the monitor output cable then remove it as well.

Try swapping out the monitor to verify if it really is the monitor or take your monitor to another system and see how it responds there.

If you are plugging the monitor into a surge strip, remove it from there and plug the monitor directly in the wall outlet.

Discussion:

There might be an ambient RFI/EMI electrical or magnetic field present around your computer location. Some of the electrical field or the conducted RFI/EMI electrical "noise" causes are considered here.

Rough summary of excessive magnetic & electric fields:

- Cause: Electrical wiring errors.

  Electrical wiring errors such as inappropriate or non-NEC code neutral to ground bonds in the facility (not at the common bus in the mains), and other non-NEC Code wiring that results in the HOT wire fields not being OFFSET by the neutral wire fields.

  Incorrect wiring will be aggravated (and will be noticed first) on a circuit where there is an Air Conditioner, copier, laser printer.

  Correction: This is an electrical problem that has resulted in a *net current* flowing in the facility and is also a shock hazard.

  Don't use devices that dump current onto the neutral line, and have an electrician correct the wiring to NEC code.

- Cause: Magnetic flux linkages.

  It is normal for transformers to use magnetic flux linkages (to couple primary to the secondary).

  Correction: Keep transformer based equipment away from sensitive equipment.

  There are other corrective measures here that can be discussed on the design level and on the application level.

  If the transformer is used to power a "noisy" load (high harmonics) perhaps a good harmonic filter can be used between the transformer and the load (example a good UL 1283 noise filter or Surge suppressor with UL 1283 filter).

- Cause: Motors also use magnetic flux linkages in normal usage.

  Correction: Keep large, active, motors away from sensitive equipment (and try to keep them on a different circuit if possible).

  The use of a good harmonic filter on that circuit will help reduce the harmonics (for example, a good surge suppressor with a UL 1283 RFI/EMI filter, or a Line Conditioner).

- Cause: UPSs, especially when on inverter (during brownout or blackout) create magnetic & electric fields.

  Correction: Keep them away from sensitive loads, and advise manufacturer of problems encountered with the UPS.

  The UPS may have a faulty inverter circuit or part, or may be in need of a re-design.

Loss of color after warmup

If there is a general loss of picture but there is light on the screen if the brightness is turned all the way up, then this is a video input, video amplifier, RGB driver, or power supply problem.

If it recovers after being off for a while, then you need to try a cold spray in the video/controller to identify the component that is failing. Take appropriate safety precautions while working in there!

If it stays broken, then most likely some component in the video circuitry, controller, or its power supply as failed. There is a good chance that it is a bad colder connection - the trick is to locate it!

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Miscellaneous Problems

Contour lines on high resolution monitors - Moire

These fall into the category of wavey lines, contour lines, or light and dark bands even in areas of constant brightness. (Some people may refer to this phenomenon as "focus or Newton's rings".) These may be almost as fine as the dot pitch on the CRT or 1 or 2 cm or larger and changing across the screen. If they are more or less fixed on the screen and stable, then they are not likely to be outside interference or internal power supply problems. (However, if the patterns are locked to the image, then there could be a problem with the video board.)

One cause of these lines is moire (interference or beat patterns) between the raster or pixels and the dot structure of the CRT. Ironically, the better the focus on the tube, the worse this is likely to be. If the individual pixels do not cover enough phosphor dots, then the actual color and brightness displayed won't match what the video card is generating and this will depend on the actual location of the pixel relative to the phosphor dots. Trinitrons, which do not have a vertical dot structure should be immune to interference of this sort from the raster lines (but not from the horizontal pixel structure). Slot mask CRTs (not that common on monitors) also have fewer problems with vertical moire.

You can test for moire by slowly adjusting the picture size. If it is moire, you should see the pattern change in location and spatial frequency as slight changes are made to size. Changes to position will move the patterns along with the picture without altering their character and structure significantly (though fine detail will change).

If they are due to the raster line structure - your focus is too good - the patterns will remain essentially fixed in position on the face of the CRT for horizontal size and position adjustments - the patterns will remain fixed under the changing image.

How to eliminate it? If moire is your problem, then there may be no easy answer. For a given resolution and size, it will either be a problem or not. You can try changing size and resolution - moire is a function of geometry. Ironically, I have a monitor which is nicer in this respect at 1024x768 interlaced than at 800x600 non-interlaced.

Some monitors have a 'Moire Reduction Mode' switch, control, or mode. This may or may not be of help. One way to do this is - you guessed it - is to reduce the sharpness of the beam spot and make the picture fuzzier! Another approach adds a high frequency dither to the beam spot position which may result in a headache! You might find these cures to be worse than the disease.

Another cause of similar problems is bad video cable termination creating reflections and ghosting which under certain conditions can be so severe as to mimic Moire effects. This is unlikely to occur in all colors with a VGA display since the termination is internal to the monitor and individual resistors are used for each color (RGB).

I think it is ironic that some people will end up returning otherwise superb monitors because of moire - when in many cases this is an indication of most excellent focus - something many people strive for! You can always get rid of it - the converse is not necessarily true!

Moire and shadow mask dot pitch

(From: Bob Myers (myers@fc.hp.com).)

The density of the holes in the shadow mask set an upper limit on the resolution supported by that monitor. Lower resolutions work just fine; there is no need to have the logical pixels in the image line up with the physical holes in the mask (nor is there any mechanism to make this happen), and so you can think of this as the "larger pixels" of the lower-res image simply covering more than one hole or slot in the mask.

As the effective size of the pixels in the image approach the spacing of the mask holes, individual pixels are no longer guaranteed to cover enough phosphor dots on the screen to ensure that they are constant color or constant luminance, but an image will still be displayed which ON AVERAGE (over a reasonably large area) looks OK. Actually, the specified "top end" format ("resolution") for most monitors usually is at or slightly beyond this point - the effective pixel size is somewhat UNDER the dot pitch.

Sources of external interference that can affect the monitor display

The following list is just some of the ways your picture can get screwed up through no fault of the monitor. It's sort of amazing they work as well as they do! Most of these are discussed in greater detail in subsequent sections.

Static/DC magnetic fields:

- Unshielded/inadequately shielded multimedia speakers
- Stereo loudspeakers
- MRI scanner next door.

Transient magnetic fields:

- Kid's (or adults) playing with magnets
- Electro-Magnetic Pulse (EMP) from nearby lightning strike or nuclear blast
- Changing monitor location or orientation without degaussing.
- Shift in Earth's magnetic field every 10-20K years. :)

AC magnetic fields (usually at power line frequency):

- AC or DC wall adapters/transformers
- Fluorescent lamps (magnetic ballast)
- Laser printer and other peripherals
- TV, VCR, DVD, or other A/V equipment
- Additional computer monitor(s) too close
- Large appliances including furnace, A/C, fridge, microwave

- Wiring in walls (unbalanced load/shared Neutral)
- Wiring in electrical service panel
- Outside wiring and power distribution equipment

Radio Frequency Interference:

- High power radio transmitter nearby (broadcast, military, amateur)

Power Line Transmitted Interference:

- Lighting on dimmers (incandescent/halogen lamps/fixtures)
- Motor speed controls (ceiling fans)
- Fluorescent lamps (all types)
- Vacuum cleaners/shop equipment/other brush type motors
- Equipment using switchmode power supplies
- Heavy industry down the street

Interference affecting video signal:

- Lack of earth/safety ground (line filter ineffective)
- Ground loop caused by PC and monitor plugged into different circuits
- Cross connected buildings resulting in ground loop

Interference between monitor and VCR or TV

> "I've got a desktop computer with a VGA monitor above it. To the left of it (a few inches away), I have a VCR with a Commodore composite monitor above it (1084 model). I don't have Cable TV or anything special, just a simple antenna connected to the VCR to pick up the two local TV stations.
>
> The reception is pretty good with the computer off, but the problem arises when I turn the computer on. The VCR is already plugged into a different outlet than the computer. Since I am into video production, I need this setup as it is laid out (close together).
>
> So, how can I shield the VCR from the interference from the computer? Can I do something with the antenna to make the signal stronger, or can I place some kind of material between the VCR and computer?"

Your PC is a serious RF emitter. Areas of leakage include the case as well as the possibly the monitor and cable. Turn off the monitor and/or unplug the video cable to see if it is the latter.

You PC's case may not have adequate shielding. Better cases have grounding fingers and proper RF shielding throughout - that is one reason they are more expensive. This may be an option.

The VCR may be picking up the interference internally or via its antenna.

There may be some options but you first need to determine where the interference is coming from and where it is being picked up.

Cable installed upside-down - now monitor does not sync correctly

> "I have an old vga monitor that I screwed up. I plugged it into the vga card upside down. Now I know that seems impossible, but believe me, it isn't.
>
> Now the vertical is fine, but the horizontal is all screwy. (is that a word? screwy?) It's about 8" wide and can't be adjusted to normal size.

> The result is a very, um, interesting image. Is it possible that I did some minor damage like blowing a cap, diode, or horizontal transistor?"

I'll give you 100:1 odds that you bent the H sync pin and it is now bent over and not inserted in its hole. Remove the connector, and examine the pins - if this is the case, take a pair of needlenose pliers and **very carefully** straighten it out. If it was pushed in, grab hold and pull it out to the same length of the other pins and if necessary, put a drop of adhesive at its base to prevent it from being pushed in again. If it breaks off or is unreachable, you will need to replace the connector (unless the shell comes apart which is usually impossible or at least not easy on newer monitors).

Isolated spots on display

These could be a problem with the video source - bad pixels in the video card's frame buffer or bad spots on a camcorder's CCD, for example. Or, they could be dirt or dead phosphor areas in the CRT. Except for problems with the on-screen character generator, it is unlikely that the monitor's circuitry would be generating isolated spots.

You can easily distinguish between video problems and CRT problems - missing pixels due to the video source will move on the screen as you change raster position. CRT defects will remain stationary relative to the screen and will generally be much more sharply delineated as well.

There is a specification for the number and size of acceptable CRT blemishes so you may have to whine a bit to convince the vendor to provide a replacement monitor under warranty.

Power saving problems

Modern monitors are usually designed to permit software to control various levels of power saving ('green') features from blanking the screen to totally shutting down. Problems can occur if the software to control these features is not compatible with the monitor or not set up correctly or is attempting to control a monitor that lacks power saving modes or is defective or incompatible.

A monitor that behaves normally under most conditions but emits a high pitched whine when the computer attempts to direct it into power saving mode is probably not understanding the commands or does not have the appropriate power saving features. It probably behaves about the same as if there is no video signal - which indeed may be the case as far as it is concerned.

Many monitors not receiving proper sync signals are perfectly happy driving everyone in the office insane with that high pitched whine. Others will blow up eventually.

Recommendation: Don't use power saving until you have the proper software and you know what your monitor supports. Of course, your monitor could be defective and your current software is actually fine. Check your user manuals to determine compatibility and setup parameters. Also see the sections: Monitor life, energy conservation, and laziness and Implications of power saving modes.

Monitor drift?

Problem: I have a 17" monitor that has an image that EVER SO SLIGHTLY drifts to the left (and stops) after a long day's work (heat, I suppose). Also, the vertical height shrinks a little bit. Is this at all normal/acceptable?

How much is 'ever so slightly'? There are a fair number of components whose values could alter the position/size of a monitor image. I do not find it at all surprising that there should be a small shift due to heat. It really depends on many factors including the basic design, quality of components, ventilation/cooling, etc. Of course, it is possible to have a monitor that has a component that is worse with respect to temperature. Could also be related to line voltage depending on the regulation of your monitor's power supplies.

In general, my feeling is that if it is not objectionable (a 1/2" shift would be objectionable) AND it's severity is not changing with time, you can ignore it.

Many monitors do this. TVs do this but you are not aware of it since they are already 5-10% overscanned for just this reason, as well as compensating for component aging and line voltage fluctuations.

A can of cold spray or a heat gun will be useful to track down the bad component but it could be a frustrating search.

Monitor shuts down or goes blank at certain scan rates

It could be the monitor's components have drifted and are now marginal at your one or more of your scan rates. However, first check with an oscilloscope if possible to confirm that your horizontal and vertical timing are indeed as expected.

Some video cards modify horizontal and vertical frequency as part of their software size adjustment in their Setup program. For example, with ATI cards, even though the general resolution option in the DOS Install program may be 800x600 at 75 Hz, adjusting the horizontal size can actually vary the horizontal frequency over a greater than 10% range. A similar variation is possible with the vertical rate.

Does just the picture go away or does power die to the monitor? If you can see the neck of the CRT, the filaments glow orange when it is operating. Does this glow disappear indicating that the deflection/HV is shutting down?

There could be a number of possibilities - no way of knowing if it will be easy or inexpensive to repair without testing. It could be power supply, HV supply, X-ray protection, etc.

Monitor flickers when disk accessed

This is almost certainly a software problem. First, try moving the monitor away from the PC as far as the cable will stretch. If it still occurs, then it is probably not the monitor. Could have to do with power saving (just a guess) or some other incompatibility. Nothing the PC does should affect the monitor in any way once the refresh rate is set.

Buzzing monitor

Do you actually mean buzz - low frequency as in 50 - 120 Hz? Or, do you really mean high pitched whine. If the latter, see the section: High pitched whine or squeal from monitor with no other symptoms.

- If it is from inside the monitor - make sure it is not your multimedia speakers or sound card picking up interference - it is in the deflection (probably vertical) or power supply. Either of these can vary in severity with picture content due to the differing current requirements based on brightness. It could be a power supply transformer, deflection yoke, or other magnetic component. Even ferrite beads have been caught buzzing when no one was looking. :-) Any of these parts could vibrate if not anchored securely or as they loosen up with age.

  Some hot-melt glue, RTV silicone, or even a strategically wedged toothpick may help. A new part may or may not quiet it down - the replacement could be worse! For yoke noise, see the section: Reducing/eliminating yoke noise.

- There is a slight possibility that the AC power in your home or office has some harmonic content - the waveform is not sinusoidal. This might be the case if you try to run on the same circuit as an active dimmer or something else with thyristor control. Proximity to heavy industry could also cause this.

Relocating the offending device to another branch circuit may help. You could also try a line conditioner (not just surge suppressor) which includes filtering. Else, petition to have that paper manufacturer move out of the neighborhood :-).

- Sometimes, it is simply a design or manufacturing defect and the only alternative is a replacement - possibly a different brand. It may be more difficult to quiet down a buzz than a high pitched whine.
- Some monitorss are simply poorly designed. You cannot infer the severity of this annoyance from any specifications available to the consumer. It is strictly a design (e.g. cost) issue. The size of the monitor is not a strong indicator of the severity of the problem but there will be some relationship as the power levels are higher for larger units. The best you can do is audition various monitors very carefully to find one that you are satisfied with.
- One those rare monitors that have a cooling fan, its bearings may be worn or in need of cleaning and lubrication, or a blade may be hitting something.

High pitched whine or squeal from monitor with no other symptoms

Sometimes this is continuous. In other cases, it comes and goes almost as though there is an intelligence at work attempting to drive you crazy. All the more so since a technician may not even be able to hear what you are complaining about if their hearing is not as sharp at high frequencies as yours. Even high resolution computer monitors running at high horizontal scan rates (beyond human hearing) can have these problems due to the switching power supplies as well as subharmonics of the horizontal scan rate exciting mechanical resonances in the magnetic components or even a portion of the sheetmetal used for shielding if in close proximity to a magnetic component.

If it is a new monitor and you think the sounds will drive you insane, returning it for a refund or replacement may be best alternative. However, you may get used to it in time.

Note: if the whine only occurs when the monitor is unplugged from the computer or the computer is turned off, this is probably normal. Without valid sync signals the monitor defaults to a horizontal rate which is within the audible range (less than 20 kHz). Any vibrating components will be readily heard. It is usually not a sign of impending failure.

In most cases, this sound, while annoying, does not indicate an impending failure (at least not to the monitor - perhaps to your mental health) or signify anything about the expected reliability of the unit though this is not always the case. Intermittent or poor connections in the deflection or power supply subsystems can also result in similar sounds. However, it is more likely that some part is just vibrating in response to a high frequency electric current.

There are several parts inside the monitor that can potentially make this noise - the horizontal flyback transformer and to a lesser extent, the deflection yoke and associated geometry correction coils would be my first candidates. In addition, transformers or chokes in the switching power supply if this is distinct from the horizontal deflection circuitry.

You have several options before resorting to a 12 pound hammer:

- Confirm that the horizontal scan rate being used by the video card is well within the range supported by the monitor. If it isn't, change it to be a one that is - in addition to possible whining, this is stressful on the deflection and power supply and may result in an expensive repair in a very short time. Even if the scan rate is supposed to be fine, changing it slightly (e.g., 5 percent) might help just because it shifts the deflection frequency away from a mechanical resonance. However, this may not be a long term solution.

- As much as you would like to dunk the monitor in sound deadening insulation, this should be avoided as it will interfere with with proper cooling. However, the interior of the computer desk/cabinet can be lined with a non-flammable sound absorbing material, perhaps acoustic ceiling tiles. Hopefully, not a lot of sound energy is coming from the front of the monitor.

- Move the monitor out of a corner if that is where it is located - the corner will focus sound energy into the room.

- Anything soft like carpeting, drapes, etc. will do a good job of absorbing sound energy in this band. Here is your justification for purchasing those antique Persian rugs you always wanted for your computer room :-).

If you are desperate and want to check the inside of the monitor:

- Using appropriate safety precautions, you can try prodding the various suspect parts (flyback, deflection yoke, other transformers, ferrite beads) with an insulated tool such as a dry wooden stick. Listen through a cardboard tube to try to localizing the source. If the sounds changes, you know what part to go after. Sometimes a replacement flyback will cure the problem unless it is a design flaw. You do not want to replace the yoke as convergence and other adjustments would need to be performed. Other transformers can be replaced.

- Sometimes, tightening some mounting screws or wedging a toothpick between the core and the mounting or coils will help. Coating the offending part with sealer suitable for electronic equipment may quiet it down but too much may lead to overheating. A dab of hot-melt glue or RTV silicone may help. Even replacement is no guarantee as the new part may be worse. For yoke noise, see the section: Reducing/eliminating yoke noise.

- A few monitors have internal cooling fans. The whine may be due to worn or dry bearings. If this is the case, the fan must be serviced as it is not likely doing it job and damage due to excessive temperatures may eventually be the result.

Note that the pitch of the whine - the frequency - may not even be audible to a technician assigned to address your complaint. The cutoff frequency for our hearing drops as we get older. Someone over 40 (men more so than women), you may not be able to hear the whine at all (at least you can look forward to silence in the future!). So, even sending the monitor back for repair may be hopeless if the technician cannot hear what you are complaining about and you are not there to insist they get a second opinion!

Monitor whines in power saving (standby) mode

(From: Bob Myers (myers@fc.hp.com).)

In standby, the monitor is not being supplied with horizontal sync, and so the horizontal deflection circuits are free-running. (If they're still powered up in a given monitor design when in standby mode, that is; there are no standards governing what actually gets shut down in the various power-saving states.) It's likely that in this case, the horizontal is free-running at a frequency which is audible, and you're hearing a whine from a vibrating transformer core (for example, the flyback). This will NOT have anything to do with the timing used when the monitor is on and running normally, so it's no surprise that changing the refresh rate didn't affect this.

You can either have a technician try to track down the offending component and try to keep it from making the noise (usually by adding some "goop" to prevent or at least reduce the audible effects of the vibration), or you might try (if your system permits it) using one of the other power-management states instead of standby. Removing BOTH the horizontal and vertical sync signals places the monitor in the "off" condition (I'm assuming compliance to the VESA DPMS standard throughout this discussion), in which just about everything should be shut down. However, since this will remove the heater supply from the CRT as well, it WILL take longer to recover from the off state.

Reducing/eliminating yoke noise

(From: Terry DeWick (dewickt@esper.com).)

Carefully look under vertical core next to plastic liner, on top and bottom is a plate called the astigmatism shunt, it has come loose. Work RTV, epoxy, or service cement onto it to glue it down and noise should quit.

(From: TVman (tvman@newwave.net).)

I have fixed a total of 27 of these sets with noisy yokes by removing the yokes and using motor armature spray sealant.

If you carefully mark the EXACT position of everything (yoke, purity magnets), and slide the yoke off the CRT, then once the yoke has been sealed with motor armature spray sealant and has dried thoroughly, put the yoke back EXACTLY where it was, there should be no problems.

The only thing I have had to do was set the purity on one set, but it was off a little to begin with.

Monitor was rained on

Was the monitor plugged in when the leak started? Any piece of equipment with remote power-on capability has some portions live at all times when plugged in and so there may have been damage due to short circuits etc. Substantial damage could have already been done.

Otherwise, you may just need to give it more time to dry out. I have had devices with keypads getting wet that required more than a week but then were fine. There are all kinds of places for water to be trapped and take a long time to evaporate.

If the monitor got wet while unplugged or it has a mechanical (hard) on/off switch, then give it a lot of time to dry out completely. Assuming all visible water is drained, a week represents a minimum safe time to wait. Don't rush it.

Generally, some moisture will not do any permanent damage unless the unit was on in which case you will simply have to troubleshoot it the old-fashioned way - one problem at a time.

Monitor was dropped

If your work area is maintained like that of Nedrie in the movie "Jurassic Park", you might not even notice if one of your monitors fell off the table! This is no way to treat a monitor.

However, mishaps do happen.

Assuming it survived mostly intact - the CRT didn't implode, you could still have a variety of problems. Immediately unplug the monitor!

If you take it in for service, the estimate you get may make the national debt look like pocket change in comparison. Attempting to repair anything that has been dropped is a very uncertain challenge - and since time is money for a professional, spending an unknown amount of time on a single repair is very risky. There is no harm is getting an estimate (though many shops charge for just agreeing that what you are holding was once a monitor, or was it a fish tank?)

This doesn't mean you should not tackle it yourself. There may be nothing wrong or very minor problems that can easily be remedied. The following are likely possibilities:

1. Cracked circuit boards. These can be repaired since monitors usually have fairly wide open single or two sided boards.

2. Broken circuit components. These will need to be replaced.

3. Broken solder connections particularly to large heavy components on single sided boards. Reflow the solder. If the trace is cracked or lifted, repair as in (1).

4. Broken mounting brackets. These are usually made of cheap plastic and often don't survive very well. Be creative. Obtaining an exact replacement is probably not worth the trouble and expense.

5. Components knocked out of line on the CRT envelope or neck - deflection yoke, purity magnets, convergence magnets and coils, geometry correction magnets. These will need to be reattached and/or realigned. Some CRTs use little magnets glued to the funnel portion of the CRT envelope. If any of these have come loose, it could be quite a treat to figure out where they went and in what orientation.

6. Internal damage to the CRT - popped or distorted shadow mask, misaligned electron guns. Unfortunately, you will probably have no way of identifying these since you cannot see inside the CRT. They will not be apparent until all other faults have been remedied and the TV set is completely realigned. At that point, extremely severe purity or convergence problems that do not respond to the normal adjustment procedure would be one indication of internal damage. Give the TV a nice funeral. See the "Sony1" and "Sony2" photos in James Sweet's Sony/Trinitron Directory for some screen shots showing the symptoms resulting from a monitor falling on its face. :(

If you still want to tackle a restoration:

As noted, unplug the monitor even if it looks fine. Until you do a thorough internal inspection, there is no telling what may have been knocked out of whack or broken. Electrical parts may be shorting due to a broken circuit board or one that has just popped free. Don't be tempted to apply power even if there are no obvious signs of damage - turning it on may blow something due to a shorting circuit board.

Then, inspect the exterior for cracking, chipping, or dents. In addition to identifying cosmetic problems, this will help to locate possible areas to check for internal damage once the covers are removed.

(At this point, most people will assume there is no interior damage and plug the set back in and turn it on. My recommendation is to resist this temptation since as noted, this could result in further damage making the repair more expensive if there are circuit problems. However, if the unit was on at the time of the "incident" or you are really determined to get to the conclusion and would just throw the thing in the trash if it doesn't work or blows up, go for it! But, if you're the more cautious type, continue with the systematic diagnosis and repair procedure that follows.)

Next, remove the cover. Confirm that the main filter capacitors are fully discharged before touching anything. Check for mechanical problems like a bent or deformed brackets, cracked plastic parts, and anything that may have shifted position or jumped from its mountings. Inspect for loose parts or pieces of parts - save them all as some critical magnets, for example, are just glued to the CRT and may have popped off.

Carefully straighten any bent metal parts. Replace parts that were knocked loose, glue and possibly reinforce cracked or broken plastic. Plastics, in particular, are troublesome because most glues - even plastic cement - do not work very well. Using a splint (medical term) or sistering (construction term) to reinforce a broken plastic part is often a good idea. Use multiple layers of Duco Cement or clear windshield sealer and screws (sheetmetal or machine screws may be best depending on the thickness and type of plastic). Wood glue and Epoxy do not work well on plastic. Some brands of superglue, PVC pipe cement, or plastic hobby cement may work depending on the type of plastic.

Inspect for any broken electronic components - these will need to be replaced. Check for blown fuses - the initial impact may have shorted something momentarily which then blew a fuse.

There is always a risk that the initial impact has already fried electronic parts as a result of a momentary short or from broken circuit traces and there will still be problems even after repairing the visible damage and/or replacing the broken components. This is most likely if the monitor was actually on but some modern monitors have circuitry that is energized at all times. (If power is controlled by a tiny tiny pushbutton this is the case.)

Examine the circuit boards for any visible breaks or cracks. These will be especially likely at the corners where the stress may have been greatest. If you find **any** cracks, no matter how small in the circuit board, you will need to carefully inspect to determine if any circuit traces run across these cracks. If they do, then there are certainly breaks in the circuitry which will need to be repaired. Circuit boards in consumer equipment are almost never more than two layers so repair is possible but if any substantial number of traces are broken, it will take time and patience. Do not just run over them with solder as this will not last. Use a fine tipped low wattage soldering iron and run #22-26 gauge insulated wires between convenient endpoints - these don't need to be directly on either side of the break. Double check each connection after soldering for correct wiring and that there are no shorts before proceeding to the next.

If the circuit board is beyond hope or you do not feel you would be able to repair it in finite time, replacements may be available but their cost is likely to be more than the equipment is worth. Locating a junk unit of the same model to cannibalize for parts may be a more realistic option.

Degauss the monitor as any impact may magnetize the CRT. Power cycling may work but a manual degaussing is best.

Once all visible damage has been repaired and broken parts have been replaced, power it up and see what happens. Be prepared to pull the plug if there are serious problems (billowing smoke or fireworks would qualify).

Perform any purity, convergence, or other realignment as needed.

Then proceed to address any remaining problems one at a time.

Really cleaning a monitor inside and out

(From: Dr. Ludwig Steininger (drsteininger@t-online.de).)

Often I get defective monitors, which are more than 5 years old, and have been run in offices for 8 to 10 hours/day. So, their case and pcbs usually are very dirty and dusty.

What do I do (it's no joke!): After removing the case I carefully put them in a bath (on a flexible layer) and let them have a intensive shower of pure cold water (for 1 to 2 minutes). Additionally, the case is cleaned with soap or a detergent containing liquid (being careful, not to spill to much of it onto the PCBs). After rinsing with fresh clear water, dust and other kinds of dirt are removed and the monitors look new again. Then I allow all drops of water to run off. This can effectively be supported by turning the monitor on another side from time to time (duration: approximately 1 hour). Before turning on AC again, I let the wet monitor dry in ambient air for about 2 days (in the sunshine this can be finished in 1 day only).

This procedure has been applied for many monitors. I've never had any bad experiences (it's very important to wait, until the pcbs are really dry!). Considering this experience, I just can't imagine, that it might not be possible, to "save" a TV set or computer monitor, which has been drowned or some liquid has been spilled, and AC has been plugged off ASAP (although I've never had such a case). I think, that in such a case, it's important to have a rapid shower in order to prevent corrosion and deposits.

By the way: I know a German company, which uses water from cleaning PCBs of computer hardware for cleaning them after being contaminated by smoke from a fire.

So, in case of spillage, one has nothing to loose. Just try to shower your monitor or TV set!

Setup menus will not go away or hieroglyphics on screen

Both these problems could be caused by a faulty microcontroller or its associated circuitry. However, bad connections in the vicinity of the controller logic could also be at fault.

Unless you see something obvious, you will need schematics.

Setup Adjustments Lost

Many modern monitors have RAM, somewhat like the CMOS SETUP memory in your PC, that store all factory adjustments. When power is lost, there is power surge, lightning strike nearby, nuclear detonation or EMP, it may have put bad information into the ram and thrown it out of adjustment. There is a way to get into the service mode (depress and hold a secret button down and turn set on, special combination of buttons on the remote, etc.) and then use the remote to reinitialize and adjust the problems out.

HOWEVER, IF YOU DON'T KNOW WHAT YOU DOING YOU COULD GIVE YOURSELF WORSE PROBLEMS. YOU COULD EVEN BLOW THINGS OUT WITH SOME MONITORS!

The service manual will be essential to have any chance of successfully reinitializing everything without causing damage due to incorrect settings.

If it's not an adjustment problem you probably have a bad part - somewhere.

If you do manage to get into the setup menu and are willing to take the risk without service information, try not to make any unnecessary changes and document every change you make!!! That way you can go back if you do anything wrong (hopefully).

Monitor doesn't work after being in storage

So the monitor you carefully stuffed in a corner of the garage is now totally dead. You swear it was working perfectly a year ago and just have to get that state-of-the-art Commodore 64 up and running!

Assuming there was absolutely no action when you turned it on, this has all the classic symptoms of a bad connection. These could be cold/cracked solder joints at large components like transformers, power resistors, or connectors and connectors that need to be cleaned or reseated. By 'no action' I mean not even a tweet, bleep, or crackle from anything.

To narrow it down further, if careful prodding of the circuit board(s) and various large components with a well insulated stick does not induce the set to come on, even momentarily, check the following:

1. Locate the horizontal output transistor. It will be in a TO3 metal (most likely on an older set) or TOP3 plastic package on a heat sink. With the set unplugged, confirm that there is no voltage across C to E and then measure between them with an ohmmeter. In at least one direction it should be fairly high - 1K or more. This confirms that the HOT is probably good.

(There is also a slight chance that there is a low voltage regulator in addition to the horizontal output, so don't get them confused. The horizontal output transistor will be near the flyback transformer and yoke connector.)

2. Trace back from the HOT collector to the flyback and through the flyback to the B+ feed from the power supply. Clip a voltmeter between this point and the HOT emitter. Make sure the leads are well insulated and can't accidentally short to anything. (This test can be performed across C to E of the HOT but if the horizontal deflection were to start up unexpectadly, the meter could be damaged by the high voltage pulses on the HOT collector. But if you can't find the B+ source, it may be worth the risk.) Plug it in and turn it on.

   - If the problem is in the low voltage (line) power supply, there will be no substantial voltage across C-E.

     You should be able to trace from the power line forward to find the bad part though a schematic will help greatly.

   - If the problem is in the startup circuit or horizontal oscillator/driver, then there will be something on the order of 100 to 160 V across C-E.

     In this case, a schematic may be essential.

Note: don't assume that the metal parts of the chassis are ground - they may be floating at some line or B+ potential. Also, the HOT emitter may not be connected directly to ground.

Cheap monitors with multiple intermittent problems

If the monitor is a non-name or the company has since gone belly up (no surprise, right?) you may have a monitor with one of those circuit boards best described as bad solder joints held together with a little copper. In this case, prodding with an insulated stick and the use of a few select 4 letter words may get it going. The circuit boards may be double sided with what were called 'rivlets' for vias. The rivlets were relatively massive - literally little copper rivets - and they were not adequately heated or tinned during assembly so there were bucketloads of cold solder joints that show up during middle age. I repaired one of these by literally resoldering top and bottom of every one of the darn things with a high wattage iron. Or, the soldering just may be plain, well, horrible. Carefully going over every connection is the only solution. Sometimes, removing the solder from suspect joints, cleaning both the component lead and trace, and then resoldering will be needed if corrosion has set in.

Monitor has burning smell

Assuming there are no other symptoms:

If this appears after extended operation - an hour or more - it may just be a build up of dust, dirt, and grime over the years. After understanding the safety info, some careful vacuuming inside may help. Just don't be tempted to turn any screws or adjustments!

Dust is attracted to the high voltage section in particular - even the front faceplate of the CRT collects a lot and should be wiped with a damp cloth from time to time.

If the symptoms develop quickly - in a few minutes or less, then there could still be a dust problem - a power resistor may be heating a wad of it but other possibilities need to be considered.

If not dust, then probably in the power supply but realize that TVs don't have a nice metal case labeled 'power supply'. It is just a bunch of stuff scattered around the main board. Without identifying the part that is heating, a diagnosis is tough especially if the set really does work fine otherwise. However, if a series regulator were faulty and putting out too much voltage, the set could appear to work properly but in fact have excessive power dissipation in certain components. If cleaning the dust does not solve the problem, you will probably need a schematic to identify the correct voltages.

Static discharge noise and picture tube quality

This question came up with respect to a large screen TV but may apply to large screen monitors as well.

> "I bought a 29" TV a couple of weeks ago and I have noticed that after being switched on for > about 15/20 minutes, whenever the picture changes from a "light" scene to a darker scene, the set makes a crackling noise. It sounds as though there has been a build-up of static and it is being discharged. I have never noticed this in a TV before and I was wondering if this is normal and acceptable behaviour for a large-screen TV?"

It probably is normal. Whether it is acceptable is a personal matter. In some geographic areas no countermeasures are taken at all...

When the scene changes from bright to dark, the beam current is reduced to practically zero. As a result, the high voltage rises. (The high voltage supply has a relatively high internal impedance.) The high voltage is connected to the inside layer of the picture tube. A voltage change on the inside will also cause a voltage change on uncovered parts of the outside, especially on the part of the picture tube that is hidden under the deflection coils. This causes little sparks between the picture tube surface and the inside of the deflection coils and this is accompanied by a crackling sound.

On the better picture tubes, a dark "anti-crackle coating" is painted on the picture tube near the deflection coil. This is a very high impedance coating, dark black, much darker than the usual aquadag coating over the rest of the picture tube. You should be able to see the difference.

If, on the other hand, the outside of the picture tube near the deflection coil is not coated then you have a problem. Then you will hear strong crackling also at switch-on and switch-off. Normally you shouldn't see such a 'cheap' picture tube on the European market...

The area of the picture tube around the anode connector is also not coated, for obvious reasons. Normally that should not cause any significant sound. Same goes for the front of the screen and neither should the anode cable crackle.

In a dark room you should be able to see from the tiny blue flashes where the sound comes from. This is perhaps best observed at switch-on and switch-off (with a black picture on the screen). Try and keep the back cover mounted !

Loudspeakers and monitors

Loudspeakers incorporate powerful magnets - the larger the speaker, the larger the magnet. However, anyone who goes ballistic when the mention is made of a loudspeaker near a TV or monitor, should take their Valium.

The fringe fields outside the speaker box will not be that great. They may affect the picture perhaps to the point of requiring degauss. The normal degauss activated at power-on will usually clear up any color purity problems (assuming the loudspeakers have been moved away). At worst, manual degauss will be needed. The CRT will not be damaged. The maximum field - inaccessible at the voice coil - is quite strong. However, even for non-shielded loudspeakers, the magnetic field decays rapidly with distance especially since the core structure is designed to concentrate as much of the field as possible in the gap where the voice coil travels.

Speakers specifically designed for use with multimedia computers have (or should have) specially shielded magnet structures or an additional magnet with its field set up to cancel the main magnet's fringe field which will minimize these effects. Nonetheless, if you see any indication of discoloration, move them to a greater distance.

However, keeping unshielded (e.g., megawatt stereo) speakers away from CRTs is a good idea.

Now, you really should keep your superconducting magnetic resonance imager magnet at least in the next room.....

Should I replace all the electrolytic capacitors if I find a bad one?

When a bad capacitor is found in a monitor, the question of course arises as to the likelihood of other capacitors going bad in short order. It might be worth checking (other) caps in the power supply or hot (temperature) areas but you could spend you whole life replacing **all** the electrolytics in your older equipment!

Black powder being generated inside monitor?

You have just noticed a black powder spontaneously appearing from inside your computer monitor. What is it? The monitor seems happy as a clam.

Well, it is probably just air-born dust that is collecting there due to the air flow in your area and high voltage static fields. The monitor is acting like an electrostatic dust precipitator. If there were really black powder being generated inside, I would expect you would smell something really really bad and the monitor would not continue to be happy.

Sweet little old ladies and TVs from attic

The following story is specifically for a TV but the same applies to any electronic servicing. Always confirm the customer's complaints first!!

Then verify that everything else works or you will never know if your efforts have affected something unrelated.

(Original request from rogerj@apex.com):

> "A sweet little old lady has duped me into repairing her old G.E. 13" color TV. Wanted me fix bad volume pot..... "oh it has such a good picture"... she says.
>
> Stupidly w/o even turning it on, (big mistake) I begin to open the set. After 15-20 min. of travail, I discover that a previous "repairman" has glued the case shut!
>
> Now w/ set open, I turn it on and this picture is LOUSY. Bad color, and very poor convergence. But I don't know if I'm to blame for banging it around trying to open it up. Also, no hor. or vert. hold. (fixed that w/a few caps) This things probably been sitting around for a few years."

Well, you certainly did not kill the caps. Anything that sits for a few years - probably in a damp unheated attic - is suspect.

Did you find the adjustments on the yoke assembly tight? If so, you probably did not move anything very much either. She may remember the good picture it produced before being stuffed away in the attic.

> "Anyway after going through all the adjustments, the convergence at the sides is still bad and the horizontal size is a tad insufficient (w/no adjustment available)"

Could be that the convergence (including pincushion) circuits are still faulty - not just misadjusted.

Other things that can effect horizontal size while still giving you a complete picture:

1. Voltage to horizontal output transistor low. Is there a voltage regulator in your set? The one I have has none. I assume your line voltage is ok.

2. Increased resistance or inductance of the yoke windings. For all you know, the yoke may have been replaced with the wrong part.

3. Yoke improperly positioned on tube neck.

4. Excessive high Voltage. This is usually not adjustable.

I bet the thing hasn't worked properly in 10 years.

Disposing of dead monitors (CRTs and charged HV capacitors)

I don't know what the law says, but for safety, here is my recommendation:

Treat the CRT with respect - the implosion hazard should not be minimized. A large CRT will have over 10 tons of air pressure attempting to crush it. Wear eye protection whenever dealing with the CRT. Handle the CRT by the front - not the neck or thin funnel shaped envelope. Don't just toss it in the garbage - it is a significant hazard. The vacuum can be safely released (Let out? Sucked in? What does one do with an unwanted vacuum?) without spectacular effects by breaking the glass seal in the center of the CRT socket (may be hidden by the indexing plastic of the socket). Cover the entire CRT with a heavy blanket when doing this for additional protection. Once the vacuum is gone, it is just a big glass bottle though there may be some moderately hazardous materials in the phosphor coatings and of course, the glass and shadow mask will have many sharp edges if it is broken.

In addition, there could be a nice surprise awaiting anyone disconnecting the high voltage wire - that CRT capacitance can hold a charge for quite a while. Since it is being scrapped, a screwdriver under the suction cap HV connector should suffice.

The main power supply filter caps should have discharged on their own after any reasonable length of time (measured in terms of minutes, not days or years).

Of course around here, TVs and monitors (well, wishful thinking as I have yet to see a decent monitor on the curb) are just tossed intact which is fortunate for scavengers like me who would not be happy at all with pre-safed equipment of this type!

Apple/Sony monitor dies after variable length of time

The following discussion relates to failures of the X-ray protection tap on a Sony part affectionately known as the 'big red cap' or the HSTAT block in some Sony manufactured monitors.

> "This is a (Apple) Sony 13" monitor, 4 years old. After being turned on for 30 minutes, the display goes completely blank and the front LED goes off. If the power is shut off for 10 minutes or so, it will come back on for another 15 minutes or so, then go blank again, etc. The +120v and +65v from the power module is still present when it blanks out, but no other voltages (+12, +960, etc) are present on the main circuit board. I've been told it might be the HV capacitor is bad; would like to hear a 2nd or 3rd opinion before buying a new capacitor."

That is the same diagnosis a friend of mine got for her monitor with that identical problem. Replacing the capacitor did fix the problem.

That 'big red capacitor' is a Sony part which includes some kind of low voltage sense connection as well. It is used to shut the monitor or TV down should the HV increase resulting in increased risk of X-ray generation. Unfortunately, the resistors inside often go bad causing the unit to shut off erroneously. The guy at the place where she got it repaired said that the capacitor is one of the most common problems with those monitors. $70 for the part + $50 for labor, ouch!

These used to be only available from Sony. Why can't Sony design monitors like everyone else? Sure, I know, theirs are better (well, except for the unsightly stabilizing wires on Trinitrons!). Now, however, less expensive replacements can be had at places like Computer Component Source.

For testing, it may be possible to disconnect the sense output. With shutdown disabled, the monitor should continue to run BUT WITH NO X-RAY PROTECTION. Therefore, this should only be used for testing - a replacement will be required.

Note: On some models, the sense wires need to be connected during startup or else it will never come on.

CAUTION: On some models (like the Sony CPD1302), the sense signal may be used for actual HV regulation. Thus, if the sense wire is disconnected, (or the divider inside the Hstat block fails open) there is no feedback and it is possible for the high voltage (and probably B+) to increase until the HOT (and possible other components) blow.

(From: Duke Beattie (beattie@wsu.edu).)

The low voltage connection of the 'big red cap' is part of the "X-ray protection" circuit. If the high voltage to the crt goes to high it is supposed to shut down the whole thing. Unfortunately the sensor inside goes bad and puts out the wrong voltage and that shuts down the world. The part is available at "Computer Component Source" for about $30, it is a "M041" (Sony/Apple part number" These things go out with great regularity. So if your Apple monitor shuts down this is probably the culprit.

(From: A.R. Duell (ard12@eng.cam.ac.uk).)

On some of the older Trinitrons (certainly on the 13" Trinitron monitor I have), the HSTAT pot is connected as a potential divider on the EHT supply. The slider of the pot is connected to the static convergence electrode, but a tap on the lower end of the pot goes to the protection circuit. Something like this:

```
            Static Conv Electrode
                  o
                  |
                  V
    EHT---------/\/\/\-------\/\/\---+---\/\/\-----+
                                     |             |
                                     o            _|_
                                 Protection      ///
```

If the EHT rises too high, then the voltage at the protection point also rises, and a shutdown signal is sent to the scan processor.

All those resistors are encapsulated in the HSTAT block which has an EHT input from the flyback, a Coaxial EHT output (EHT and Hstat electrode) to the CRT, an earth wire, and a 2 core cable (earth and Protection) that goes to the scan board.

Unfortunately, if those resistors change in value, then the protection circuit may operate even at the normal EHT voltage. And as they're all potted in one block, you have to change the complete unit.

(From: Neil brown (nbrown@whispa.co.nz).)

When your monitor works do you see faint diagonal white line on it?

If so the cutoff need adjusting and it will cause the symptoms you describe exactly, If it doesn't come on after a "rest" then yes it may be a bad cap but I have realigned a lot more than I have replaced HV caps!

Also on the adjustment board there is a resister that goes and pushes the cutoff up high, from memory it is a 1 M resister and it drifts up high.

More on the Apple/Sony 'big red capacitor thing'

(From Terry L. Wright (terryl@wolfenet.com).)

The big red thing has been called a capacitor, a voltage tripler and a diode assembly not to mention other less polite names. It is in fact at the root of the failure in this monitor but does not necessarily need to be replaced. You will find a low voltage shielded wire comes from the red block. It goes to a four lead jack and plug which connects to the main board. The two pins that the shielded cable goes to are marked ground and Href, short for high voltage reference. If these two pins are shorted together the unit will no longer shut off by itself.

Why does this work? Because the red block contains a voltage divider, the output of which tells the main board if the 25 Kilovolt supply to the crt goes too high. When the red block ages the relative values of the internal resistors changes and the block output increases. The main board interprets this as excessive high voltage and shuts the horizontal output down to protect the circuit and ostensibly to protect from Xrays. By shorting the output you can force the main board to assume that the voltage is not too high. Note that you have also disabled any protection that the circuit may have provided from Xrays or high voltages. Personally I do not care about this as I have never seen this monitor fail in any way to cause excessive second anode voltage.

Editor's note: failure (open) of a snubber capacitor across the HOT is one failure that can result in excess high voltage. Thus, I would consider this a temporary 'for testing' solution unless you add some other mechanism for detecting excess high voltage. First confirm with a high voltage probe that the monitor isn't shutting down properly - due to excess high voltage! In addition, the original problem may get worse and eventually affect the convergence and other functions of the Hstat unit. --- sam

(From: David J. Pittella (ddc_pitt@ix.netcom.com).)

I spent 8 years working for a very large Apple authorized service provider.

The original 13" Model MO-401 (not the MO401LL/B) actually had a bad run of these high voltage capacitors. Apple did have a warranty extension on specific date ranges of these parts, I would doubt this is still in effect ... but you could check.

The 'big red' high voltage capacitor is Apple P/N 910-0058, it is mounted to the bottom of the chassis on this display. This part connects between the flyback and the anode connector on the CRT, there is also small grey cable from this device to the "D" (main) board.

The "C" board (on the neck of the crt) is notorious for cold solder joints on the CRT connector. I would always resolder these whenever I worked on this display.

CTX monitor intermittent or blows fuse

Initial symptoms are erratic startup or shutdown sensitive to temperature or vibration. Eventually, the monitor will go totally dead if the original problems are not dealt with.

Look for a vertically mounted daughterboard. This board contains an IC UT3842 which is the pulse width modulator IC for the switcher supply. ECG makes a replacement although I don't have the number handy. Make sure you check associated parts on this card for damage, as this circuit usually fries pretty well.

The entire cause of these problems is generally bad solder joints on the back side of that daughter board. Unsolder it from the main board, and fix those first. Where a connector is used (P104) resolder this as well. Then replace Q101, the 18 V zener next to it (ZD101), and the .39 ohm resistor if necessary. Note: The zener is for protection only. Therefore its exact voltage rating is not critical - anything over about 6 V will work.

(From: Keith Scott (kscott@news.HiWAAY.net).)

Exactly! Every 14 or 15" CTX I've worked on had the MOSFET, zener and the low ohm resistor toasted. BTW, they use the low ohm resistor as a fuse to keep them catching on fire when the other stuff shorts out.

(From the editor).

Once the fuse blows, several parts have gone belly-up and will need to be replaced in addition to the soldering of the daughter board.

(From: Bill Rothanburg (william.rothanburg@worldnet.att.net).)

Replacing the fuse will not fix the monitor. The odds are rather overwhelming that you have been bit by the infamous CTX 'daughter board with bad solder joint' flaw. If you have the ability to handle a soldering iron, order the repair kit from CCS (1-800-356-1227). This will contain all of the parts and instructions on fixing this problem. IMPORTANT!!! Remove the daughter board, resolder all of the joints on the connector, and reinstall the daughter board.

CCS sells a kit for $13.99, includes 2SK955, 1N5248 18V zener, .39 R, and fuse. #07-1512 800 356-1227 They also warn of solder breaks on plug of daughter board. The service manual is available from CTX for $15, 800 888-2120 (compared to $50 from CCS!!).

Gateway Crystalscan and MAG monitor problems

The following applies to several Gateway monitors including the CS1572FS (very common) and CS1776LE, as well as similar models from MAG (who is the actual manufacturer of these Gateway monitors).

> "I have a Gateway CS1572 FS monitor. Recently, a high pitched whine accompanied by faint dark lines scrolling from top to bottom appeared. Initially the problem disappeared after a warm-up period, but now it is constant. Can anyone give me info on: solving similar problem, or a source for schematics on this type of monitor. Gateway wants me to send it to MAG, but that sounds like big $$$."

Other related symptoms: Wiggling raster, possibly only at higher scan rates.

R331 is a common failure in the power supplies of Gateway CS1572 monitors. Apparently, a number of other models also use this design, and got the same batch of bad resistors :-).

It is supposed to be 91K. 1 W but gradually increases in value until regulation is compromised. While it is marked 1%, hand selecting a 5% metal film resistor that is within tolerance will work fine and even this may not be needed as the voltage adjustment pot is in series with R331. Therefore, if you have the adjustment procedure, a 1% resistor is unnecessary in any case. Then, adjust the B+ to the value marked.

Note: It is probably a good idea to replace R331 for these symptoms even if it tests good. In some cases, it would appear that these resistors fail at full voltage but not when tested with a multimeter.

If symptoms persist, check ZD302 (12.2 V?).

While you are in there, check for bad solder connections or damage to R302 and Q105 (swivel base hits these).

Allergies from monitors?

Aside from eye, back, or finger strain, there may be two possible sources of actual chemical/gaseous emissions:

1. The materials used in some of the electronic components as well as the plastics of the case can outgas - possibly for quite some time after manufacture. This is made worse due to the heat inside.

2. Ozone production. This is caused by electrical discharges - corona - from various high voltage terminals. Ozone really shouldn't be a problem with a monitor in good condition but it is possible. And, as a monitor ages and collects all sorts of dirt and dust, it is more likely.

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7. Back to Monitor Repair FAQ Table of Contents.

Items of Interest

Web sites with monitor specifications

Of the half dozen or so Web sites that I used to have for extensive monitor information, only Monitorworld has survived as far as I can tell: They still have the important specifications for a wide variety of monitors indexed by manuracturer and model:

- Monitor World

I am only recommending this site for the information on monitor specifications, not necessarilly for other products or services since I haven't evaulated them. Note that since this data comes from undetermined sources, it isn't always to be accurate. Sorry for the lack of additions Web sites but believe it or not, I am not usually informed when any particular company goes belly-up or their Marketing department decides that fluff is more important than substance and they pull the plug on the pages with useful information. :(

How do multiscan monitors determine and store the scan parameters?

With modern SVGA multiscan monitors, once a particular resolution and scan rate is set up, there is rarely a need to readjust size, position, and other parameters. How is this accomplished?

(From: Bob Myers (myers@fc.hp.com).)

It's different for different designs, of course, but in general today's 'digitally controlled' monitors recognize various timing modes by counting the horizontal and vertical sync pulses to determine the line scan and vertical refresh rates.

Any input within a certain tolerance of a recognized pair of frequencies here is assumed to be that timing, and a set of stored numbers corresponding to that timing are then read from a memory and used to set up the adjustments. In most of these monitors, the various adjustable parameters - size, centering, etc., - are controlled by voltages coming from a set of D/A converters, so the stored information is basically just a table of numbers that get sent to the D/As when that timing is recognized.

The number of both factory and user presets available varies from product to product, of course, but there's usually somewhere between 8-15 of each. The exact number is going to depend on how much memory is available, and how many different parameters need to be controlled for each recognized timing.

Unless the output of the graphics controller is an exact match for the timing used at the factory when the preset information was generated, there may still be slight errors, for obvious reasons. Fortunately, the widespread acceptance of timing standards (such as those produced by VESA) are reducing the severity of this problem.

Monitor reliability with SVGA

There are parts in the monitor which may get hotter with SVGA but if it is designed for SVGA resolution, there should be no problem (assuming you are not running in an excessively hot room or with the ventilation holes covered).

A good quality auto-scan monitor should not mind switching screen resolutions frequently (though doing it every few seconds continuously may stretch this a bit).

Newer auto-scan monitors should also be smart enough not to blow up if you feed then a scan rate which exceeds their capabilities. However, there are a lot of poorly designed monitors out there.

If it is supposed to run SVGA, use it at SVGA. If it blows up, switch to a different brand. There are a lot of crappy monitors being sold on their own and bundled with PCs.

How high a refresh rate should I use?

It is the vertical refresh rate that impacts display appearance. The visual effect of too low a vertical scan rate is excessive flicker.

Up to a point, higher is better. Everyone agrees that appearance improves up to at least 70-75 Hz (vertical) non-interlaced but beyond this point is a hotly debated issue (and a topic for a never ending discussion on your favorite Internet newsgroup). The use of interlaced scanning can reduce apparent flicker for a given scan rate for typical gray scale or color images but may result in annoying flickering or jumping of fine horizontal lines in graphics and text displays.

In any case, you must not exceed the maximum scan rate specs of your monitor. See the section: Web sites with monitor specifications if in doubt. Also, very high refresh rates may result in decreased graphics performance particularly with DRAM based video cards due to bus contention between the PC memory accesses and the video readout to the RAMDAC.

And, a horizontal scan rate below the specified limits may blow the HOT instantly.

For the discussion below, the key words are "well designed". There are a lot of mediocre monitors out there!

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The dissipation in the deflection coils rises sharply with the horizontal scan frequency. The horizontal scan frequency is of course higher at higher resolution and higher vertical refresh rates. But the monitor will have been designed to handle that, unless you don't permit adequate ventilation. Component failure occurs often during mode-switching, not due to keeping the monitor in one mode or another.

It is a popular myth that a (well-designed) monitor could be damaged by connecting it to a signal source with frequencies that are out of range. These will be (should be) automatically blocked by the sync circuitry and you will simply not get a stable picture. There will be no damage, and if there would be (most likely from a too LOW line frequency) then it would be done immediately. No need to rush setting things right.

So my advice would be to go ahead, use whatever resolution you like. The acceleration of the wear will be insignificant, you'll probably want a better monitor long before it is technically worn out. If you want to be kind to your monitor, then keep the contrast below maximum, use a black-screen screen saver and keep the dust and smoke and moisture and grease away.

Number of colors and monitor type

> "I have a CTX CVP-5468 that will not do more than 16 colors in windows. It is being driven by an Orchid Kelvin 64 VLB board, but had the same problem with an ATI card. When using it in linux under x-windows the same thing and more than vga and it goes blurry and very pixelated."

It is really not possible for this to be a monitor problem as the signals are analog - continuous - the monitor displays whatever it is given and does not even know the color depth except to the extent that cards are often set up via software to use different scan rates for different color depths (bits/pixel) often due to hardware memory/bandwidth limitations.

For the ATI in particular, I know that you can use ATI's DOS Install program to set it up for each resolution and mode - try this. I bet your monitor is fine.

Various video standards

Here is a link:

- Standards for analog component video

Monitors, humans, and flicker

(From: Bob Myers (myers@fc.hp.com).)

The flicker-fusion frequency for emissive displays such as CRTs cannot be given as a single number applicable to all people, all displays, and all ambient conditions. It is dependent on the particular individual, the size and brightness of the display (and the characteristics of the phosphor, if a CRT), the viewing distance, and the ambient lighting conditions.

For a typical color CRT computer monitor, at typical brightness levels and viewing distances, the image will appear "flicker free" to 90% of the population by the time the refresh rate has reached the upper 70 Hz range; into the low 80 Hz range, and you cover 95% of the population. Given the statistics, there are probably a few people who could still see flicker by the time you got above 90 Hz, but there sure aren't many of 'em.

The effects of the screen refresh rate on perceived motion have more to do with the relationship between that rate and the ORIGINAL sampling rate (i.e., ~60 Hz for standard video), and higher refresh rates are definitely NOT always better in this regard. Depends on the artifact in question.

Is fluorescent lighting a significant source of flicker?

(From: Bob Myers (myers@fc.hp.com).)

Actually, this is a myth. Ambient light flicker is at best a second-order effect in determining perceived flicker levels, and then only through modulating the display's contrast ratio. (Ambient light flicker isn't even considered in the flicker calculations of the various ergonomic standards, although the ambient light *level* is a concern.)

The notion that fluorescent lamps flicker and that this somehow produces a "beat" with the screen refresh is simple to disprove. First, if this were so, 75 Hz screen refresh would appear WORSE than 60 Hz, since it's farther removed from the line rate. In reality, the reverse is true - and if you REALLY want to maximize perceived flicker, turn OFF all the lights. The display will then appear to flicker MUCH worse, as one determining factor in flicker is the APPARENT brightness of the screen (how bright the screen is in relation to its surroundings). Lastly, people don't realize that fluorescents DON'T flicker at the line rate; being essentially plasma displays wherein the plasma emissions exicte a phosphor, these tubes flicker at TWICE the line rate - too high to be perceived. Fluorescents show a flickering appearance when they're failing, but that's a different kettle of fish altogether.

(Also note that a large percentage of fluorescent lighting these days uses electronic rather than magnetic ballasts. Most of these do not suffer from significant power line flicker (100/120 Hz) flicker as they are driven at 10s of kHz by what are essentially switching power supplies. Any variation in intensity is at too high a frequency to matter. This is true of most compact fluorescent lamps, many cheap fixtures, as well as large (newer) office installations or retrofits. --- sam)

Interlaced vs. non-interlaced monitors

The difference between interlaced and non-interlaced displays is in the video timing. Nearly all monitors can handle either. Monitors are specified as non-interlaced because for a given screen resolution and vertical refresh rate, this is the tougher (higher) horizontal (H) scan rate and it is desirable to minimize flicker in a graphical display (Fine horizontal lines will tend to flicker on an interlaced display). The H scan rate is double the interlaced H scan rate since all scan lines rather than just the even or odd lines are being displayed for every vertical scan.

Digital versus analog controls on monitors and picture quality

> "Could someone tell me if there's a noticeable difference in picture quality between analog and digital monitors? Is digital worth the extra money?"

There is no inherent reason for a digital monitor to have a better picture but as a practical matter, I would expect this to be the case in the vast majority of monitors - especially models from the same manufacturer. The digital monitors will be the ones that the designers concentrate on. Digital controls (both those you can access and those used only during setup at the time of manufacturing or servicing) permit more flexibility in setting parameters and automated more consistent adjustments on the assembly line (at least this is possible in principle).

For the average not terribly fussy PC user, the major difference is in the convenience of not having to adjust size and position whenever the scan rate changes. In my opinion, while the price difference between monitors having analog or digital controls but with the same screen size, resolution, and scan range specifications may seem excessive, the added convenience of digital controls and scan rate parameter memory makes the added cost well worthwhile.

Should I be concerned about very frequent scan rate switching

This question arises in a PC software development environment where the programmer needs to go back and forth between a Windows display and a DOS debugger, for example.

Obviously, without knowing the precise design of your monitor, there can be no definitive answer. It is true that some older monitors blew up if you looked at them the wrong way. Newer monitors from well known manufacturers like Nokia, NEC, and many others are designed with a moderate amount of scan switching in mind. However this is stressful for the monitor's power supply and deflection circuitry. I would suggest that you use a dedicated mono monitor for debugging if you really are switching multiple times per minute. If you cannot afford the space, you can probably assume that if the first few days of this kind of treatment have not induced a failure, the monitor is robust enough to withstand it indefinitely. If you really are switching many times per minute 8 hours or more a day, then what may wear out are the internal relays (the clicks you hear are from these). You are still talking about years, however. They are rated in 100s of thousands or millions of operations when used within their ratings.

Or, just go for the peace of mind of an extended warranty or service contract.

What is monitor video bandwidth and why is it important?

(From: Bob Myers (myers@fc.hp.com).)

Video bandwidth is an indication of the frequency range over which the monitor's video amplifiers are capable of doing their job, which is to translate the video signal at the monitor inputs (about 0.7 volt, peak-to- peak) to something like 35-40V peak-to-peak at the CRT cathodes. Higher bandwidths ARE better, UP TO A POINT.

The bandwidth required is NOT given by multiplying the numbers in the format (what most call the "resolution") by the refresh rate; even allowing for the required blanking time, what THAT gives you is the pixel rate or "pixel clock". As the fastest thing that happens in a video signal is one dot on followed by one dot off, the fastest FUNDAMENTAL frequency in the video signal is half the pixel clock. Normally, you might think you'd want to cover some of the harmonis to "sharpen up" the pixel edge, but that's actually less important than you might think (in part due to the fact that the CRT screen itself, being made up of discrete dots of color, already has the effect of "sharpening up" the image AND limiting how sharp it's going to get, anyway).

There's also the problem of "bandwidth" not being measured or speced consistently by all manufacturers, making it difficult to compare one product to another. Some simply give a "max. video rate supported" number, which is about as useless a spec as one can imagine. (It's just telling you the pixel rate of the fastest timing supported - but says nothing about the image quality at that timing!) Still, a claimed bandwidth of about 2/3 to 3/4 of the fastest pixel rate to be used should indicate adequate performance - beyond that, you need to compare products with the good ol' Mark I eyeball. Using this rule of thumb, a monitor intended for use at 1280 x 1024, 75 Hz (a 135 MHz pixel rate) needs a speced amp bandwidth of around 100 MHz. (But just to show how far you can trust this particular number, I know of a product which does a very nice job of displaying 1600 x 1200 at 75 Hz - slightly more than a 200 MHz pixel rate - but which has a video amp bandwidth of only about 100 MHz, if measured per certain definitions!)

I find the rise and fall time of a full-scale (white to black or black to white) video signal, as measured at the cathode, to be a much better spec, and here would look for something not slower than 2/3 of the pixel period for the timing of interest. But these numbers are rarely quoted in consumer-oriented spec sheets, and even these take some care in applying.

Why a good monitor may produce a fuzzy picture

The ultimate sharpness of the picture on your monitor depends on many factors including but not limited to:

1. Focus of the electron beam spot(s) at the face of the CRT.

Affected by: quality of the CRT and its supporting circuitry and adjustment of focus control(s).

2. Convergence of the RGB electron beams at each point on the face of the CRT.

   Affected by: quality of the CRT, deflection components, and how carefully the convergence adjustments were done during manufacture (or repair). In many cases, it is this last item that is most critical. Bad quality control during final setup can ruin a monitor manufacturer's reputation - and has.

3. Moire reduction (if any or if enabled) reduces the effective sharpness of the electron beam either through actual defocusing or a high frequency dither. IMO, the net effect is almost always bad.

   Affected by: enabling and magnitude of moire reduction.

Items (1) through (3) are somewhat independent (though not entirely) of scan rate. The newest high-end monitors have a fairly comprehensive set of digital (on-screen) adjustments for these but may still not produce acceptable results for every monitor.

4. Bandwidth of the video amplifiers in the monitor - essentially how quickly the intensity can be altered by the video signal.

   Affected by: design of video amplifier circuitry and circuit board layout. This used to be much more of an art than it is today. Integrated circuits have replaced many of the discrete components used in the past resulting in simple designs with clean circuit board layouts.

5. Bandwidth of the digital to analog converter (D/A, DAC, or RAMDAC) of the video card.

   Affected by: DAC or RAMDAC chip used, supporting circuitry, and video card board layout. As with (3), these are largely cookbook designs these days.

6. Dispersion in the video cable - how smeared out the video signal becomes traveling through the cable.

   Affected by: quality and length of video cable. Since cables often come attached to the monitor nowadays, you don't have much control of this. Just don't add problems such as switchboxes.

7. Reflections from any impedance discontinuities in the cable - video card DAC, video card connector, monitor connector, monitor video amplifier input, monitor termination. All of these will introduce just a bit of mismatch - or perhaps much more - which will add up to either barely detectable fuzziness or totally unacceptable ghosting or ringing at vertical edges.

   Affected by: connectors and circuit board layouts of both video card and monitor input as well as any additional connectors or a switchbox.

Items (4) through (7) are heavily dependent on scan rate since higher scan rates translate into higher video bandwidth. Any degradation of the edges of the video signal - transitions from black to white, for example - will be much more visible at the higher scan rates - they will be spread out resulting in pronounced blurring, ghosting, or ringing.

Thus, it is critical to use the highest quality components wherever possible. While you don't have control over what is on your video card and inside your monitor, selecting a high quality video card and monitor should help. If you have the option to use a BNC cable (at least your monitor has BNC jacks on the back), try out a high quality BNC cable - you may be pleasantly surprised at the improvement in edge definition and overall sharpness.

Ghosts - card or monitor?

(From: Bob Myers (myers@fc.hp.com).)

This isn't as simple as it may appear. 'Ghosts' are caused by reflections of the video signal edges, caused by impedance mismatches between the driver (graphics card), the video cable, and the monitor video inputs. Add in the problems caused by the video connectors, and you wind up having to say that this is really (most often) a system problem, and all the parts get some of the blame.

With that said, the practical answer is that you should avoid using anything other than a single, reasonably-good-quality video cable, with decent connectors, between your PC and monitor, this being the part that you have the most control over. The more breaks in the cable - adding extension cables, switchboxes, etc. - the more chances you have for a mismatch in the line. BNC connectors (or the new VESA EVC connector) are MUCH better in this regard than the 15-pin D "VGA" connector (although if you're getting good results with the D connector, don't worry about it). Also, do NOT make the mistake of using anything other than 75 ohm coax for your video cables. Just to mention one common mistake, LAN cable is *50* ohms, so it's NOT going to work here!

If you've done all you can with the cable, the next place to go is the monitor itself; there's probably something wrong with the video input termination. By the way, a simple way to confirm that what you're seeing IS a ghosting (reflections) sort of problem is to use a DIFFERENT LENGTH of the video cable. Since the ghost is the result of a reflection going from the monitor back to the PC and then back up the line, the length of the cable affects where the ghost appears relative the edge which caused it. Inserting a longer cable moves the ghost out (to the right), while a shorter one will move it closer in (to the left). If you change cable lengths and the ghost doesn't move, you most likely have a problem within the monitor itself, past the video inputs.

BTW, longer cables may also make the ghost less distinct, due to the increased attenuation of the signal by the cable. Unfortunately, the longer cable also means more attenuation of the video signals that you WANT, in addition

Extension cables and monitor ghosting

(From: Bob Myers (myers@fc.hp.com).)

With an extension cable, there is the chance that this ghost is being caused by an impedance mismatch AT THE CONNECTOR OF THE EXTENSION; unless the cable is completely the wrong impedance, it is unlikely that the cable itself (meaning the actual "wire") is the culprit. But any break in the cable (connectors, switchboxes, etc.) is a chance for a mismatch.

But before blaming the cable, there's another possibility to check out. One commone source of ghosting is a poor termination of the line at the monitor itself and at the graphics card driving it. It can look worse with an extension simply due to the extra cable length moving the "ghost" farther away from the image causing it. (The ghost is, after all, just a reflected signal that went back DOWN the cable, got reflected again at the controller, and sent back up to the monitor. Added cable length makes this round trip longer, and moves the ghost farther to the right of the original edge in the displayed image.) If this is the case, the you will also see the ghost without the extension - it'll simply be much closer to the original edge that it's "ghosting". In that case, a better extension cable can actually make the appearance of the ghost worse - a lower-loss cable means that more of the reflection will get through back to the monitor!

If it is being caused by the extension cable, you may get better results by using BNC connections instead of the D-sub at the point where the cables mate. The D-sub is a pretty poor connector in terms of providing the proper impedance. Using a pair of 15D-to-5-BNCs back to back may give better results.

Driving multiple monitors from a single PC

Where BNC monitors are involved and daisychaining is acceptable, additional circuitry is generally not required for reasonable distances. BNC cables for R, G, B, and possibly H and V sync, are run from the source to each monitor in turn with only the last one being terminated in 75 ohms (the others MUST be Hi-Z).

Some newer BNC monitors do not have a Hi-Z option for termination so daisychaining is not even an option with these.

Attempting to drive multiple monitors in a star configuration without buffering the signals will generally result in poor results - reduced brightness and contrast (by 1/n where n is the number of monitors) and ghosting and other signal degradation. However, nothing will blow up so for 2 monitors it may be worth trying.

In either of these cases, what is needed is a distribution buffer amplifier. One such circuit is shown at:

8. http://www.anatekcorp.com/driving.htm

This includes simple emitter follower circuits for each high speed signal.

Using a PC as a monitor test pattern generator

Almost any PC with at least a medium performance SVGA video card can be programmed for a wide range of resolution options, dot clocks, horizontal and vertical sync timing, and sync polarity. Some can be programmed to generate composite sync and sync-on-green as well.

DOS/Windows/Win95 will suffice for most PC applications using drivers supplied by the video card manufacturer but for complete flexibility, run under Linux - take a look at the Xfree86 documentation for more details.

Test patterns can be created with any graphics applications and then saved for rapid recall.

Of course, for different output levels and impedances you will need some extra electronics. A normal SVGA card only produces R,G,B video and H and V sync signals compatible with doubly terminated 75 ohm cables. As noted, some will generate composite sync and/or sync-on-green. See the "Sync-on-Green FAQ" for more information on how to do this if your card is not capable of it. For NTSC/PAL video generation, additional hardware will be needed. See the section: Displaying computer video on a TV.

Monitor testing programs

There are a variety of PC compatible software programs for testing of SVGA computer monitors. These display various test patterns and color charts which are appropriate for the procedures discussed in this document.

Here are a few pointers:

- The monitor test program "NTest" is very often recommended on the comp.sys.ibm.pc.hardware.video Newsgroup. This was originally available from Nokia but since Nokia sold their monitor division to Viewsonic, it has disappeared so here is a copy. I'll be happy to link to the Viewsonic site if they replace it.

  - Nokia Ntest Monitor Test.

- ComputerCraft provides a shareware program for testing monitors and video cards. I have not tested it but as they say: "If you are aware of the dangers, Monitors 1.01 is a powerful tool." See the document: Performance Testing of Computer and Video Monitors, specifically the section: "WARNING and DISCLAIMER" for some of these. This shareware program can also test video cards for characteristics and graphic modes.

- Monitors 1.01.

(From: Mark E. Nikl (markn3@infoave.net).)

In the download section of the Web site, there is a file called monitors. It will give you all the test patterns and setups for gray scales, HV regulation, tell you about you video card and much more. I just ran across it the other day. You can even set up the pincushion and lots more.

- SONERA Technologies markets a set of programs called "DisplayMate" available for DOS and Windows/Win95. This is supposed to guide you through the monitor testing and setup process with a series of test pattern 'slides'. I have not tried it so I cannot comment on its utility.

  A demo version with a few test patterns, more information on their products, and some video tech tips, and some test patterns are available at:

  - Display Mate Home Page and Demo.
  - Test Patterns.

  A subset of these test patterns is available courtesy of PC Magazine at: http://www8.zdnet.com/pcmag/features/monitors/test/. I don't know how long this will be available but for now, it is really easy to use and doesn't require that you even exit Windows. You may use it on 640 x 480, 800 x 600, 1024 x 768 screen resolution or windows of these size. Test patterns are provided for color rendition, horizontal resolution, dot/cross hatch, and more. The images files may be downloaded and saved as well.

- PassMark has a product that appears to have a fairly comprehensive set of features including 25 test patterns, display of monitor and video adapter information, and support for multiple resolutions, color depths, and display types. It can be downloaded for free with a 15 day evaluation, then costs $15:

  - PassMark MonitorTest.

Using a TV tuner card in a PC

These ISA, EISA, or PCI cards put TV programs or other NTSC/PAL source material into a window on your PC's monitor screen. The question has come up as to whether this will damage the monitor in the long term.

I would not think that there should be any problems unless you tend to turn the brightness up much higher than normally used for computer activities. If anything, the constantly changing picture will be better than a stationary window. However, moving it to different locations every so often will not hurt.

Similar comments apply to other types of image and video captures as well.

IMHO, I still think it is silly to use an expensive PC and monitor to watch TV.

What is color temperature and what does it affect?

Some monitors have the capability of selecting or adjusting for the 'color temperature' of the display. NEC AcuColor on the 4/5/6FG series of monitors is one example.

The terminology refers to the spectral output of an ideal black body source at that actual physical temperature. It essentially sets the appearance of a white screen. For example, a color temperature of 9300K will appear blue-white while 6300K will appear yellow-white.

It only affects the relative balance of R,G,B and has nothing to do with refresh rates or anything performance related. Unless you are doing work where the exact colors matter or are using multiple monitors where the colors need to match, use whichever setting ismore pleasing

What is this goop around some electrolytic capacitors and other components?

That goop is probably glue and generally harmless - it is there to hold down the components aganst vibration. I have heard of it sometimes decomposing and shorting stuff out but I doubt you have that problem.

Therefore, unless you find a bad cap in the focus or related circuit, we are still looking at a flyback problem.

What does the flyback (LOPT) transformer do?

The typical flyback or Line OutPut Transformer (LOPT) consists of two parts:

1. A special transformer which in conjunction with the horizontal output transistor/deflection circuits boosts the B+ (120 V typical for a TV) of the low voltage power supply to the 20 to 30 kV for the CRT as well as provide various secondary lower voltages for other circuits.

   A HV rectifier turns the high voltage pulses into DC and the CRT capacitance smooths it. The HV may be developed from a single winding with many many turns of wire or a lower voltage winding and a diode-capacitor voltage multiplier.

   The various secondary voltages power the logic, tuner, video signal, vertical deflection circuits, and CRT filaments. In fact, with many TV designs, the only power not derived from the flyback is for the keep-alive circuitry needed to maintain channel memory and provide startup drive to the horizontal deflection/high voltage system.

2. A voltage divider that provides the focus and screen supplies. The pots are in this divider network - and these things fail resulting poor focus, uncontrolled brightness, or fluctuating focus and/or brightness. A total short could also result in failure of other components like the horizontal output transistor. In some monitors, the focus and screen divider and/or controls are external to the flyback and susceptible to dust and problems particularly on humid days. The resistance of these circuits is so high that dirt or other contamination can easily provide a bypass path to ground especially when slightly damp.

Tony's notes on setting convergence on older delta gun CRTs

(From: ard12@eng.cam.ac.uk (A.R. Duell))

The older delta-gun tubes (3 guns in a triangle, not in a line) can give **excellent** pictures, with very good convergence, provided:

1. You've set those 20-or-so presets correctly - a right pain as they interact to some extent.

2. The CRT is set up in the final position - this type of tube is more sensitive to external fields than the PIL type.

Both my delta-gun sets (a B&O 3200 chassis and a Barco CDCT2/51) have very clearly set out and labeled convergence panels, and you don't need a service manual to do them. The instructions in the Barco manual are something like:

"Apply crosshatch, and adjust the controls on the convergence board in the numbered order to converge the picture. The diagrams by each control show the effect".

Here's a very quick guide to delta gun convergence where the settings are done using various adjustments on the neck of the CRT (if you don't have a service manual but do know what each control does, and where they all are - otherwise, follow the instructions in the service manual --- sam):

1. Apply a white crosshatch or dot pattern to the set. Don't try and converge on anything else - you'll go insane. It's useful to be able to switch between those 2 patterns.

2. Before you start, set the height, width, linearity, pincushion, etc. They will interact with the convergence. Also check PSU voltages, and the EHT voltage if it's adjustable. That's where you do need a service manual, I guess.

3. Turn off the blue gun using the A1 switch, and use the red and green static radial controls to get a yellow croshatch in the middle of the screen. These controls may be electrical presets, or may be movable magnets on the radial convergence yoke (the Y-shaped think behind the deflection yoke).

4. Turn on the blue gun and use the 2 blue static controls (radial and lateral) to align the blue and yellow crosshatches at the center of the screen. Some manufacturers recommend turning off the green gun when doing this, and aligning red with blue (using *only* the blue controls, of course), but I prefer to align blue with yellow, as it gives a check on the overall convergence of the tube.

5. Turn off the blue gun again. Now the fun starts - dynamic convergence. The first adjustments align the red and green crosshatches near the edges - I normally do the top and bottom first. There will be 2 controls for this, either a top and a bottom, or a shift and a linearity. The second type is a *pain* to do, as it's not uncommon for it to affect the static convergence.

6. Getting the red and green verticals aligned near the edges is a smilar process.

7. You now have (hopefully) a yellow crosshatch over the entire screen.

8. Now to align the blue. This is a lot worse, although the principle is the same. Turn on the blue gun again, and check the static (center) convergence

9. To align the blue lines with the yellow ones, you'll find not only shift controls, but also slope controls. Use the shift controls to align the centers of the lines and the slope controls to get the endpoints right. These interact to some extent. You'll need to fiddle with the controls for a bit to work out what they do, even if you have the manual.

The convergence over the entire screen should now be good....

A word of warning here... The purity is set by ring magnets on almost all colour CRTs, but on PIL tubes, there are other ring magnets as well - like static convergence. Make sure you know what you are adjusting.

Jerry's comments on convergence and other advanced CRT adjustments

(From: Jerry G. (jerryg@total.net).)

Convergence alignment is not something you can do yourself unless you have the proper calibration instruments and skills. It takes lots of experience and time. There are published specs for most of the good monitors. Most of the time they are as follows:

There is the 'A area', 'B area', and 'C area'. On a 15 inch monitor the A area would be a diameter of about 4 inches. The B area would be about 7.5 inches. The C area would be the outside areas including the corners. These numbers are approximate. There are actually standard specs for these areas. They are expressed in percentage of screen viewing area. Therefore the inches would vary with the CRT size.

The higher the price (quality) of the monitor CRT, yoke, and scanning control circuits, the tighter the convergence can be aligned by the technician. For the A area on a good monitor, the maximum error should not exceed 0.1 mm. For the B area it should not exceed more than about 0.25 mm. And for the C area, it can be allowed up to about 0.3 mm. Most of the monitors that I have repaired, seen, and used did not meet these specs unless they were rather expensive. With these specs there would not be any real visible misconvergence unless you put your nose very close to the screen... A lot of the ones in the medium price range they were about 0.15 mm error in the A area, about 0.4 in the B and greater than in the C area. This also annoys me because I am very critical.

If one has the skills and test gear he or she can do a better job on most monitors. It is a question of the time involved. To see the convergence errors a grating or crosshatch pattern is used. A full raster color generator is required for the purity adjustments as well. This is necessary to align the landing points of the CRT guns. The exact center reference and purity adjustments are done with the ring magnets on the CRT neck. The yoke position angle adjustments are also done for the side and top-bottom skewing as well. Everything interacts!

The corners are done with various sorts of slip or edge magnets. As for corner convergence skewing, button magnets are used. The color purity will be effected as you go, and must be also corrected. These adjustments interact on one another, and the processes continues until the convergence and purity are good at the same time...!

I don't recommend the amateur or hobbiest, or even the do-it-yourselfer to attempt this alignment procedure. The test gear would exceed the cost of a really good monitor anyways...!!! And without the proper skills required, he or she would only make it worse anyways...

As for purity specs, the color change from any corner to any corner must not exceed an error of more than 200 degrees Kelvin. The error in the B area should not exceed 300 degrees kelvin. This applies to a white raster. Most of the monitors I see don't get better than about 300 degrees Kelvin. And some are even 1000 out! The purity errors are best checked with a full Red raster using 100 % saturation. Then the other color vector angles are checked with cyan, and then magenta. The color temperature stability should be the same in all aspects.

A color spectrometer should be used to judge this error factor. As far as the eye is concerned, it will see a purity error of more than about 500 degrees Kelvin if the person knows what to look for...

When changing the CRT, this alignment must be done completely. Most shops do not even employ people who are skilled to a proper alignment, or don't even own the instruments to do it right, and the poor customer get back a monitor that is not in specs...!

Use of surge suppressors and line filters

Should you always use a surge suppressor outlet strip or line circuit? Sure, it shouldn't hurt. Just don't depend on these to provide protection under all circumstances. Some are better than others and the marketing blurb is at best of little help in making an informed selection. Product literature - unless it is backed up by testing from a reputable lab - is usually pretty useless and often confusing.

Line filters can also be useful if power in you area is noisy or prone to spikes or dips.

However, keep in mind that most well designed electronic equipment already includes both surge suppressors like MOVs as well as L-C line filters. More is not necessarily better but may move the point of failure to a readily accessible outlet strip rather than the innards of your equipment if damage occurs.

Very effective protection is possible through the use of a UPS (Uninterruptible Power Supply) which always runs the equipment off its battery from the internal inverter (not all do). This provides very effective isolation power line problems as the battery acts as a huge capacitor. If something is damaged, it will likely be the UPS and not your expensive equipment. Another option is to use a constant voltage transformer (SOLA) which provides voltage regulation, line conditioning, and isolation from power spikes and surges.

It is still best to unplug everything if the air raid sirens go off or you see an elephant wearing thick glasses running through the neighborhood (or an impending lightning storm).

GFCI tripping with monitor (or other high tech equipment)

Ground Fault Circuit Interrupters (GFCIs) are very important for minimizing shock hazards in kitchens, bathrooms, outdoors and other potentially wet areas. They are now generally required by the NEC Code in these locations. However, what the GFCI detects to protect people - an imbalance in the currents in the Hot and Neutral wires caused possibly by someone touching a live conductor - may exist safely by design in 3 wire grounded electronic equipment and result in false tripping of the GFCI. The reason is that there are usually small capacitors between all three wire - Hot, Neutral, and Ground in the RFI line filters of computer monitors, PCs, and printers. At power-on and even while operating, there may be enough leakage current through the capacitors between Hot and Ground in particular to trip the GFCI. Even for ungrounded 2 wire devices, the power-on surge into inductive or capacitive loads like switching power supplies may falsely trip the GFCI. This is more likely to happen with multiple devices plugged into the same GFCI protected outlet especially if they are controlled by a common power switch.

Therefore, I do not recommend the use of a GFCI for computer equipment as long as all 3 wire devices are connected to properly grounded circuits. The safety ground provides all the protection that is needed.

Monitors on foreign power

Using a monitor on a different voltage or frequency is usually not a serious problem.

Your PC and monitor should be fine requiring at most a transformer (not just an adapter for heating appliances, however) to convert the voltage. They both use switching power supplies which don't care about the line frequency.

Some power supplies are universal - they automatically adapt to the voltage they are fed without requiring even a transformer but don't assume this - check you user manual or contact the manufacturer(s) to determine if jumpers or switches need to be changed. You could blow up the PC or monitor by attempting to run it on 220 VAC when set of 115 VAC. If you are lucky, only a fuse will blow but don't count on it.

For non-switching power supply devices like printers and wall adapters that use line power transformers, in addition to matching the voltage (or setting jumpers or switches), running on a lower line frequency may be a problem. There is a slight chance that the power transformer will overheat on 50 Hz if designed for 60 Hz. (The other way around should be fine.) It is best to check the nameplate - it should tell you. If it does not, then best to contact the manufacturer.

Lifespans of Monitors

(From: Bob Myers (myers@fc.hp.com).)

Most manufacturers will quote an MTBF (Mean Time Before Failure) of somewhere in the 30,000 to 60,000 hour range, EXCLUSIVE OF the CRT. The typical CRT, without an extended-life cathode, is usually good for 10,000 to 15,000 hours before it reaches half of its initial brightness. Note that, if you leave your monitor on all the time, a year is just about 8,000 hours.

The only "tuneup" that a monitor should need, exclusive of adjustments needed following replacement of a failed component, would be video amplifier and/or CRT biasing adjustments to compensate for the aging of the tube. These are usually done only if you're using the thing in an application where exact color/brightness matching is important. Regular degaussing of the unit may be needed, of course, but I'm not considering that a "tuneup" or adjustment.

How do monitors know when to enter power saving modes?

(Portions from Bob Myers (myers@fc.hp.com).)

If the monitor complies with the VESA DPMS (Display Power Management Signalling) standard, it will go into power saving modes when either horizontal or vertical sync is disabled. Different combinations of the sync signals indicate different levels of power management, distinguished by how much the power is reduced and the expected recovery time. The greater the power savings, the greater the recovery time is expected to be. For instance, one thing that may distinguish the greater power savings states is turning off the CRT filament, something that you don't recover from in just a second or two.

You can tell which power saving mode is active by how long the monitor takes to come back to life:

1. Video blanking - image will appear instantly when any key is pressed since this is just a logic level inhibiting the video drivers.

2. Full shutdown - a warmup period of around 15 seconds will be needed for the image to reappear since the filaments of the CRT need to warmup.

Monitor life, energy conservation, and laziness

A common misconception about the care and feeding of computer monitors is that they should be left on all the time. While there are some advantages to this, there are many more disadvantages:

1. CRT Life: The life of a monitor is determined by the life of the CRT. The CRT is by far the most expensive single part and it is usually not worth repairing a monitor in which the CRT requires replacement. The brightness half-life of a CRT is usually about 10-15K hours of on time independent of what is being displayed on the screen. 10K hours is only a little more than a year. By not turning the monitor off at night, you are reducing the life of the monitor by a factor of 2-3. Screen savers do not make any substantial difference especially with modern displays using X-Windows or MS Windows where the screen layout is not fixed. With video display terminals, the text always came up in the same position and eventually burned impressions into the screen phosphor. With modern CRTs, the filaments can be left to minimize the time needed for a picture to appear since this doesn't affect CRT life very much.

2. Component life: The heat generated inside a monitor tends to dry out parts like electrolytic capacitors thus shortening their life. These effects are particularly severe at night during the summer when the air conditioning may be off but it is still a consideration year around.

3. Safety: While electronic equipment designed and manufactured in accordance with the National Electrical Codes is very safe, there is always a small risk of catastrophic failure resulting in a fire. With no one around, even with sprinklers and smoke alarms, such an failure could be much more disasterous.

4. Energy use: While modern monitors use a lot less energy than their older cousins, the aggregate energy usage

is not something to be ignored. A typical monitor uses between 60 and 200 Watts. Thus at a $.10 per kWH electric rate such a monitor will cost between $48 and $160 a year for electricity. During the night, 1/2 to 2/3 of this is wasted for every monitor that is left on. If air conditioning is on during the night, then there is the additional energy usage needed to remove this heat as well - probably about half the cost of the electricity to run the monitor.

The popular rationalization for what is most often just laziness is that power-on is a stressful time for any electronic device and reducing the number of power cycles will prolong the life of the monitor. With a properly designed monitor, this is rarely an issue. Can you recall the last time a monitor blew up when it was turned on? The other argument, which has more basis in reality is that the thermal cycling resulting from turning a monitor on and off will shorten its life. It is true that such thermal stress can contribute to various kinds of failures due to bad solder connections. However, these can be easily repaired and do not effect the monitor's heart - the CRT. You wouldn't leave your TV on 24 hours a day, would you? Full power saving where virtually everything including the CRT filaments is turned off is really best but the delay before a picture appears may be 20 seconds or more.

Also see the section: Thermal cycling and component life.

Most of the newest ('green') monitors have energy conserving capabilities but it is necessary for the software to trigger these power reduction or power down modes. However, many monitor still in use lack these features. And not all workstations or PCs are set up to support them. If you have such a monitor and computer to support it, by all means set up the necessary power off/power down timers.

However, using the power saving modes of a 'green' PC with an older monitor can potentially cause damage since some of the modes disable the sync signals. A 'green' monitor which can detect a blank screen and and use this as a trigger can easily be used with a screen saver which can be set to display a blank screen - on any PC or workstation.

Even if the monitor does not support power saving modes, a blank screen or dark picture will reduce stress on the CRT and power supply. Electronic components will run cooler and last longer.

Please make it a habit to turn your monitors off at night. This will extend the life of the monitor (and your investment) and is good for the environment as well. For workstations, there are good reasons to leave the system unit on all the time. However, the monitor should be turned off using its power switch. For PCs, my recommendation is that the entire unit be turned off at night since the boot process is very quick and PCs are generally not required to be accessible over a network 24 hours a day.

Thernal cycling and component life

(From: Bob Myers (myers@fc.hp.com).)

In a CRT monitor, the shortest-lived component BY FAR is the CRT itself, and it ages (more properly, the cathode is aging) as long as the heater is on and the tube is under bias. Most monitors don't get around to turning the heater down or off until they enter the DPMS "suspend" or "off" modes. (And no, screen-savers do NOT help here - the tube is still on and the cathode is aging.)

Other factors - simply having the circuits hot and powered up in general means that they're aging. Clearly, they're NOT aging when they're off. This needs to be balanced against the thermal-cycling sort of stresses that you mention which happen during power cycling, and this is why I recommend shutting off only when you're going to be away for an extended period, such as overnight. This is, of course, most important for those components which have clear heat-related aging, but most do to some extent. Esp. vulnerable are things like electrolytic caps, for obvious reasons.

The bottom line is that nothing is ever going to last forever, and trying to maximize the life of the product is an exercise in making tradeoffs between various aging/failure mechanisms.

Minimum and maximum lifespan of monitors

(From: Bob Myers (myers@fc.hp.com).)

There's no way to set a "minimum" or "maximum" life, as there's quite a variation from unit to unit. Some small percentage will fail right out of the box ("infant mortality") while others will run happily for years. We normally speak of a mean, or average, life expectancy, as in "MTBF" ("mean time before failure"). In a CRT display, the CRT itself is usually the limiting factor in this, and in THAT specific case we usually speak of "mean time to half-bright" instead, since it's rare for a CRT to simply die once it's past its early operating life. (Excluding such things as mechanical damage and so forth, of course.) Mean-time-to-half-bright is just what it says: how long, on average, can you operate the tube before the brightness drops to half its initial level for a given set of operating conditions. (Brightness is ALWAYS slowing decreasing throughout the tube's life, due to the aging of the cathode and the phosphor.) For most tubes with standard cathodes, this will be in the neighborhood of 10K-15K hours (a little over a year to not quite two years of continuous operation).

Implications of power saving modes

(From: Bob Myers (myers@fc.hp.com).)

Energy Star and similar power-saving certifications generally don't specify what is done inside the monitor to achieve the power reduction, just the maximum power dissipation in the "reduced power" state(s). Still, most designs WILL either reduce the voltage to the filament, or shut it off completely, depending on the degree of power reduction needed for a given state.

Thermal stresses would be damaging to the heater and cathode if they happened significantly more often than the daily power-down (you DO turn you monitor off for the night, don't you?). The way to use these features properly is to NOT set up the system to enter the more reduced states ("suspend" and "off") until a reasonably long period has passed with no action. Use the "standby" state for the first level, the one you enter after a few minutes (10?) of inactivity, and don't go beyond that unless the system is inactive long enough to suggest thay you're going to be away for a while. But make sure that the system WILL get to the deepest level of power reduction supported - with the monitor as close to full off as you can get - when you're going to be away for a really long while, like overnight. Turning the monitor off overnight is the best thing you can do for it.

And no, I don't think these monitors will be that much more difficult to service, just because they've got power management. This is usually a fairly simple addition to the power supply, and doesn't really affect the complexity of the rest of the unit. But modern monitors DO tend to be more complicated anyway - what with digital controls, on-screen displays, etc. - and so are somewhat more difficult to repair. It just doesn't really have much to do with the power-saving bits.

Methods to prevent screen burn-in on fixed format monitors

When TVs or monitors are used to display the same pattern day in and day out, screen burn is likely to result. This may happen with TVs used extensively for video games and text display terminals - both situations where the format of the screen is relatively fixed. It is not likely with TVs under normal usage or monitors used with windowing systems (e.g., Win95, X-windows) where the display changes from time-to-time.

With TVs, your only options are to reduce the brightness or get the kids (you?) to participate in less mind numbing activities.

For monitors, here are three approaches (they can obviously be used together).

9. Blank or dim the screen or use a screen saver when not in use (won't prolong CRT life but will reduce possibility of burn-in).

10. Only set the brightness and contrast as high as needed for comfortable viewing. Subdued ambient illumination will allow these to be greatly reduced (and save energy as well!).

11. Randomize the display. On a text entry terminal, for example, the system could be set up to vary the position of the text on the screen by a small amount - a random number of pixels horizontally and scan lines vertically less than the character size. This could be done every time it is switched on or periodically. Of course, unless you are the designer or programmer, this option probably isn't very viable!

    There will always be some degradation of the phosphor even during normal use. With changing scenes, it will simply result in a long term darkening of the screen and reduction in maximum brightness (independent of the reduced mission from the electron guns). This effect is likely very slight but my advice is to keep contrast (peak whites) only as high as you need and turn the brightness down when not using the monitor for a few minutes. Also see the section: Monitor life, energy conservation, and laziness.

Monitors, heat, and cooling fans

Electronic equipment in general most often really likes to be kept cool. Up to a point, cooler is better. However, to save a few cents and to avoid complaints about noise, few monitors come equipped with internal cooling fans even though these could substantially reduce the internal temperature and may prolong a trouble free life.

Without a fan, there are still (possibly) simple steps that can be taken to keep the monitor happy:

- Keep the ambient temperature low. There is no need for the humans to freeze, but if you are uncomfortably warm, so is your monitor.

- Run the monitor at the minimum brightness for your needs. It is better for the monitor and energy conservation use lower ambient illumination and lower brightness. Stress on both the CRT and power supply components is reduced and the monitor will run cooler.

- When idle, use a screen blanker (or screen saver that displays a dark picture) or take advantage of any power saving modes that may be supported. As above, this will reduce stresses on the monitor's components and save energy as well. Of course, turn all the monitors off at night. See the section: Monitor life, energy conservation, and laziness.

- Make sure the monitor's ventilation holes are not covered or blocked in any way. There should be several inches of clearance on all sides, top, and bottom. Make sure dust doesn't collect - suck it out with a portable vacuum cleaner.

However, even if you follow these recommendations (or have no control over some aspects of your monitor's environment and operation), some monitors run excessively hot.

While I don't know of any controlled studies on this topic, anecdotal evidence suggests a substantial benefit to forced air cooling for some monitors.

It doesn't take much - even a CPU style 1.5 inch fan will make a noticeable difference in nearly total silence.

The best place to mount such a fan is probably on the plastic case in the vicinity of the high power components - power supply or horizontal deflection. Provide a hole and grill to match the fan. Orienting it to blow outward may be better for general cooling. However, it will be easier to cool specific parts if the fan blows in and with a filter, this will also reduce dust infiltration.

Power can be tapped from any convenient source which provides a voltage that is compatible with the fan. For example, a 12 VDC fan can run on anything from 8 V (or somewhat less) to 15 V or so with a corresponding variation in speed. The current used by such a fan is generally negligible so it shouldn't be a problem to find a source with enough excess capacity.

If you really want to be slick, add a circuit to adjust fan speed based on scan mode (higher scan modes->higher air flow) and/or temperature.

Why are prices of video monitors so high compared to similarly sized TVs?

> "How come I can buy a 32" Sony Trinitron TV set for $800, but when it comes to buying a monitor for my PC, $1400 only gets me a no-name 20" tube?
>
> Why can't a giant like Sony produce a PC monitor anywhere close in cost to an equivalently sized TV set?"

Well, the bottom line is that there isn't much in common between a TV and computer monitor when one gets down to the details. The basic principles of raster scan display apply to both and that is about it! Monitors would already be much more expensive if it weren't for the additional fact that many more TVs are manufactured and sold than monitors - which drives down their prices still further:

(Some of this from: Mike Stewart (mstewart@whale.st.usm.edu).)

There are several significant factors being overlooked here:

1. Economy of scale. There are still *many* more TV sets being sold than computer monitors. Manufacturers order TV chipsets in much larger quantities. This drives down the price.

2. Resolution. NTSC TV signals aren't even VGA resolution. Try getting that 32" Sony Trinitron XBR to give you 1280x1024. A computer monitor has a CRT with a resolution about 2 to 3 times that of a TV of similar size in both horizontal and vertical directions. The beam is also more sharply focused.

3. Refresh rates. NTSC TV signals come at one refresh rate, period. You either watch broadcast NTSC at 59.94Hz (interlaced), or you don't watch it at all. No nice, clean 72Hz NI display on there. (NOTE: This only refers to the 99+% of TV playback equipment that contains no line- doubling circuitry. That's fair, as you'll pay a good bit more for a non-interlaced, line-doubled NTSC picture than the previous poster was complaining about, anyway.)

   Therefore, a auto-scan monitor needs more sophisticated deflection and power supply circuitry. It must run at much higher scan rates and this complicates the circuitry as well.

4. Geometry. The precision of a good computer monitor is much greater then any TV. The sides will be parallel and square. Adjustments are provided to eliminate pincushion, keystone, and trapazoid distortions.

5. Stability. The image on a high quality computer monitor is rock solid and does not shift position or change size as components warm up, or the power line voltage fluctuates, etc.

(From: Bob Myers (myers@fc.hp.com).)

The basic reason for the cost difference between CRTs for computer and TV is that they are NOT the same product

AT ALL.

They do not share ANY major component. The glass is different (for one thing, computer tubes are still almost ALL 90 deg. deflection; TV glass is for 110-114 deg. deflection). The electron guns are different (different spot size vs. brightness tradeoff). The shadow masks are different (computer displays use a much finer dot pitch than the same size TV tube). Even the phosphors used are sometimes different. They are aimed at different markets, with different requirements, and so are completely separate designs. They most often are not even produced on the same production line.

Beyond the CRT, every other major part of the display design is different, mostly owing to the difference in horizontal rates required (~15.7 kHz for TV, vs. 30-85 kHz and often MUCH higher for computer displays) and the need for multifrequency operation in the computer market, combined with the need to hold to much tighter geometry, convergence, etc. specs at these higher rates.

In short, the only thing that's the same between a TV set and a computer monitor is that they're both boxes which make pictures on a glass screen. Sort of like the Queen Elizabeth II and the Exxon Valdez - yes, they're both big metal things that float in the ocean, but there's not really all THAT much in common between the two designs.

Why is the resolution of a computer monitor so much better than a TV

Of course, computer displays may run at resolutions of 1280 x 1024 or more. These are not limited by minor considerations such as channel bandwidth, and to a lesser extent, cost. These are separate issues from why a computer monitor display is so much better even when the number of scan lines is the same - as with NTSC versus basic VGA (640 x 480).

1. NTSC (525/30) is fundamentally limited by the bandwidth and color encoding of the composite video signal. This is the most significant factor limiting any possible display on a TV via the RF/cable/antenna, or composite or NTSC (direct A/V) inputs to perhaps half of VGA resolution horizontally.

   PAL (625/25) more closely matches an 800x600 SVGA format but still suffers from similar limitations in horizontal resolution.

2. Monitors are designed to provide sharp focus at the expense of brightness. TVs don't have great focus but produce brighter display. This limits both horizontal and vertical resolution.

3. Monitor CRTs are designed with much finer dot/line pitch in the shadow/slot mask or aperture grill - often better than 2:1 smaller than similar size TVs.

4. TVs use interlaced scanning. Jitter in the vertical also affects perceived display quality.

Where a TV/monitor has direct RGB inputs, the limitation is primarily due to (2) to (4) though they may not have the same high bandwidth circuitry as a more costly computer monitor.

There are other factors but these are the most important.

Combined TV and computer monitor

> "This is a 27" VGA monitor which should also be able to be used as an NTSC television monitor. Can anybody comment on it?"

IMO, I think the entire idea of a combined TV/computer monitor is silly especially when the likely cost premium is taken into account. Watching the boob tube will tie up your entire PC. The optimal size for TV and computer use is not the same nor are the requirements in terms of scan rate, resolution, brightness, and sharpness. Thus, the design will be inherently more expensive and include more compromises.

So, I will probably be proved wrong by record sales of these things...

Problems with designing a combination TV and computer monitor

(From: Bob Myers (myers@fc.hp.com).)

It's possible, and has been done (for instance, Toshiba has one product and offerings from other companies are available or are on the way). But such designs ARE compromises, and won't give the best performance possible in either application.

There is a fundamental difference between CRTs designed for TV use, and those used in computer monitors. It's a brightness/resolution tradeoff - TV tubes are run about 3X or so the brightness of a typical computer monitor, but sacrifice the ability to use small spot sizes and fine dot pitches to do this. You don't see very many color tubes running at 100 - 150 fL brightness and still using an 0.28 mm pitch!

So, what about truly digital monitors?

The following issue is distinct from that of flat-panel technology which of course is rapidly replacing the CRT in computer monitors.

> "I am really interested in this Digital Revolution (DVD, HD-TV) but what about PC monitors? Wouldn't it be great to have a monitor that was also compatible with HD-TV? I want to buy a new 17" or 19" but I don't want to invest in CRT (analog technology), when will Digital PC Monitors be coming out?"

(From: Bob Myers (myers@fc.hp.com).)

Being compatible with HDTV just means having the right front end to interpret the signals, just as using NTSC video on a current computer monitor requires a decoder. I seriously doubt that we'll see computer displays which are DIRECTLY capable of handling the HDTV data stream.

Having said that, there is ALREADY a standard for a digital display interface, which was approved by VESA last year. The new "Plug & Display" interface standard supports BOTH digital and analog video outputs on a single standard connector, enabling monitors with either sort of interface to be easily supported. (The host uses ID information from the monitor - already a standard feature of most CRT displays - to decide which interface to use and how to configure it for a given monitor.) There are already products on the market (a few) or in development using the new interface.

Having said THAT, don't count the CRT monitor out just yet; it'll probably be with us for some time yet, and there's little reason to use a digital interface for a CRT-based display (since, under the new standard, you're going to have BOTH flavors of interface available anyway). Actually, there is very little inherent advantage for MOST display technologies in the interface itself being "digital" (even LCDs are "analog" at the pixel level); the problems most non-CRT displays have today with "analog" video have to do with getting a good TIMING reference with which to sample the video, NOT with whether that video is encoded in digital or analog form.

About sync polarity options

Many video cards provide polarity options for each scan mode. Why?

Probably to be compatible with older monitors. Most modern monitors are auto polarity detecting so the settings should not matter.

(Note that some of the digital PC video standard did have specific sync polarity specifications.)

Some software programs that directly access the video card may even be changing sync polarity - for apparently no reason - without you being aware of it.

Your video card determines the maximum video rate you can generate. The monitor has to be able to lock to it. So, if you cannot setup higher than some specified rate (i.e., the options do not exist in your menu), it is a function of the video card and drivers. If you can set it but the monitor displays garbage or nothing at all, it is a limitation of the monitor. The sync polarity rarely makes any difference and if it does, the effects will be obvious - picture shifted left/right/up/down on screen - or just won't sync at all.

If you experience problems of this type, experimenting with the sync polarity may be instructive.

If you do not know what your monitor wants and you have the option, set both horizontal and vertical sync polarities to be negative as this is nearly always acceptable (for studio video and VGA/SVGA monitors).

(From: Bob Myers (myers@fc.hp.com).)

This was used in older systems to identify certain display modes, but in general modern monitors accept either polarity equally well. Recent display timing standards have all been written specifying positive-polarity sync (the sync pulse is at logical "1" rather than "0"), but the use of negative polarity usually won't do anything except possibly cause the image to be off-center by the width of the sync pulse.

VESA Display Data Channel standard

(From: Bob Myers (myers@fc.hp.com).)

This defined several protocols for digital communications between a host system and its display. DDC provides 3 different modes:

```
DDC1 - A unidirectional (display to host only) serial communications system
         which provides basic display ID and feature support information
         (including supported timings, display size, colorimetry and gamma,
         etc.) to the host.  This uses pin 12 on the 15-pin "VGA" connector as
         a data line.


DDC2B - Adds clock (pin 15) and return (pin 11, I think - I'm at home, and
         don't have the standard with me) to enable at least ID information to
         be obtained via an I2C interface.  I2C is a bidirectional interface,
         but display control via DDC2B is not defined at this time.


DDC2AB - Full ID and control of the monitor via ACCESS.bus.  As ACCESS.bus is
         basically a command and protocol definition on top of the I2C
         hardware interface, this uses the same lines as DDC2B.
```

DDC was the first and only definition of the 15-pin D-subminiature video output connector which VESA has provided. No further definitions on this connector will be made, as VESA is instead concentrating on the new

Enhanced Video Connector standard which is due out later this year. This will define a completely new connector which will include support for DDC and separate syncs as in the 15-pin D-sub, and will also include support for audio I/O, video input, and the USB and P1394 serial interfaces.

Identifying connections on unknown or cut monitor cables

Obviously, this is best done with a schematic. However, since such a luxury may not be possible, how can you go about figuring out where all the wires go? Easy answer - very carefully.

For the following, I assume a VGA/SVGA monitor. You need to identify the grounds, video signals, H and V sync, and monitor sense lines. The procedure is described with respec to a cut cable but if you are trying to identify an unknown connector type on the monitor, the same comments apply to the wiring **inside** the monitor.

First identify the grounds. Use an ohmmeter between each wire and the shell of the video connector on the monitor. Resistance will be less than an ohm for the ground wires. These will often be colored black. The shields of the RGB coaxes will also be connected to ground.

The high bandwidth video signals will always use individual coaxial cables. These may even be color coded red, green, and blue. If not, you can determine which is which later on. If there are only three such coaxes, they are the video signals. If there are four, the extra one may be the H sync. If there are five, the extra two may be the H and V syncs. Testing between these wires and ground with an ohmmeter should measure 75 ohms for the video terminations.

Display a lively screen on your PC at a resolution you know the monitor should support (remember, trying to drive a monitor of unknown scan rate specifications beyond its ratings is like playing Russian Roulette.) When in doubt, VGA (640x480, 31.4 kHz H, 60 Hz V) should be safe.

Turn up the brightness and contrast on the monitor. If you are lucky, even without any sync, there will be a visible raster. Set it to be just visible. If there is none, then it should appear once there is valid sync.

You will need to bring out wires from the video connector on your PC.

Connect the ground of your video card to the ground wires you already identified on the monitor cable.

Attach a wire in series with a 200-500 ohm resistor to H sync (pin 13) on the VGA connector.

Momentarily touch the end of this wire to each of the remaining unidentified wires (including the coaxes if you have 4 or 5 of these and it is not obvious which are the video signals) on the monitor. When you find the H sync input, the raster should lock in and probably brighten up. If the monitor was originally whining due to lack of sync, it should quiet down.

Once you have located H sync, you can remove the resistor and connect the wire up directly.

Now, attach the video signals. It is likely that you will now have a picture but it will be rolling on the screen. Some monitors, however, will not unblank until they receive both valid H and V sync. Use your resistor with the V sync output of the video card (Pin 14) on the remaining unidentified wires. Once you find the V sync input, the display should lock in solid.

The only remaining unknowns are the monitor sense lines. For older monitors - those without the ACCESS.bus interface, you can just wire up the sense lines to the appropriate levels (Color: ID0 (Pin 11) to ground, ID1 (Pin 12) NC).

See the document "Pinouts for various connectors in Real Life(tm)" for detailed hookup information". Replacement

VGA connectors are readily available.

Also see the section: Replacing the cable on an HP D1182A monitor for some hints and helpful 'hassle savers(tm)'.

Replacing monitor cables or connectors

Many intermittent or erratic loss of color or loss of sync problems are due to a bad cable - more specifically, bad connections usually between the male pins and the wires. Or, perhaps, one or more pins were accidentally broken off as a result of the connector being forced in the wrong way around.

Unfortunately, it is all too likely - particularly with newer monitors - that the shell is molded on and impossible to non-destructively remove to access the connector for wire repair or pin replacement.

You have several options:

- For name brand monitors, entire replacement cables may be available. These will be pricey ($25 to $50 typical) but are by far the easiest solution.
- The connector itself can be replaced. Places like MCM Electronics stock VGA (HD15) male connectors and pins. These may be either solder or crimp type (both can actually be soldered if you work at it). It takes a steady hand, bright light, and patience to solder the fine wires to the tiny pins. A crimp tool is probably not worth the investment for a single repair.
- If you can locate a dead monitor with a good VGA cable still attached, it is possible to cut and splice the wires away from the connector. Use an ohmmeter to identify which signal pin connects to which color coded wire on each cable and then solder and tape the individual wires. It won't be pretty but should work reasonable well.

Replacing the cable on an HP D1182A monitor

(From: Marion D. Kitchens (jkitchen@erols.com).)

By following the procedure in the section: Identifying connections on unknown or cut monitor cables, I was able to get a D-15 correctly connected on the ends of an HP D1182A monitor's video cable. This was a monitor that came to me with the D-15 missing. The only remaining unknown is the brown wire but the monitor seems to work fine without it (however, see below).

Cable Wire	Internal Pin #	Function	Resistance	D-15 Pin	Notes
White Coax	5,4	Red Video	75	1,6	shield is 6
Black Coax	3,1	Green Video	75	2,7	shield is 7
Red Coax	7,6	Blue Video	75	3,8	shield is 8
Red	8	Gnd	0	10	red & blue are
Blue	9	V. sync	1K	14	twisted pair
Yellow	10	Gnd	0	10	yellow & clear are
Clear	11	H. Sync	500	13	twisted pair
Brown	12	ID0??	Infinite	11??	Works OK w/o

Internal pin numbers refer to a 12 pin, in-line connector inside the monitor. It is mounted on a circuit board (model XC-1429U printed on board) that is mounted on the neck of the CTR. There are 12 pins, but one is blank -- nothing connected. I have called that one pin # 2 for reference, and the pin furthermost away I called pin #12. Double numbers mean the first is connected to the coax center conductor, and the second is the coax shield.

The double numbered pins under D-15 above mean connect the center conductor of the coax to the first pin number, and the coax shield to the second pin number. All the coax shields should measure zero Ohms to ground, and all the center conductors should measure about 75 Ohms to ground. Ground is the outer shield of the video cable, which is connected to the D-15 connector shell when doing the wiring job.

Pins 5 & 10 are also listed as ground connections on the D-15 connector. I suspect these are for the H. sync & V. sync, but do not know that for a fact. I connected what I believe to be both ground returns (per the twisted pairs show above) to pin 10.

The currently unconnected brown wire does have a signal of some sort on it. At least when trying to find the H. sync and V. sync wires, I got screen reactions if I connected it to some pins on the D-15 connector. Since it was the only "left over" wire when I got H. sync & V. sync correct, I suspect it to be the ID0 wire. Yes? No? Maybe? Nothing seems to happen when I connect it to D-15 pin #11. The monitor SEEMS to be OK without the brown wire connected to anything (but the color balance is a bit off, green and blue OK, but red is a pale pink). An Ohmmeter connected between ground and the brown wire "acts like" it is charging a capacitor -- resistance starts low and increases with time to several 10's of Meg. Is that a clue?

As an aid in finding the correct wiring connections I make a special floppy. It is a bootable floppy for use in the A: drive. Boot the computer from that floppy. First format a system floppy for the A: drive. Then copy the ANSI.SYS file from your C:\DOS\ files to the floppy. Next write a CONGIF.SYS file to the floppy, containing one line --- DEVICE=A:\ANSI.SYS Now write three batch files to the floppy, one for each color.

```
RED.BAT file
  PROMPT  $p$g$e[41m
  CLS


GREEN.BAT
  PROMPT  $p$g$e[42m
  CLS


BLUE.BAT
  PROMPT  $p$g$e[44m
  CLS
```

In trying to find the H. sync and V. sync, I found it most helpful to use the following procedure.

1. Connect all of the ground wires, and one of the coax center conductors (any one at random) to D-15 pin #1.

2. Boot the computer from the above floppy. Watch the drive light to determine when the boot process is completed. Hit RETURN twice to get past the new time and date that it asks for.

3. Turn on the monitor, and type RED to run the red batch file.

4. Now follow the procedure in the section: Identifying connections on unknown or cut monitor cables to find the H & V sync wires. When you have them correct you should see a colored screen (it might be red, green, or blue) and two "A:>" prompts on screen. Make sure the brightness control is set for maximum brightness, and that contrast is high.

5. Once you have a readable screen, find the correct coax to produce a red screen when connected to D-15 pin #1. Then type GREEN to run the green batch file, and find the correct coax to produce a green screen. The remaining coax is, of course, the blue video. But verify that anyway by typing BLUE to run the blue batch file.

6. Now you should be able to get red, green, and blue screens buy running the respective batch files.

To aid in the trial and error process of finding all the correct wiring, I made a small (3 by 4 inch) PCB with 15 connection points and a large grounding point, and mounted a D-15 connector on one edge. The 15 copper traces were wired to the D-15 connector so that pin numbers 1 through 15 followed a simple series across one edge of the PCB. The 15 traces were about 1/4 by 1 inch to make life easy. I even soldered 220 Ohm resistors to pin numbers 13 & 14 on the board to make that easy too. With this "aid" I used a video extension cable to bring my working point to the front of the test bench, and had plenty of working room for all those trial and error connections. Yes, I do like 'hassle savers(tm)'!

How can I determine monitor specifications or whether it supports SVGA?

There is no easy way to tell by just examining the monitor visually. Even those with only a 9 pin rather than a 15 pin connector are sometimes SVGA (e.g., Mitsubishi AUM1381 and NEC Multisync II which will do 800x600 at 56 Hz V non-interlaced and 1024x768 interlaced at 43 Hz V).

You cannot even safety test scan rates on all monitors - some (mostly older ones) will blow up or be damaged by being driven with incorrect video.

For a monitor that you already have, looking it up in a monitor database is really the only way to be sure of its capabilities (well, pretty sure - these listings are not always correct!). See the section: Web sites with monitor specifications for on-line resources. If this doesn't help, you try posting the information you have (model number, FCC code, etc.) to the newsgroups: comp.sys.ibm.pc.hardware.video and sci.electronics.repair. Where none of this is production, here are some quickie tests:

1. Check the video connector. If it has a high density (VGA) 15 pin connector then there is a greater likelihood of SVGA but not always.

2. Check the manufacturing date on the back. If it has a manufacturing date of 1991 or later, the likelihood of it supporting SVGA is higher as demand for VGA-only monitors was rapidly declining by this point.

3. Check the dot pitch on the CRT by examining the screen with a magnifier. If it is really coarse, the monitor probably cannot do anything beyond VGA.

4. Become familier with the major manufacturers and models so that you will recognize the common SVGA models.

5. Check the databases listed in the section: Web sites with monitor specifications.

While not conclusive, positive results on the first 3 of these tests definitely increases the likelihood that it supports at least some SVGA modes. Of course, if you recognize a model number, you have dramatically increased your odds of success - assuming it works!

From: Adrian Kwong (a.kwong@ieee.ca).)

Most new monitors employ frequency protection. The symptom that you will typically see is, a complete lack of video. Most monitors with multicolored power LED's, usually change color to indicate an error. Some monitors like Nokia's, will flash the screen on and off (black and white) to indicate that the over-frequency protection circuits have been activated.

I have blown a few monitors by setting the video resolutions either too high, or setting the vertical refresh to something that puts the horizontal frequency waaay above the rated specifications.

I actually have no idea how some of these monitors actually received a UL or CSA approval stamp, as I have seen some of these monitors catch on fire. Most of the 'blow outs', were just capacitors that exploded and about a room full of smoke fills the vicinity.

All of the monitors that I blew up, were really old monitors with no frequency protection.

Is CRT replacement worth it?

The sad fact is that even if you can obtain a new CRT you won't have the proper set up for getting proper alignment and convergence. They generally use various permanent magnet glued to the perimeter of the yoke to set the geometry of the raster. It takes a special factory jig to do this step or really great persistence and patience. However, if you have the time and will resist punching a hole in the new CRT before you finish, by all means.

Also, consider the cost of a new CRT may be more than half the cost of the monitor when it was new.

Replacing a monochrome CRT is a snap in comparison.

A better (or at least less stressful) approach is to locate a monitor that died due to a circuit problem and salvage the CRT including the yoke and all the other magical magnets and coils.

(From: Andy Cuffe (baltimora@psu.edu).)

I have found that most 15" monitors use compatible CRTs. I just put the CRT from an old Gateway2000 with analog controls into a nice 2 year old monitor. As long as the yokes and CRT sockets are similar it should work fine. Don't try to swap the yokes or you will never get it converged.

An informal history of X-ray protection

(The following is from: Marty).

Most of the old tube type color TV sets used a shunt HV regulator tube, usually a 6BK4. If it failed, or some component in the HV circuit failed, the high voltage, normally 25 kV, could go up to 35kV or more, causing some X-Ray leakage from the CRT. In the early 70s when news of this radiation scare was first announced, there was a public outcry to immediately fix the problem. The Feds hastily imposed a requirement on manufacturers of TV sets to somehow render a TV set "unwatchable" if the HV exceeded rated limits.

The manufacturers first response was to follow the letter of the law and the first "HEW" circuit simply blanked the video when the HV exceeded a setpoint to make the set "unwatchable".

It was quickly noticed that the HV was not turned off with this circuit and the CRT still could emit some radiation. Many TV sets with this feature were left on so the consumer could listen to the sound, so the feds tightened the requirement.

By this time new TV sets were all solid state and some manufacturers experimented with HV shutdown circuits, but most of these circuits were poorly designed and not reliable.

Zenith thought they had the answer by regulating the HV with a bank of 5 capacitors across the horizontal output transistor to "hold down" the HV to 25kV. If one capacitor opened, the HV would only rise about 2kV, not a dangerous situation. This wasn't good enough for the feds.

The "fix" that Zenith finally came out with, was a "4 legged capacitor. Two legs were the emitter return for the horizontal output transistor, & two legs were the HV holddown capacitor (the equivalent value of the bank of 5 caps). This "fix" was accepted by HEW and millions of TVs were produced. It worked so well, that other manufacturers soon followed the lead (Magnavox, GE, etc.).

Then the worst happened! The 4 legged monsters started failing in a large numbers. Not opening completely & not shorting out. They sometimes allowed the HV to skyrocket to over 50kV. Some of them even cut the necks off of the CRTs.

Zenith issued a recall on those models with the problem (more than one entire model year). After several "improved" versions of the capacitor, the problem was fixed but that recall almost bankrupted the company. Other companies had failures too, but usually not as dramatic as Zenith's.

Magnavox used the HV holddown capacitor, both single & 4 leg version in several 70s era TV sets and is a good candidate for fireworks as well.

Turning a TV (or monitor) into an oscilloscope?

This question comes up so often and it does sound like a neat project to give a defunct TV a second life. Don't expect to end up with a Tek 465 on the cheap when you are done. However, it could be a fun learning experience.

CAUTION: See the safety recommendations below.

You will be severely limited in the performance of such a scope. TVs and monitors are designed to operate at a very narrow range of horizontal scan rates and the high voltage is usually derived from the horizontal deflection. So, you would need to retain the original deflection system for this purpose at least.

1. You will need to disconnect the defection yoke from the horizontal and vertical deflection circuits of the TV or monitor without killing the HV. (also, doing all this without killing yourself as well). Depending on the design, this may be as simple as unplugging the yoke connector. More than likely, you will need to substitute a load for the horizontal deflection coil. A coil from another sacrificial similar TV or monitor would probably suffice.

Warning: at this point you have a really bright spot in the middle of the screen which will turn to a really black spot if the brightness is not turned way down really really quickly.

2. For the horizontal, you need a ramped current source. You are driving a non-ideal inductor (the deflection coil) so it has both inductance and resistance. Thus the waveform is a trapezoid - a voltage ramp (for the resistive part) superimposed on a voltage step (for the inductive part). This should not be too difficult. Don't expect to be able to achieve really fast sweep. Even running at normal TV rates is non-trivial.

3. Similarly, for the vertical you need to drive with a voltage (your signal) controlled current source. However, if you just screwing around, then the linearity etc. for the vertical may not be that important. In this case, one way is to put a current sensing resistor in series with the deflection coil and use this in a power op amp type of feedback arrangement. (You could do this for (2) as well.

4. There is a good chance that the original brightness control will work as an intensity adjustment. However, with some TVs and monitors, this depends on receiving a valid video signal. You may need to improvise. If you do want to control the intensity from a signal source, you should be able to tap into the drive signals going to the little board on the neck of the CRT.

5. Don't expect high bandwidth, uniform response, or any of the other things you take for granted with a decent scope. That takes work. However, as a fun project, this certainly qualifies. Interchanging the functions of the

horizontal and vertical deflection yoke (and rotating it 90 degrees) may provide a better match of horizontal and vertical bandwidth to your intended applications or experiments.

6. With a color TV or monitor, these experiments could be quite interesting and educational but there may be color fringing effects since you are not compensating for certain aspects of dynamic convergence at all.

7. SAFETY: Once you disconnect the deflection yoke from the TV or monitor's circuits, move the original circuits out of the way and put a barrier between between you and the rest of the TV or monitor. All you will need are connections to the deflection yoke on the CRT (unless you want to do intensity modulation in which case you will need to drive the video output(s) to the CRT cathodes. I would recommend against doing this if your unit is one of those with a totally 'live' chassis as there would be additional safety hazards and circuit complications).

(From: Lance Edmonds (lanceedmonds@xtra.co.nz).

Some years ago ELEKTOR and Electronics Australia magazines published articles on a design for this. Dick Smith Electronics in both NZ & Australia used to sell the kit.

Max Bandwidth was a startling 10 or 15Khz. Enough for elementary audio servicing.

Those magazines also published designs for delayed sweep & trigger modules as additions to any basic 'scope. Plus, a storage scope design, logic analyzer design, and a Dual trace emulator design.

Enough to keep the average hobbist/experimenter happy for quite a while (g).

(From: Dale H. Cook (dhcook@rev.net).)

Every few months someone will pop up with this question. A TV would not make a very good scope. Bandwidth would be limited and the amount of work needed to build the horizontal and vertical amplifiers, sweep and triggering circuits and so on wouldn't be worth the effort. You'd need even more work to add modern features such as delayed triggering and variable hold-off. Don't even think about multiple channels and the advantages they offer. In a time when I see used Tek 465s offered for $200 it certainly doesn't pay to try to convert a TV. If you are just looking for a challenging electronic project I can think of several that have a far better chance of yielding something useful. Now, if you were starting with an antique set that used an electrostatic CRT you might do a bit better, but a 1937 Dumont will set you back about $3,000.00 or so - a little too much of an investment.

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

I've worked on the vector monitors that were used on some of the 1970's minicomputers. These are essentially X-Y displays (not raster scanned), and would make audio-bandwidth 'scopes if given a timebase. I would guess at a bandwidth of the order of 100kHz.

Some of them (DEC, certainly, maybe Tektronix) were electromagnetically deflected like a TV. However, there are a couple of things to be aware of. Firstly, the output amplifier, which drives the yoke at constant current, is pretty complex. Secondly, the yoke is specially made - the 2 sets of coils are pretty similar (unlike those in a TV), and the inductance is critical.

So, while I'll keep these monitors running, I'd not want to have to covert a TV into one :-).

(From: David Katz (DAVEkATZ@prodigy.net).)

If by chance what you want is an X-Y display for audio, not a (more typical) X-T, it's easy. Just put a resistor in series with each yoke (about 100 ohms, 5 W) and drive them with a stereo amp.

(From: Steve Roberts (osteven@akrobiz.com).)

Your best hope might be to get a older generation heart monitor from a hospital, these have a professional X-Y display module to begin with, and are surprisingly easy to hack, mine was $10 at the local surplus shop. The ultra long persistence phosphor is a pain/blessing depending on what you are doing.

For a description of what one person did, see: Dan's Home-Built O-Scope Page.

(From: Alan (revidyks@rocketmail.com).)

Apparently it's pretty hard to produce a decent scope.

It is, however, pretty easy to use the CRT as something like a scope, which I did recently with the built-in green screen monitor of a thing called a Kapro 2X. It was being thrown away, so I said I'd take it and have a look inside before throwing it away.

I wondered what if it was possible to drive the CRT from a source other than the computer video circuitry, so I did some tests, worked out how and by what voltage the deflectors were driven, (about 1v, 0.3A measured as an AC voltage).

Once I'd worked out that this was about the same as the output from a small stereo amp, I removed the horizontal signal from the CRT and hooked one channel of my stereo across the horizontal deflector , left the vertical deflector hooked up to it's (60Hz?, 30Hz?) signal, and switched it on. The results look pretty good, I get a full-screen moving trace of the sound wave. One other thing that I did was make the beam intensity constant by turning a knob marked 'B-SUB' a bit, this would have flooded the screen with 'white' ordinarily, but was perfect for me as I could now remove the computer motherboard all together.

I also tried connecting the left and right channels across the horizontal and vertical deflectors respectively (first disconnecting them from their normal inputs), which produced some really cool looking lissijous (sp?) figure type things, that change and throb with the music- each CD seemed to have distinctive characteristics. Maybe I'll try two different pieces of music across the axes, could be interesting...

I'd love to try throwing some different signals of different frequencies and shapes across the axes too, especially in combination a with musical one. The 'best' results so far, have been from music with a strong bass, simple beat (cymbals with a bass drum look great), and not too many layers of guitars, vocals, etc. (too many sounds and it's an uninteresting mess...)

If you want more information or have any advice on or experience with this sort of thing, mail me...

If you're thinking of trying any of this, remember (in case you don't know) that TVs/Monitors can be REALLY dangerous even when switched off and unplugged. See the section: SAFETY.

Displaying a video signal as a picture on an oscilloscope

I am not sure why anyone would really want to do this other than as an experiment - it would be interesting one.

If a composite video signal is the input, you will need a sync separator. For VGA, the sync signals are already available.

You will have to construct a vertical deflection voltage ramp generator which can be locked to your vertical sync signal.

The horizontal timebase of the scope will be fine for the horizontal deflection and should easily lock to your horizontal sync pulse or (if the scope has a TV trigger mode) directly to the video signal.

A video amplifier will be needed if your Z axis does not have an internal amplifier (you need .7 V p-p to be full brightness range.) Unless you provide automatic gain control, this will need to include offset (brightness) and gain (contrast) adjustments. Even if there is an internal amplifier, it may not have the required bandwidth for the video signal.

However, the overall brightness may be disappointing - a scope is not designed for overall high brightness. The beam focus will not be as good as that on a little TV either.

Could a monitor be modified for 3D (stereo) display?

The whole idea of stereo 3-D vision to put the left and right views to the appropriate eyeball. There are two common ways of doing this:

1. Use different colors for the two views with color filters in from of each eye to separate the views. This is what were often used for the really bad (content wise) sci-fi movies of the '50s.

2. Display alternate views on the same monitor screen but use LCD shutter glasses to allow each eye to only see the appropriate view. This requires increasing the refresh rate to avoid unacceptable flicker.

The first approach can be used with any TV and a pair of monochrome video cameras. Of course, true color cannot be used since pure colored images are needed to separate the stereo views.

Alternating views with synchronized LCD glasses is a possibility but and has been used commercially but requires special hardware to synchronize to the computer's video card. Best results are obtained with refresh rates of at least 120 Hz permitting 60 full left-right frames per second. If you try to this with a regular TV or CGA monitor, the resulting refresh rate would be 30 Hz with a 50% duty cycle which is likely to be useful only as a short experiment - else your viewers will likely develop splitting headaches.

Should I use a VGA to BNC cable if my monitor has BNC connectors?

(The following assumes a normal video card with a mini-DB15 VGA/SVGA connector - if yours has BNC connectors, the improvement may be even greater.)

The answer is an unqualified maybe. In principle, the BNC cable should have higher bandwidth and better transmission line characteristics (impedance, termination) and result in sharper crisper images with less ghosting, ringing, and other artifacts. However, this will only likely be significant at higher refresh rates (1024x768 at 75 Hz and beyond) and depending on your monitor and video card, you may see no change - or it may even get worse. It is best to purchase a good quality VGA to 5-BNC cable with a return privilage and try it. I suggest a 5-BNC cable even if you only need 3 or 4 connectors so that it will be compatible with any monitor or video card you might have in the future. Cost should be in the $25 to $70 range.

Potential advantages of using the BNC connector inputs on your monitor with a good quality cable are:

- higher video bandwidth -> sharper display.
- proper connectors (at one end, at least) and correct termination implies less ghosting and ringing.

For a good monitor with a high quality video card, the difference can be dramatic - as is the case with my ATI GPT and NEC 5FG.

(From Bob Myers (myers@fc.hp.com).)

However, one should also note that connecting via BNCs generally disables monitor "plug 'n' play" features, since these are based on ID information conveyed on dedicated pins (using the VESA DDC & EDID standards) on the 15-pin "VGA" connector.

As of last year, a new connector standard - the VESA Enhanced Video Connector, or EVC - has been released, which will provide both greatly improved video signal performance AND support for DDC and a number of other features.

Most current monitors comply with the VESA Display Data Channel (DDC) standard which provides a path and protocol for getting some basic ID information (model, manufacturer, supported timings, chromaticites, etc.) back from the monitor. Under that standard, the following new signals have been added to the DB-15 connector:

```
        Pin 9:  +5 VDC from host
        Pin 12: Serial data
        Pin 15: Data clock
```

Pin 10 (the old sync return pin) now does double duty as the return/reference for DDC. The DDC system uses the I2C spec for one level of implementation, although a base level is also provided in which the data is clocked back from the display by the vertical sync pulse.

The old 4-line ID scheme using pins 4, 11, 12, & 15 is obsolete. I can't think of too many hosts, or ANY monitors, still using it.

Additional information on the EVC standard is available from the VESA web site, http://www.vesa.org.

And one manufacturer's way around the preceeding:

(From: Russ Smith (smith@ur-guh.com).)

The Nanao F2-21 I'm using is connected via 5 split-out BNCs on its end; on the OTHER end is the standard VGA connector - that connector plugs into not the video card, but a little "black box" which performs the plug-n-play identification. That little widget plugs into the PnP-compatible video card (Matrox Millenium).

Thus, even though BNCs are used at the monitor end and the monitor itself can't communicate anything useful, the information is none-the-less communicated.

A hack that works.

Building a 5 BNC cable

This is straightforward, if time consuming and tedious.

The five coaxial cables (75 ohm, RG59 typical) are wired as shown in the table. The corresponding VGA connector pin numbers are in ().

```
     Coax Center         Coax Shield
  --------------------------------------
    Red Video  (1)      Red Return (6)
    Green Video  (2)    Green Return (7)
```

```
Blue Video  (3)     Blue Return (8)
H Sync (13)         Ground (5,10)
V Sync (14)         Ground (5,10)
```

Tie pin 11 (ID0) to Ground to indicate a color monitor. Leave pin 12 (ID1) open.

Make sure that the lengths of the cables are fairly well matched - to within a couple of inches - to assure that the 3 color channels line up precisely. (One foot of cable is about 1.5 to 2 ns of delay which is significant for a 10 ns dot clock!).

Also note (see the other sections on BNC cables) that you will lose your Plug and Play capabilities without the direct control connections to the monitor (or for monitors without these featuers).

That's it!

You will wish that your fingers were about 10 times smaller than they are, however. :-)

Using a workstation monitor on a PC

These are nearly always fixed frequency monitors with a scan rate that is not compatible with typical SVGA cards.

They may have a special connector like a 13W3 or 3, 4, or 5 BNC connectors. Some have a non-standard connector.

While these normally use standard analog video signal levels, you have a couple of problems out of the starting gate:

1. The fixed scanning frequencies of most of these monitors are not directly compatible with typical SVGA standards. Many high end boards like the ATI ProTurbo can scan at 1280x1024 probably at an appropriate refresh (horizontal is going to be the critical one) rate. Also, boards that allow software adjustment of size (like the ATI) are in effect changing scan rates as well so that gives another degree or two of freedom.

   However, many typical video cards do not provide this degree of flexibility.

2. The monitor needs sync-on-green (3 BNC connectors), composite H and V sync (4 BNC connectors and 13W3) or at least a VGA to BNC adapter cable (5 BNC connectors). Your VGA card normally puts out separate syncs.

   Many video cards have a software mode (probably accessible in the setup program) to enable composite sync output so for these at least there is no problem with a 4 BNC monitor.

   You can build a circuit to generate the required video for a 3 BNC monitor if you are so inclined. See the "Sync on Green FAQ" for detailed information and schematics.

3. What you do for booting since the default will be VGA (at least for DOS/Windows. If you only use your PC at one fixed high resolution, than this may not be that much of a problem..

There are specialized boards that will emulate standard VGA/SVGA modes using a fixed frequency monitor. For more information, see the document: Notes on Approaches to using Fixed Frequency or Non-Standard Monitors on PCs.

Tweaking the deflection rate of a fixed frequency or non-standard monitor

Pulling a fixed frequency monitor by more than a few percent will likely be a problem. I know this is not the answer you were looking for but getting a new inexpensive video card may be a better solution.

Other types of monitors - XGA for example - may be variable or multiple frequency but incompatible with VGA/SVGA. Some adjustment may be possible but how far you can go will depend on many factors.

If not, you are looking for an adjustment called horizontal oscillator, horizontal frequency, or horizontal hold. If you do tweak, mark everything beforehand just in case you need to get back to the original settings.

There is a slight risk of damage, particularly when lowering the horizontal rate as this increases peak current to the horizontal output transistor. This may result in immediate failure or more stress on components resulting in failure down the road. I have no idea with your monitor.

An alternative that may be possible is to use the setup or install program that came with your video card to decrease horizontal size and then adjust vertical size if needed. This would best be done while monitoring with a scope or multiscan monitor. A byproduct of software adjustments to size will often be a change in the scan rate of a few percent which may completely cover what you need. The reason this may work is that these adjustments vary the length of the H and V video back-porch which affect the total scan time.

I know I can do this with my ATI cards.

Also see the document: Approaches to Using Fixed Frequency or Non-Standard Monitors on PCs which includes a specific modification to permit an IBM9517 XGA monitor to be used at VGA/SVGA scan rates.

Displaying TV on a computer monitor

My general recommendation is that if you have the space, buy an inexpensive TV - the quality in the end may in fact be better. And, it will be usable without tying up your expensive monitor and (maybe) PC.

Some older monitors like the Mitsubishi AUM1381 and Emerson CGA (which also has a speaker) include a composite NTSC input jack requiring only a baseband video source like a VCR. These do produce a very nice picture. However, most newer auto-scan VGA/SVGA monitors do not go to low enough horizontal scan rates. To display NTSC or PAL on these requires a scan convertor (likely to be very expensive) or at least a scan doubler (less expensive but not as good).

For the case of older monitors with digital (TTL) inputs, see the section: Modifying a CGA (or EGA) monitor for NTSC or PAL input.

You can also buy video input cards complete with tuners ('PCTV') which will put TV into a window and allow you to idle away the time you are supposed to be working while watching 'Mork and Mindy'.

While various convertors are advertized to use a computer monitor with video from a VCR or other source, keep in mind that if it sounds too good to be true, it probably is like the claim of a $200 box for this:

OK, let me get this straight - this card/box will enable a 31.4 kHz horizontal scan rate monitor (VGA) be used as a TV - yes or no? It thus includes a video A/D, full screen frame buffer, D/A, and all the other tuner stuff for under $200? I don't think so. A scan doubler - which is a subset of the above - will not result in a high quality picture since it will display pairs of lines interleaved or leave alternate lines blanked reducing brightness. Or does the impressive advertisement leave out the key requirement that the monitor sync at the NTSC horizontal scan rate of 15.734 kHz (most newer monitor do not)? Or is it a board that plugs into a PC and indeed does use the resources of the PC including the VGA card and bus?

In any case, get a written money back satisfaction guarantee.

Modifying a CGA (or EGA) monitor for NTSC or PAL input

These are often high quality monitors and would make nice TV displays - especially as there are many no doubt gathering dust on their way to the dumpster!

However, these are digital (TTL) monitors with respect to the video inputs and proper linear video amplifiers may not even be present. Therefore, you may need to implement both the NTSC or PAL decoding as well as boosting the signal levels to the hundred volts or so needed to drive the CRT.

The scan rate of CGA is the same as NTSC so deflection is not a problem.

For PAL (625/50) instead of NTSC, the vertical rate will need to be reduced to 50 Hz but this should not be a problem. The horizontal scan rate is close enough (15.625 kHz).

Similar comments apply to EGA monitors that have a compatible scan rate. EGA represents a range of scan rates between 15.75 kHz and 21.85 kHz so this should not be a problem.

Picture instability of computer monitor used to watch videos

Assuming you have one of those older computer monitors that syncs to TV scan rates (NTSC/PAL/SECAM/whatever) or have found some other way to adapt your monitor to TV signals, you may find that when attempting to use it with a VCR, there is a bending or jittering at the top of the picture.

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The problem is with the timebase instability of modern VCRs. At the end of each frame there is a phase jump of up to +/- 20 microseconds in the H-sync. The line PLL in a computer monitor is way too slow to follow this jump. The line PLL in a television is switched to a fast mode to follow it just fast enough. This has never been a requirement for computer monitors. You may need a timebase corrector. You may be unable to afford it. Some VCRs have one built in. All Laserdisc players have built-in TBC. Video-CD and DVD don't need it.

Driving multiple non-daisy-chained monitors from one video source

It is not possible to just connect monitors in parallel. The terminating resistors (75 ohms) of each monitor will also be in parallel reducing signal strength and resulting in various problems with cable termination including ghosting, ringing, etc.

A simple circuit to implement a video splitter is shown at:

- Anatekcorp Articles Page.

This is just a set of emitter following buffer amplifiers and should suffice for many applications. Various companies including Elantec, Analog Devices, Maxim, and others have video amplifier chips as well but the basic approach may be adequate for your needs.

Displaying computer video on a TV

Assuming this means NTSC:

1. You need to convert RGB to NTSC - there are single chips for this. Try Sony, Philips, Motorola, and others. These will combine the R, G, B, H sync, and V sync into a single composite video signal using a minimum of additional components.

2. You need to match the scan rate to NTSC - 15.734 kHz horizontal. Even basic VGA is twice this - 31.4 kHz. If your video card can be programmed to put out interlaced NTSC rate video then this is easy. If not, it is more difficult. If you want to use anything higher res than VGA, it is a very non-trivial problem requiring the construction of a scan convertor which includes a video A/D, full frame store, interpolator/readout timing, video D/A. Unless you are an experienced digital/analog designer, you really do not want to tackle any of this.

For the special case of VGA->NTSC, you may be able to get away with just storing a single scan line since the horizontal frequency is (almost) exactly twice the NTSC horizontal of 15.734 kHz. A double buffer where one buffer is storing while the other is reading out at approximately half the VGA pixel rate should work. With appropriate timing, even lines become the even field for NTSC and odd lines become the odd field (I may have this backwards). It is still not a trivial undertaking. Also, keep in mind that the quality you will get on NTSC will be poorer than the VGA due to fundamental NTSC bandwidth limitations. Also, flicker for line graphics will be significant due to the interlacing at 30 Hz. Even this is a non-trivial undertaking.

The requirements for PAL are very similar. For 625 lines systems, the 800x600 is the format that most closely matches the TV resolution.

You can also buy little boxes to do this. Quality is general not great as you are seriously limited by NTSC/PAL and the VCR. Except for presentations on existing TV rate equipment, it is probably not worth the effort. This is totally useless for any serious computer applications.

For professional presentations, modern video projectors are available that use high resolution LCD panels and real-time scan conversion. However, they are still relatively expensive).

HDTV as computer monitor - Can it be worth it?

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

Some info:

12. HDTV at 1080 lines interlaced uses a line frequency of 33.75 kHz.
13. Line-doubled PAL runs at 31.25 kHz, line-doubled NTSC at 31.47 kHz.
14. Philips has made VGA televisions capable of 31, 35 and/or 38 kHz.

Now what sort of computer performance does that buy you?

- 31 kHz: 640x480 NI @ 60 Hz
- 35 kHz: 800x600 NI @ 56 Hz
- 38 kHz: 800x600 NI @ 60 Hz

In other words: nothing to write home about compared to today's computer monitors. My 17A goes up to 95 kHz. TVs are good enough to be used as presentation displays - to be watched from a distance. They will also make excellent game displays. But you don't want to use them for word processing. Just because it is sold as an HDTV display does not mean that the sharpness will be that much better. Certainly not as good as that of a computer monitor.

HDTV monitors will never have only composite inputs, because composite=CVBS is used only for PAL/Secam/NTSC. Most likely it will have YPbPr inputs (Y,B-Y,R-Y), which is inconvenient with a computer that delivers only RGB. If you are lucky it will have a VGA input or a Golden Scart (a Thomson standard for RGB HDTV signals).

Hold on to your 17" computer monitor...

What is Kell factor with respect to interlaced displays?

(From Bob Myers (myers@fc.hp.com).)

The Kell factor - which has to do with the fact that we're often undersampling an image from the standpoint of the Gospel According to St. Nyquist - IS a factor in the reduction of vertical resolution, but interlacing plays a part as well. This comes from at least two factors:

1. The monitor or receiver usually cannot precisely interleave the two fields.

2. More importantly, there are steps taken to reduce the interline flicker which reduce the effective vertical resolution. This includes running the line width of the display somewhat larger than would otherwise be the case, and in interlaced cameras, discharging the entire screen (including the lines from the "other" field) after every field scanned.

Interlace is particularly troublesome on moving images, where you will often perceive momentarily "missing" details. There was a LOT of discussion regarding the gory details of interlacing in the recent HDTV debates within SMPTE and other groups.

Weird phenomenon of the month

Talk about unusual. This was posted to sci.electronics:

> "Something VERY strange is happening, and I cant explain it.
>
> There is a "ghost" on my TV screen of the text appearing on my computer screen. They are NOT hooked together in any manner. They are about 4-5 feet apart. Although, the antenna cable runs within a foot of my computer. I am wondering what causes this to happen. I have experienced interference, but this is more like a wireless second monitor. I can turn off my monitor, and look over at the TV. The text on the TV is scrolling up every 9 seconds. (like when the v-hold isn't adjusted.) Any Ideas?"

This is probably caused by RFI - radio frequency interference - from a CGA or PC TV card being picked up on the TV's cable or antenna. Only CGA has a scan rate that is nearly the same as NTSC. Any other PC video scan rate would result in a torn up or rolling picture.

(From: Bobby Richardson (boreal@vance.net).)

That is indeed RFI, and during the heyday of CGA was called 'Really Free Intelligence' in military intelligence circles because, with a highly directional, well-tuned antenna, intel ops could read the target's monitor just like looking over their shoulder.

Big Al's rules of thumb on monitor repair

1. Use an isolation transformer. A variac can be helpful too. A cheap isolation transformer can be constructed by wiring two identical transformers of adequate power capability back-to-back. (Here is a use for those old boat anchors you can't bear to part with).

2. If it's just the power supply or flyback switching transistors that have failed, then the repair is probably easy enough and quick enough to be worthwhile. Blown power transistors are trivial to locate in the circuit and quite easy to find replacements for. In many cases I've found that the monitor would have lived a much longer life if only the transistor mounting screws had been tightened properly by the manufacturer. Make sure you use appropriate replacements and the proper heat sink parts and heat sink compound.

3. If it's the flyback transformer, then judgement should be made based on the cost and availability of the replacement part. Also, on the risk of there being additional problems beyond that of the bad flyback. Who get's to eat the cost of the part in the event you don't succeed and give up? However, determining that the flyback is indeed at fault may prove challenging without a flyback tester. Sometimes there will be obvious damage such as burnt marks, cracked plastic, or other signs of overheating. If you have the correct resistance measurements, then for the primary you may be able to detect shorted windings. You can also construct the brute force flyback tester at the end of the document.

4. If it's the CRT then make the project "someone else's problem" and give the monitor to someone else to use as a parts carcass. My life is much happier since I learned there is no disgrace in making this choice.

5. There is another common failure category which is a result of people who are too lazy to turn off the power switch at night. The constant heat causes the electrolytic capacitors to dry out and become intermittent. I often replace all of the smallest electrolytics in the power supply section especially when I know the switching transistor is good. If after a couple of hours of labor and a dozen caps I still don't have it running, I give up on these too.

6. Be realistic with yourself about the value of a used working monitor. CGA's EGA's and monochrome Hercules monitors rarely fetch more than $25 at a swap meet.

7. Don't sell a used monitor to a friend unless you want to continue repairing the thing until you're old and grey.

8. Don't put a scope on the collector of the supply or flyback transistors, unless you have a special X100 high voltage / high frequency scope probe.

Tic-Toc Tips

(From: Andy Laberge (tic-toc@wolfenet.com))

1. When you go to discharge the anode of a picture tube make sure you hook up your ground first or you may get an unexpected surprise. I have.

2. Picture tubes will hold their charge for a long time. In fact I have been bitten from a tube that was removed from a TV, discharged and allowed to sit for six months. Treat all picture tubes as though they were fully charged.

3. There is a practical reason for using an isolation transformer for troubleshooting monitors besides the safety issue. The primary side of the power supply is isolated from ground and if you start probing it with a grounded scope you will short out components that were perfectly good until then. It will cost you more time in trouble shooting and more money.

4. When looking for real small cracks in a monitor board try to use a strong indirect light to keep the glare and reflections to a minimum. You can loose a crack in the glare. Cracks also hide underneath the solder mask (the green stuff). I have scrapped away the solder mask and there pretty as you please is that little beggar. Next you want to fix it; scrap more solder mask off the trace about 1/2" on both sides of the crack. Brighten the copper using an ink eraser (it has abrasive grit in it). Tin the exposed copper very well and then solder on a piece of

bare tinned buss wire. This is sort of an acquired art. Cut the bus wire about 6" long. Next bend the wire at 90 degrees at the 5" mark you now have an L that is 1" on the bottom and 5" on the stem. Hold the stem and solder the bottom to the PCB on top of your excessively soldered crack. Now just clip the stem off. You should now have a crack that is bridged by a soldered on wire which will give your cracked board the added strength that it needs. If there are near-by traces you should also check these for possible hairline cracks or the starts of some. On boards with high trace density this method may not be possible; in that case use small gauge (#30) Kynar covered wirewrap wire and solder it to the associated trace pads on opposite sides of the crack.

5. Some connections won't take the solder very easily. In that case remove all the old solder with either wick or a solder sucker. Pre-tin the connector until it excepts the solder readily and then solder the connector and it's pad. If you don't do this you will end up with a cold solder joint underneath your new solder.

6. If you are a person that is for some reason or other always moving or unplugging your monitor; go out and buy yourself an extension for your monitor signal plug. Hook the monitor signal plug to the extender and then use the male end of the extension plug as your signal plug. If you bend one of these pins it will be a lot cheaper then having to buy a signal plug for your monitor if you can find one.

7. In some VGA monitors you may have video smearing with dark letters on a light background. This maybe caused from some low value electrolytics (usually around 1 uf) that have gone bad in the video driver circuits. Usually you can check these in circuit with an oscilloscope or out of circuit with a capacitance checker.

8. Other filament problems might be low voltage caused from a leaky filter capacitor in the filament circuit. The capacitor will dropped the filament voltage down. A resistor can increase in value causing the filament current to drop off. Both of these problems can give you a faded picture look. A filter capacitor that has opened up will give you a bright picture full of noise and that is hard to trace especially if you are looking for it in the video.

9. Homemade degaussing coils can be made using three degaussing coils (out of junked monitors) in series that way you do not need a ballast load and it acts more like the heavy duty degaussering coils. They still get warm though.

10. When checking a focus control the main thing to look for here is that the best focus is not on one end of the control. If it is then your focus control block is bad or falling out of tolerance.

11. High voltage regulation circuits can give you some weird problems. One particular monitor would shut down when it went from high white screen to a black screen. High voltage will elevate when the screen is darker and sometimes exceed the high voltage safety limit activating the shut down circuit.

12. Changing CRT's is more of an art that gets better with practice. Some color CRT's line right up with a new tube and some take over four hours experimenting with results that still do not fall within specs.

13. Capacitors in the primary of the SMPS may go bad and cause the shape of the switching pulse to be distorted; the SMPS becomes inefficient and causing over heating and lower voltage. Change the capacitors if they look bad; shrinking of the vinyl casing or leakage underneath (looks like a leaky battery in a radio). Capacitors with 105 degree temperature ratings are recommended in power supplies instead of 85 degree types because of the self generated heat. Everything in the power supply is a suspect of failure. SMPS transformers can even fail although it is rare. Some produce a high audio frequency whine at times due to material oscillations and load conditions.

14. Metal film resistors can cause weird shut down and start up problems. These are usually found in the power supply over current sense circuits. These resistors check good cold but fail after applying heat to them. When cool they would seem to run all day but if heat is applied they fail faster. The value of these resistors would fall between 100k and 500k usually.

15. A good flyback source: Component Technology 1-800-878-0540

Monitor service and how to get some

A typical monitor warranty is something like: 2 years parts, 1 year parts and labor (i.e. you have to pay for labor the last year of your warranty). What should you do when you are totally unsatisfied with warranty service or when your monitor blows up 1 day after the warranty expires.

(From material provided by a former head service guy for a major computer sales/service company.)

The behind the scenes secrets to get what you want are to do one or a multiple of the following:

1. Call the "Service" (it appears they really aren't) Department of the company you procured the monitor from, and kindly ask to speak with the Service Manager. If they ask for your name, they will most likely pass it on, as well as your service history... The manager will be "not at his desk". They will ask to take a message... say something like "I would like to discuss a service contract" (free money) or "I would like to speak to him about your firm's good service" (appeal to his ego). These are positive things they like. They person on the phone will get your # and you will hear back within maybe an hour or so. Reason: Service people like myself live in a very, VERY negative world... in the back of our minds we like to hear good and hide from the every day bad. He will call back thinking good and when you get him, you can either beat him up, or butter him up... depending on your personality or style. The later is best. The nicer you are to someone, the more they will do for you... treat him like you've known him for years... talk to him on a one on one type style... tell him what has happened in a very calm, relaxed mood... sit back and relax... imagine yourself as Jack Nicolson.(?) Talk as long as you can... joke, talk about golf, whatever... The longer you are on the phone with him, the more likely he is to do something.

2. Hardball! Tell'em you are going to call the Attorney General and get this monitor covered under the Lemon law in your state if they don't get it fixed NOW! They will have to give you a new monitor if the machine has to be fixed under warranty more than 3-times in a 1-year period.

3. Call the manufacturer. Tell them your monitor is bad and that the company that sold you the monitor has sent it to for service multiple times and that you must have it fixed because it monitors a dialysis machine for a 5-month old baby with liver cancer and a broken leg or something like that... Pull their strings. Kindly let them know you aren't pleased with the monitor and you would like to send it in personally... (yes! you can do this!) The key acronyms are RMA# or RA# or MRA#.... they all refer to Return Merchandise Authorization number in some form.

4. (This one is from sam) Threaten to plaster their miserable product name all over the Internet. Note that I do not believe one should actually do this - posting whiney messages to a bunch of newsgroups is largely non-productive and may leave you open to legal repercussions. But, the threat will need to be taken increasing seriously as the importance of Internet as an international medium expands exponentially.

When you send it the monitor, the RMA# has to be on the box. Call the manufacturer at their 800 number. Ask for Customer Service. Tell them the story (kindly) and say that you would like to get an RMA#. This is a type of laundry ticket # they give you to track the monitor's progress... and they report directly to you when you call the RMA department to check on it's status. If they won't do this for an individual person, ask for an address of an Authorized Repair Depot. You will have to call the repair depot and get an RMA#.

Let them know you would like to deal with them directly. I would use tip (3) as a last resort, (just before I call the Attorney General).

I would also be careful of the game they may be playing: let the warranty on labor run over so we can get some money.

Shipping damage 1: why monitors are like basketballs

(From: Stephen Swann (swann@panix.com).)

Monitors are more prone to shipping damage than most other computer components, and it doesn't help that they typically pass through several people's hands (several stages of shipping) before they get to you: factory -> distribution center -> vendor -> you.

And from what I've seen first hand of shipping practices (I put in a couple of months working in a distribution warehouse during college), you can safely assume that each stage of shipping is roughly the equivalent of your monitor being dropped down a flight of stairs.

You wouldn't *believe* the abuse that UPS and FedEx can subject packages to. In fact, putting a *FRAGILE* sign on the side of the box is about the equivalent of writing "KICK ME" on it. I remember receiving packages marked "FRAGILE" where the (originally cubical) cardboard boxes had been smashed into shapeless cardboard "bags", and it took us 20 minutes to figure out what the contents of the box had originally been. ("What are all these shards?" "I think it was some kind of vase" "No, it was some kind of lamp." "Where's the bulb socket, then?" "How about this squashed piece of aluminum?" "Yeah, you're right, but where's the cord then?" etc). :-) Shipping guys would think nothing of dropping "fragile" boxes from waist-high onto a concrete floor - safe in the knowledge that the package had passed through so many hands that the damage could never possibly be traced back to them. "Blameless is Guiltless" should be the motto of these folks.

Basically, what I'm saying is that if 1 monitor in 3 arrives arrives in workable condition, you should be surprised that even that one monitor survived.

Shipping damage 2: why monitors are like hammers (as in throw)

(From: Steve Cunningham (swc@tamu.edu).)

Yes folks! As a training exercise for the 2002 Summer games, Bill Baxter (not his real name), a union thug from United Parcel will attempt to beat the steroid enhanced monitor-throw record of 55 1/4 feet set by Udo Schrank of the former East Germany.

But seriously folks--UPS and I just "go round 'n' round!" Over the past two years, they have broken about one third of the monitors shipped to us, even those packed in the original polystyrene foam. One monitor had the case shattered, and the tube neck sheared off--even though the monitor was packed securely in the original box and foam. The stock response from UPS is that "it probably wasn't packed securely," or some such drivel, while ignoring the obvious--they are careless with fragile merchandise.

The latest outrage was when I was taking a short nap in my house (I work out of my house), and a very loud crashing sound startled me awake. My wife said that it sounded as if someone was crashing through the front door. Turns out that the UPS dude dropped a $2000.00 70 pound 20" Ikegami monitor from waist level to the ground, hitting the front door in the process. After cooling off, I carefully inspected the monitor, and, amazingly, it wasn't destroyed (I have witnessed monitor boxes dropped from the airplane to the ground).

To add to the outrage, when I was ready to return the repaired monitor, the local UPS manager made me purchase a new box, and have foam injected into it, at a cost to the customer of about 50 bucks, before they would consider shipping it (the old box was dented, but no worse for wear). In a remarkable bit of restraint (if I don't say so myself), I calmly walked out of the UPS office (after waiting in line 30 minutes), and used a remailing company in the area to ship it via UPS at an additional fee. The customer received the monitor a few days later, and yes, it was broken. All of this despite being packed with several inches of hard foam, and in a new, sturdy, 27" Uhaul TV box. The package arrived at the customer's place of business upside down, despite up arrows.

I realize that they are a discount shipper, but, they are not paid to merely ship packages. They are paid to ship them in one piece. If they can't do that, I think that they should get out of the business and quit running an insurance scam. I can't return repaired monitors to people with the screws missing, saying, "it's because I'm a discount servicer." There is a minimum level of quality that is acceptable. Sometimes the lowest price is not the best value. As in all things human, let the buyer beware! Hopefully someone will find this useful to that end. We won't be using UPS anymore.

Shipping damage 3: why small monitors are like footballs

(From: Captain Mocha (CaptainMocha@Electra.com).)

I used to work for UPS, I loaded the trucks.

It's amazing you get anything in one piece when shipping with UPS. There are so so so so many packages that need to be loaded in those trucks in just three hours per work shift. The floor managers would encourage us to get the trucks loaded in 'any way possible'.

We used to treat the small packages as 'footballs' and try to throw them through box "goals" from the other end of the truck. We also did 'punt kicking' etc.

So get your facts straight!! It's not 'Hammer Throwing', it's football! =)

(From: Michael Schuster (schuster@panix.com).)

A friend used to work in Manhattan, NYC and during lunch hour he often passed the large camera/electronics retailer, 47th Street Photo, just as the UPS truck was unloading.

It was common for this to be accomplished by having the driver stand in the truck, and KICK the boxes to the ground one by one. So you see, it isn't a hammer throw... It's football (or soccer) that they're modeled after.

Shipping damage 4: so maybe if monitors were packed and shipped like eggs

> "After receiving my third crunched monitor this week, I've about had it with these "Brown Shirted Box Stompers-in-the-mist!" You would think that a well packed 14" clone monitor would survive a 30 mile journey while in their very incapable hands. Actually, I should apologize to Jane Goodall, or whoever that Gorilla babe was--her objects of study would probably be much more care with monitor boxes than the knuckle-walkers at UPS. I have been thinking of doing my own study as to what deceleration it takes to do the damage to a monitor that they have done. My guess is that they must have to drop the thing on concrete from 5 to 7 feet high! I've seen high impact cases shattered, tube necks sheared off, board cracked in half--sheesh, where do they get these guys? From a zoo? Sure, they reimburse the owner, but I lose the repair fee. Does anyone know if can make a loss claim also?"

(From: David Rouse (david.rouse@engineers.com).)

Actually they are probably only being normally clumsy. It probably is the packaging of the monitor that is causing the failures. A monitor is a fragile thing. It only takes about 50 g's of acceleration to kill one. This translates into about a 3-4 inch drop onto a hard surface. The packaging is supposed to protect it by spreading the shock pulse out over a longer time period. Alas, though, all styrofoam (or whatever is being used for cushioning) is not created equal. The maker was most likely trying to save a couple of pennies and use something a little too rigid. The wrong material can provide too little cushioning and in some cases even amplify the shock transmitted to the product under the right(or wrong) circumstances. FYI Trinitron tubes have really bad shock characteristics.

Cleaning plastic monitor cases

For surface contamination like grease or tobacco smoke, a variety of household cleaners will work including Fantastik, Windex, 409, etc. - some better than others depending on the type of coating. Verify that whatever you use is safe for the plastic by trying it out on an inconspicuous location first.

For ozone or heat damage which penetrates deeply into the plastic, painting may be the only a solution. Test on a non-visible section to see how deeply the discoloration has penetrated. For modest discoloration, I have had some success with water and scouring powder containing bleach.

Secret menus

> "I've seen some tantalizing references to the SECRET menu for adjusting VisionMaster Pro 17 monitor secret menu.
>
> Could someone kindly point me to some details so that I can access and properly use this covert functionality?"

(From: Scot Miller (scot@cts.com).)

Shut the power off, then switch it back on while simultaneously holding down the 'menu', '-', and '+' buttons. Then the 'menu' button works normally but will bring up the secret menu.

Reliability and performance of refurbished or remanufactured monitors

> "Considering a 21-inch monitor and have seen a number of resellers beginning to carry refurbished monitors. Under most circumstances I would walk right past anything refurbished for the shiny new model, but at the price of new 21 inchers, well... Monitor would be used primarily in Windows and for playing Quake. Locally I'm seeing prices of $1100.00 to $1300.00 with a 2 year warranty for 1st & 2nd tier products. Feedback, anyone?"

Assuming you can fully test drive it and/or get a money back no questions asked warranty, then they are worth considering. The most critical issue is the condition of the CRT make sure it is bright, sharp, and has no screen burn. If the CRT is in good condition, then there is no reason to think that the rest of the monitor will fall apart or go up in smoke. Note: Test from a power off for at least an hour condition. Once an old CRT warms up, it may appear to be better than it actually is. See the document: Performance Testing of Computer and Video Monitors for additional evaluation criteria but be warned that no monitor is perfect - some 'defects' you find may be inherent in the design or simply due to normal variations in manufacturing quality control.

The two terms 'refurbished' and 'remanufactured' may be mean the same thing. However, it would probably be worth trying to get a clarification in writing of exactly what was done to the monitor. Depending on the integrity of the reseller, these terms could mean anything from 'well, we turned it on and it didn't blow up' to 'unit was completely overhauled and restored to new specifications replacing parts where necessary'.

Ron's notes on video signal quality problems

From: pinecone@pacbell.net (Ron)

Here are some possible causes for ghosting, smearing, etc.:

1. A poor quality video cable.

2. A video extension cable (making the cable longer always makes things worse).

3. Running the video card and/or monitor too close to their maximum bandwidths.

4. Impedance mismatch between the video card and the monitor. Most cards, monitors, and cables are 75 ohms, but 50 ohm parts exist.

5. Bad video card. I've seen many video cards with this problem, and a manufacturer recently admitted to me that one revision of their board has a grounding defect that causes...ghosting.

6. Bad monitor. I think this is unlikely. Usually poor monitors produce muddy images that hide ghosting, if indeed there is any.

Monitor quality control

(From: Bob Myers (myers@fc.hp.com).)

The bottom line is that I've been involved with the design, manufacture, specification, and purchase of CRT displays for longer than I care to admit, and I can tell you one thing with absolute certainty: it is IMPOSSIBLE to maintain visibly perfect geometry, linearity, etc., on the things over a production run. You can spend hours and hours getting a given unit to look pretty darn good, but even that is iffy - it depends to much on the limitations built into that particular CRT and yoke. And even if you CAN get that unit 'perfect', this ISN'T something that you can do in normal production - not unless you find customers willing to pay SIGNIFICANTLY higher costs for the products. Despite claims to the contrary here, that has NOT been the desire expressed by the market.

(From: Gary Flynn (gary@habanero.jmu.edu).)

Many years ago I did TV repair and there were LOTS of adjustments available. I haven't cracked open a TV or monitor lately but your statement about CRT and yoke limitations jogged my memory. Are most monitors today "rack and stack" or are there internal factory adjustments? Having just ordered a 17" Trinitron based monitor and having confidence in my old TV abilities makes me want to explore :-)

(From: Sam.)

No, you will not find many of these sorts of twiddles in modern monitors. Most purity, convergence, and geometry adjustments are via strategically placed magnets glued to the CRT, the orientation of multiple magnetized rings, the position and tilt of the deflection yoke, etc. You really do not want to mess with these unless you have no choice and lots of time.

Many modern monitors control the picture adjustments via hidden menus and digital controls.

The 'good old days' are gone forever... :-) :-(.

Is Big Brother watching over your shoulder?

> "Does anyone out there know how the Timex/Microsoft watch is programmed by holding the watch in front of a VGA monitor. There must me some sort of sensor on the watch that picks up some sort of pattern on the screen retrace of the monitor...."

(From: Len Turnbow (quartlow@netcom.com).)

I know nothing about the Timex/Microsoft VGA optical communications protocol. But, sometime when you have nothing better to do, you might connect a phototransistor to a biasing source and thence to your oscilloscope. Aim phototransistor at your computer monitor and check out all the weird patterns produced as a result of various screen displays.

Before long, you will note that the leftmost edge of your scope display represents information present near the top of your screen. If you have your trigger properly set, you will also note that the whole contents of the screen are presented (top to bottom) on your scope (left to right).

With a blank white raster, you will be able to move your hand in front of the screen and see the result on your scope a la flying spot scanner. But I digress.

Armed with a borrowed copy of the Microsoft interface software and your phototransistor, you could probably reverse engineer the protocol.

Or ask someone at Microsoft.com :-). What would be the fun in that, though?

(From: David Fries (dfries@mail.win.org).)

I don't know why it would be referred to as 'the Timex/Microsoft watch', when it just includes windows software. It really should be referred to as the Timex Datalink watch. Microsoft wouldn't know anything about the protocol as it is a Timex product (and patent I believe).

I maintain the Linux software to interface with the Timex Datalink watches, model 70, 150, 150s, and Ironman. See: Datalink Library for the Ironman Watch. I can say something of the physical layer communication and that in the past I have decoded the ironman protocol by using a photocell (as opposed to a phototransistor) connected to the sound card input of another computer. A photocell varies resistance with the amount of light it receives, perfect for plugging into a sound card mic in without any other components.

There are two variations, the 150, 150s, and Ironman both send two bytes per screen refresh. There are up to nine lines lit at the top of the screen and 9 lines at the bottom. Each line is a solid white or off. The first line of each set is always on, and used as a start bit, the rest are data bits. The protocol partitions the data into packets with check bytes at the end of each packet followed by a few completely black screens before the next packet. That is why it looks like it flickers, stops, flickers, stops, etc. The screen is set to 60Hz, two bytes per refresh or 120 bytes a second, not exactly speedy by any means and that doesn't include the built in pauses.

The model 70 is similar, but only fills the top nine lines giving it an even slower transfer rate of one byte per refresh or 60 bytes per second.

The protocol makes the monitor into a serial output device because the watch doesn't pay any attention to where the lines are, only the overall brightness of the screen.

Lament of the lack of adjustment pots on the newest monitors

In 'the good old days' before digital controls and service menus, one could spend a substantial fraction of one's life tweaking monitor adjustments. The newest monitors (and TVs) are nearly totally controlled by settings stored in EEPROM. The service adjustments may only be accessible via a port connection to a PC running a special manufacturer specific setup program.

This is the wave of the future and we are stuck with it for better or worse. In all fairness, digital adjustments are less costly to manufacture and permit much more automation in the factory setup of screen geometry, color, and so forth. However, not making the setup software available for a reasonable licensing fee is a serious problem which will result in lost opportunities for smaller independent repair shops.

(From: CiaraTom (ciaratom@aol.com).)

The point is that each manufacturer has written a program for his monitor to tweak things that we used to do with a screwdriver. It is model specific, not generic, and often requires an interface (special cable, with or without circuitry in between) sometimes connecting to your parallel port, sometimes to the serial.

Goldstar does this with a special proprietary software and special cable; Viewsonic has (that cost me $220 - try to recoup that from a repair) and it is so user unfriendly that you don't even know what to do with it.

Analog versus digital LCD flat screen monitors

(From: Bob Myers (myers@fc.hp.com).)

This refers to the interface to the monitor, with "analog" generally meaning that it can plug directly into the same video connector as your typical CRT monitor. Digital-input monitors have in the past required special interface cards, but there are new standards for digital video outputs (such as the VESA "Plug & Display" connector family). The displays themselves (the inner workings aren't REALLY "inherently digital" either - although the interface to the panel itself usually is - but they ARE fixed-format devices, which brings along its own set of problems.

Digital interfaces, assuming you DON'T need a special interface card in the PC, will be less expensive than analog interfaces and will offer better performance. The performance increase doesn't come so much from having the information provided in "digital" form, but rather from having accurate timing information available. The biggest headache in designing an analog interface for these monitors is trying to generate the correct clock for sampling the incoming video. It's usually been done by multiplying the horizontal sync rate up to the proper frequency, but that is hard to do with REALLY good stability, and the phase relationship between the H. sync signal and the video isn't all that reliable. This makes for an unstable display, with what looks like considerable noise (especially when you have lots of single-pixel details).

Why is there a growth on my monitor cable?

(From: David Kessner (davidk@peakaudio.com).)

Well, it is a ferrite sleeve or bead. There's a thing called a ferrite bead which is a simple doughnut, sleeve, or bead that a wire goes through. Electrically this is similar to an inductor. There are other, larger, types that are made to clamp on to cables.

The practical effect of a ferrite bead (FB) is that it causes a resistance at high frequencies, but almost no resistance at low frequencies. Most FB's are rated at XXX ohms at YYY MHz. Small ones are typically about 25 ohms at 100 MHz, with the resistance increasing with frequency.

Usually, FB's are used to filter out high frequency noise. In a cable, if you provide a high frequency resistance then you will have less high frequency current as well. This means less high frequency signals or noise on the line. This makes the FCC happy, since you won't be emitting as much EMI/RFI.

When you see FB's on cables, it is usually put there as a quick fix. Someone will design a device and it'll fail FCC testing. Through trial and error, they will find that putting a FB on the cable will make it pass. So they put one on and ship it that way. Well designed cards either have FB's on the PCB, or they do something else to reduce the EMI/RFI emitted.

There are other uses for FB's, but this is the general use of them when cables are concerned.

(From: Douglas W. Jones (jones@pyrite.cs.uiowa.edu).)

The thing is a ferrite core. It is used to control EMI/RFI interference. They're sometimes called filter blocks, because they're a block of ferrite used as a filter, but sometimes people just call the thing "a ferrite".

You can buy after-market filter blocks from ParaCon; these just clip onto the outside of a cable. They're listed in the DigiKey catalog under the name "ferrites" on the catalog page, but they're indexed under "filter blocks".

What do they do? Two things. First, if you've got a wire coming out of your electronic whatsit, that wire can act as a transmitting antenna for any RF oscillator within the whatsit. So, the cable between your computer and your video monitor might end up transmitting not only a base-band video signal at somewhere near 10 Mhz, but it could also transmit your CPU clock signal and other annoying signals generated within your computer's box.

To keep the cable from transmitting a video signal, we use coaxial cable with a decent shield. To keep the cable as a whole from transmitting the CPU clock and other higher frequency signals, we put a ferrite core around the cable. This acts as a low-pass filter preventing common-mode signals from getting through while allowing balanced signals (properly sent over the coaxial cable) to get to the video monitor.

The second possibility to worry about is the cable acting as a receiver. This is particularly troublesome when there is a ground loop. For example, my computer and video monitor both have grounded line cords that are plugged into the wall. The computer cable to the video monitor also has a ground path, through the shield, so there's a loop, from wall outlet to computer to video monitor to wall outlet. This loop acts as a loop antenna, and it can pick up signals from around 100 Khz to 1 Mhz quite well, depending on the geometry of the loop. These could cause real problems if they were confused with logic signals inside the computer.

The standard advice to electrical engineers is: Avoid ground loops. When this advice fails, the fallback position is, break the loop with a filter. That's what the filter block does!

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15. Back to Monitor Repair FAQ Table of Contents.

Service Information

Advanced monitor troubleshooting

If the solutions to your problems have not been covered in this document, you still have some options other than surrendering your monitor to the local service center or the dumpster.

Also see the related document: Troubleshooting of Consumer Electronic Equipment.

Manufacturer's service literature: Service manuals may be available for for your monitor. Once you have exhausted other obvious possibilities, the cost may be well worth it. Depending on the type of equipment, these can range in price from $10-150 or more. Some are more useful than others. However, not all include the schematics so if you are hoping to repair an electronic problem try to check before buying.

Inside cover of the equipment: TVs often have some kind of circuit diagram pasted inside the back cover. In the old days, this was a complete schematic. Now, if one exists at all for a monitor, it just shows part numbers and location for key components - still very useful.

SAMs Photofacts: These have been published for over 45 years but have never been common for monitors. There are a few for some early PC monitors but for anything modern, forget it.

Whatever the ultimate outcome, you will have learned a great deal. Have fun - don't think of this as a chore. Electronic troubleshooting represents a detective's challenge of the type hat Sherlock Holmes could not have resisted. You at least have the advantage that the electronics do not lie or attempt to deceive you (though you may beg to differ at times). So, what are you waiting for?

Additional information

For general information on PC video cards and monitors, see the FAQ of the USENET newsgroup: comp.sys.ibm.pc.hardware.video. This document has a wealth of data on nearly everything you could possibly want to know about video for the PC world.

The FAQ is available via ftp and the WWW:

To ftp a text-only version of this FAQ, and/or the chipset list:

- Compressed Video FAQ
- Compressed Video Chipset List

The FAQ has received news.answers approval, so it should be archived at rtfm.mit.edu and all mirrors, as well as in news.answers and comp.answers.

Contributions, questions and corrections always welcome and appreciated.

The USENET newsgroup: sci.electronics.repair

Where you have a specific question on a particular monitor (or other equipment), posting the make and model and a concise description of the problem and what you have already attempted, may result in suggestions from both professionals and others like yourself who have had experience with your monitor.

See the document: Troubleshooting of Consumer Electronic Equipment for many additional on-line resources to aid in monitor servicing.

Suggested references

There don't seem to be that many readily available books on monitor repair. Here are a couple:

- Troubleshooting and Repairing Computer Monitors
  Stephen Bigelow
  McGraw Hill, 1995
  Hardcover, 304 pages
  ISDN 0-07-005408-8

  Some of the topics are

  - CRT alignment and degaussing
  - State-of-the-art plasma displays
  - Specifications and architectures of monochromw, CGA, EGA, VGA, and SVGA

- Linear, switching, and high voltage powersupplies
- Logic and drivers supporting both CRT and LCD monitors
- Graphics standards
- Sample schematics

However, a couple of people have commented that the document you are reading is more useful and better organized than this book :-). I cannot comment as I have not seen it. So, try to check it out before purchasing or make sure you can return it if not satisfied.

- Computer Monitor Troubleshooting and Repair
  Joe Desposito and Kevin Garabedian
  Howard W Sams and Co, 1997
  ISBN: 0-7906-1100-7

  Lots of diagrams and photos, schematics, and examples of problems and how they are solved. This is a good basic book.

Also, since monitors share much in common with color TVs, books on their repair would also be applicable for many problems - and may be more readily available from your local public library.

There don't seem to be nearly as many TV repair books for modern solid state TVs as I recall for old tube sets. Here are is one suggestion which you may find (or its predecessor) at your local public library (621.384 if you library is numbered that way) or a technical book store. MCM Electronics has this as well.

- Troubleshooting and Repairing Solid State TVs
  Homer L. Davidson
  2nd Edition, 1992
  TAB Books, Inc.
  Blue Ridge Summit, PA 17214

(From: Skip (skipperm@mtc2.mid.tec.sc.us))

I recently attended a monitor repair course put on by Philips electronics. They have a technical training manual which can probably be ordered without signing up for the course:

- Hi-Res Computer Display Systems
  Part # ST1496-1093LE/KGPGC
  Philips Service Co.
  P.O. Box 555, Jefferson City, TN 37760
  Phone: 423-475-0044

  This book does an excellent job of explaining how these monitors work. Most is about Philips monitors but the material is applicable to most manufacturers. This course and reading this text has help me a lot with my monitor repair efforts.

The following doesn't specifically deal with monitors but may be of interest as well:

- Video Demystified: A Handbook for the Digital Engineer
  Keith Jack
  Brooktree Corporation, 1993
  ISBN 1-8787-0709-4

FCC ID Numbers of monitors

Only a few manufacturers actually produce the vast majority of computer and video monitors. For example, Radio Shack, Magnavox, and Emerson do not make their own monitors (I can tell you are not really surprised!). All those house-brand monitors that come bundled with mail order or 'Mike and Joe's Computerama' PCs are not actually put together in someone's garage! Well, not that many, at least :-).

How do you determine the actual manufacturer? For most types of consumer electronic equipment, there is something called an 'FCC ID' or 'FCC number'. Any type of equipment that may produce RF interference or be affected by this is required to be registered with the FCC. This number can be used to identify the actual manufacturer of the equipment.

A cross reference and other links can be found at:

- S.E.R. FAQ FCC ID Links

Parts information

I have found one of the most useful single sources for general information on semiconductors to be the ECG Semiconductors Master Replacement Guide, about $6 from your local Philips distributor. STK, NTE, and others have similar manuals. The ECG manual will enable you to look up U.S., foreign, and manufacturer 'house' numbers and identify device type, pinout, and other information. Note that I am not necessarily recommending using ECG (or other generic) replacements if the original replacements are (1) readily available and (2) reasonably priced. However, the cross reference can save countless hours searching through databooks or contacting the manufacturers. Even if you have a wall of databooks, this source is invaluable. A couple of caveats: (1) ECG crosses have been known to be incorrect - the specifications of the ECG replacement part were inferior to the original. (2) Don't assume that the specifications provided for the ECG part are identical to the original - they may be better in some ways. Thus, using the ECG to determine the specifications of the parts in your junk bin can be risky.

Other cross reference guides are available from the parts source listed below.

Monitor schematics and manuals

In some cases, these may be available from the manufacturer and even reasonably priced (much less than other sources). For example, a manual for a typical CTX monitor is only $15 from CTX but around $50 elsewhere. However, more often than not, this will not be the case.

The following three companies have an extensive inventory of computer monitor service manuals and schematics. Typical prices are between $25 and $100.

- Anatekcorp (http://www.anatekcorp.com) has a set of nine CD ROM's that contain the full technical manuals (in most cases) produced by the original manufacturer. Go to: http://www.anatekcorp.com/schematic/monsch.htm. However, this would probably be extravagant for a single repair!

- Electronix (http://www.electronix.com/schematics/)

The following may only be for IBM monitors (I don't know) and doesn't appear to have a web site:

- Eagan Technical Services, Inc, 1380 Corporate Center Curve, Suite 115, Eagan, MN 55121, 612-688-0098.

  Eagan has several schematics for IBM monitors. I believe it includes the 8503, 8512, 8513, 8514, 8518 and

8511. Most are $50. The 9517 schematic is an unbelievable $165. You can order them directly from Eagan or through Sams' Photofacts, same price.

And another:

- Chuntex, 1-800-888-2120.

Also see the manuals list in the document: Troubleshooting of Consumer Electronic Equipment.

Information sources on the Internet

Many manufacturers are now providing extensive information via the World Wide Web. The answer to you question may be a mouse click away. Perform a net search or just try to guess the manufacturer's home page address. The most obvious is often correct. It will usually be of the form "http://www.xxx.com" where xxx is the manufacturers' name, abbreviation, or acronym. For example, Hewlett Packard is hp, Sun Microsystems is sun, Western Digital Corp. is wdc. NEC is, you guessed it, nec. It is amazing what is appearing freely accessible via the WWW. For example, monitor manufacturers often have complete information including detailed specifications for all current and older products. Electronic parts manufacturers often have detailed datasheets for their product offerings.

For Apple monitors (and other Apple peripherals) in particular, the E-MAC Web site (http://e-mac.com/) has a variety of information including some (mostly user) manuals, specifications, and technical forums.

Don't expect to find complete schematics (at least none of the models I checked went into this depth) but there will be specifications, setup and adjustment instructions, and, depending on model, some troubleshooting information, disassembly instructions and exploded views, etc.

Interchangeability of components

The question often arises: If I cannot obtain an exact replacement or if I have a monitor, TV, or other equipment carcass gathering dust, can I substitute a part that is not a precise match? Sometimes, this is simply desired to confirm a diagnosis and avoid the risk of ordering an expensive replacement and/or having to wait until it arrives.

For safety related items, the answer is generally NO - an exact replacement part is needed to maintain the specifications within acceptable limits with respect to line isolation, X-ray protection and to minimize fire hazards. Typical parts of this type include flameproof resistors, some types of capacitors, and specific parts dealing with CRT high voltage regulation. However, during testing, it is usually acceptable to substitute electrically equivalent parts on a temporary basis. For example, an ordinary 1 ohm resistor can be substituted for an open 1 ohm flameproof resistor to determine if there are other problems in the horizontal deflection circuits before placing an order - as long as you don't get lazy and neglect to install the proper type before buttoning up the monitor or TV.

For other components, whether a not quite identical substitute will work reliably or at all depends on many factors. Some deflection circuits are so carefully matched to a specific horizontal output transistor that no substitute will be reliable.

Here are some guidelines:

1. Fuses - exact same current rating and at least equal voltage rating. I have often soldered a normal 3AG size fuse onto a smaller blown 20 mm long fuse as a substitute.

2. Resistors, capacitors, inductors, diodes, switches, potentiometers, LEDs, and other common parts - except for those specifically marked as safety-critical - substitution as long as the replacement part fits and specifications should be fine. It is best to use the same type - metal film resistor, for example. But for testing, even this is not

a hard and fast rule and a carbon resistor should work just fine.

3. Rectifiers - many are of these are high efficiency and/or fast recovery types. Replacements should have at equal or better PRV, Imax, and Tr specifications.

4. Posistors - many of these are similar. Unfortunately, the markings on the devices are generally pretty useless in determining their ratings. Note, however, that the prices for replacement posistors may be quite reasonable from the original manufacturer so it may not make sense to take the risk of using an unknown part.

   (From: Stefan Huebner (Stefan.Huebner@rookie.antar.com).)

   In most cases you can use a standard 3-terminal-device, the resistance of the temperature dependent resistors in it are nearly identical. Here is a list of possible replacement devices:

   380000-01, 24340521, 2199-603-1201, 163-024A, 163-035A, CO2200-N66, C8ROH, QX265P05503, 32112026, 4822-A1-11240148, 02199-003-120, 15-08-001A, 5391560067, F400001.

5. Transistors and thyristors (except HOTs and SMPS choppers) - substitutes will generally work as long as their specifications meet or exceed those of the original. For testing, it is usually OK to use types that do not quite meet all of these as long as the breakdown voltage and maximum current specifications are not exceeded. However, performance may not be quite as good. For power types, make sure to use a heatsink.

6. Horizontal output (or SMPS) transistors - exact replacement is generally best but except for very high performance monitors, generic HOTs that have specifications that are at least as good will work in many cases. Make sure the replacement transistor has an internal damper diode if the original had one. For testing with a series light bulb, even a transistor that doesn't quite meet specifications should work well enough (and not blow up) to enable you to determine what else may be faulty. The most critical parameters are Vceo/Vcbo, Ic, and Hfe which should all be at least equal to the original transistor. I have often used by favorite BU208D as a temporary substitute for other HOTs in TVs and SMPS (chopper) transistors. However, for high performance monitors, a BU2508D type is a better choice. Make sure you use a heatsink (with insulating washer if applicable) and thermal grease in any case - even if you have to hang the assembly with a cable-tie to make it fit.

   However, using an HOT with much better specs may actually result in early failure due to excessive heating from insufficient and/or suboptimal base drive. See the document: TV and Monitor Deflection Systems for more info.

   Also see the section: Replacement power transistors while testing.

7. Deflection yokes - in the old days, particularly for TVs, all of these were quite similar. It was common to just swap with one that fit physically and at most need to adjust or change a width coil. With high performance auto-scan monitors, this is no longer the case. Sometimes it will work but other times the power supply won't even be able to come up as a result of the impedance mismatch due different coils and pole piece configurations. In addition, there may be other geometry correction coils associated with the yoke that could differ substantially.

   However, if you are really determined, see the section: Swapping of deflection yokes.

8. CRTs - aside from the issues of physical size and mounting, many factors need to be considered. These include deflection angle, neck diameter, base pinout, focus and screen voltage requirements, purity and convergence magnets, etc. Color CRT replacement from scratch (not using a CRT and yoke/convergence/purity assembly from another monitor) is rarely worth the effort in any case. But, trying to substitute a different CRT is really

asking for frustration.

For monochrome CRTs, there is less variation and this may be worth a try.

The following are usually custom parts and substitution of something from your junk box is unlikely to be successful even for testing: flyback (LOPT) and SMPS transformers, interstage coils or transformers, microcontrollers, and other custom programmed chips.

Substituting mainboards and other modules from identical models is, of course, possible but some realignment may be needed. Even a monitor from the same manufacturer that is not quite identical may use the same subsystems, perhaps depopulated or jumpered differently.

Horizontal output transistor pinouts

You will nearly always find one of two types of horizontal output transistors in TVs and monitors:

- Metal can - TO3 package:

```
          _
        / O \          View from bottom (pin side)
      / o   o \
     (  B   E  )       B = Base, E = Emitter, C = Collector
      \       /
        \ O / C        The metal case is the Collector.
```

- Plastic tab - TO3Pn (n = several suffixes) package:

```
        _____
       /     \
      |   O   |       View from front (label side)
      |       |
      |       |       B = Base, E = Emitter, C = Collector
      |_______|
        | | |         If there is an exposed metal tab, this is the
        | | |          Collector as well.
        B C E
```

Some other transistor types use the same pinout (TO66 for metal can, TO218 and TO220 for plastic tab) but not all. However, for horizontal output transistors, these pinouts should be valid.

Note that those with a built in damper diode may read around 50 ohms between B and E (near 0 on the diode test range) - this is normal as long as the resistance is not really low like under 10 ohms.

How do you locate the HOT

Well, it is usually the LARGEST transistor in the set near the LARGEST transformer in the set (flyback - the thing with the FAT red wire connecting to the picture tube) on the LARGEST heat sink in the set.

Got that? :-)

Or, in the good old days - oops - but that was before computer monitors...

(From: Don Wall (d.wall@nunet.neu.edu).)

Sure, it's usually the largest tube in the set, has a top cap, runs very hot, and is often a 6BQ6G or some such. (tongue firmly in cheek) Actually, back in the days of yore, the Horizontal Output Tube was frequently referred to as the HOT; guess some things don't change!

Replacement power transistors while testing

During testing of horizontal deflection circuits or switchmode power supplies, particularly where the original failure resulted in the death of the HOT or chopper, overstress on replacement transistors is always a possibility if all defective components have not be identified.

Therefore, using a part with better specifications may save you in the long run by reducing the number of expensive blown parts. Once all other problems have been located and repaired, the proper part can be installed.

However, this is not always going to work. In a TV and especially a high performance monitor, the HOT may be closely matched to the drive and output components of the deflection circuits. Putting in one with higher Vce, I, or P specifications may result in overheating and failure due to lower Hfe.

Where possible, a series load like a light bulb can be used limit the maximum current to the device and will allow you to power the equipment while checking for other faults. Some designs, unfortunately, will not start up under these conditions. In such cases, substituting a 'better' device may be the best choice for testing.

(From: Glenn Allen (glenn@manawatu.gen.nz).)

I been repairing SMPS of all types but when I started on those using MOSFETs I was blowning a few of them when replaced because something else was faulty.

Ever since I have been using a BUZ355 on a heat sink I haven't blown it. It is rated at 800 V, 6 A, and 220 W. it is a TO218 case bigger than a T0220. It seems the higher ratings allows you to do repair where as a something like a 2SK1117 or MTP6N60 will just blow.

Testing of replacement HOTs

The following is useful both to confirm that a substitute replacement HOT is suitable and that no other circuit problems are still present. However, single scan line anomalies (particularly when changing channels and/or where reception is poor with a TV or when switching scan rates and/or when no or incorrect sync is present with a monitor) resulting in excessive voltage across the HOT and instant failure are still possible and will not result in an HOT running excessively hot.

(From: Raymond Carlsen (rrcc@u.washington.edu).)

After installing a replacement HOT in a TV set or monitor, I like to check the temperature for awhile to make sure the substitute is a good match and that there are no other problems such as a weak H drive signal. The input current is just not a good enough indicator. I have been using a WCF (well calibrated finger) for years. For me, the rule of thumb, quite literally, is: if you can not hold your finger on it, it's running too hot, and will probably fail prematurely. Touching the case of the transistor or heat sink is tricky....

Metal case transistors will be connected to the collector and have a healthy pulse (>1,200 V peak!) and even with plastic case tab transistors, the tab will be at this potential. It is best to do this only after the power is off and the B+ has discharged. In addition, the HOT may be hot enough to burn you.

A better method is the use of an indoor/outdoor thermometer. I bought one recently from Radio Shack for about $15 (63-1009). It has a plastic 'probe' on the end of a 10' cable as the outdoor sensor. With a large alligator clip, I just clamp the sensor to the heat sink near the transistor and set up the digital display near the TV set to monitor the temperature. The last TV I used it on was a 27" Sanyo that had a shorted H. output and an open B+ resistor. Replacement parts brought the set back to life and the flyback pulse looked OK, but the transistor was getting hot within 5 minutes... up to 130 degrees before I shut it down and started looking for the cause. I found a 1 uF 160 volt cap in the driver circuit that was open. After replacing the cap, I fired up the set again and monitored the heat sink as before. This time, the temperature slowly rose to about 115 degrees and stayed there. I ran the set all day and noticed little variation in the measurement. Test equipment doesn't have to cost a fortune.

Removing and replacing the deflection yoke

Should you need to remove the deflection yoke on a color CRT, some basic considerations are advised both to minimize the needed purity and convergence adjustments after replacement as well as to prevent an unfortunate accident.

The position and orientation of the yoke (including pitch and yaw) and magnet assembly (purity and static convergence rings, if used) are critical. Use paint or White-Out(tm) to put a stripe across all of the magnet rings so you will know their exact positions should they accidentally shift later. If there are rubber wedges between the yoke and the funnel of the tube, assure that they are secure. Tape them to be doubly sure as adhesive on old tape dries up with age and heat and becomes useless. This will avoid the need for unecessary dynamic convergence adjustments after reassembly.

The neck is the most fragile part of the CRT so do not apply any serious side-ways force and take care not to bend any of the pins when removing and replacing the CRT socket.

The yoke and purity/static convergence assemblies will be clamped and possibly glued as well. However, the adhesive will probably be easily accessible - big globs of stuff like hot melt glue and/or RTV silicone. Carefully free the adhesive from the glass neck of the CRT. Loosen the clamps and gently wiggle the magnets and yoke off the neck. They may appear stuck from age and heat but should yield with gently persuasion.

Once the yoke is replaced, some fine adjustments of the picture rotation, purity, and static and dynamic convergence may be needed but hopefully with your most excellent diagrams, these will be minimal.

Similar comments apply for monochrome CRTs but there are far fewer issues as the yoke is positioned firmly against the funnel of the CRT and rotation and centering are usually the only adjustments. However, there may be magnets located on swivels or glued to strategic locations on the CRT envelope to correct for geometric distortion.

Swapping of deflection yokes

This should work with identical TVs or monitors. Your mileage will vary if you are attempting a swap between monitors with similar specifications. Chances of success for monitors with widely different screen sizes or scan rate specifications is close to zero.

One indication of compatibility problems would be major differences in resistance readings for the corresponding yoke windings, CRT HV and other bias levels, etc.

Before you do the transplant, see the section: Removing and replacing the deflection yoke for procedures and precautions to minimize problems in realignment.

Make a precise diagram of everything you do.

Keep the purity/static convergence magnet assembly with the original CRT if possible and install it in the same or as nearly the same position as possible when you replace it.

Once you are sure of the connections, power it up carefully - there is no assurance that your yokes are compatible. A yoke with a much lower resistance or inductance than the original may overstress components in the power supply.

You will then need to go through all the adjustments starting with purity and convergence.

Swapping of non-identical CRTs

Given the problems of just replacing a CRT with an identical new one, it isn't surprising that attempting to substitute a CRT which is not the same type will result in difficulties - to say the least. Obviously, the closer in size, scan rate (for monitors), and deflection angle, the more likely the chances of success. Where the alternative is to junk the TV or monitor, it may be worth a shot - and you may get lucky!

It may be best to transfer as much as possible with the CRT - yoke and purity and convergence magnets. The connectors to the yoke may need to be changed but this may be the least of your problems. Difference in yoke impedance and other characteristics may result in anything from incorrect size to a truly spectacular melt-down! The latter is much more likely with SVGA monitors compared to similar size/deflection angle TVs.

Where the neck size is the same, the yoke can be moved from one CRT to the other but you will have to do a complete purity and convergence set up and even then you may have uncorrectable convergence errors. See the section: Swapping of deflection yokes.

(From: J. G. Simpson (ccjgs@cse.bris.ac.uk).)

Monitors are generally designed by choosing a CRT, then the EHT, then designing a yoke to scan the CRT, then designing a driver circuit to drive the yoke.

In a CRT test lab it's common to have variable supplies for EHT and other voltages, a small selection of yokes, and variable amplitude drive circuits.

EHT affects scan sensitivity, brightness, spot size. You can't get high brightness and small spot size on a large monitor with 3 kV of EHT. Virtually every variable has some effect on convergence. Spot size is important, in as much as you want most of it on the phosphor and not the shadow mask.

Provided the neck size is the same you can swap tubes in yokes but don't expect it to work very well. Different tube manufacturers may use radically different gun structures. A given yoke and its driver may give underscan or overscan and it's pretty well certain that convergence will be way off.

The military spends a small fortune on trying to get the drop into the yoke and it flies with no adjustment or convergence CRT. For the rest of us swapping a CRT is a pain in the butt.

Decayed glue in electronic equipment

Larger components like electrolytic capacitors are often secured to the circuit board with some sort of adhesive. Originally, it is white and inert. However, with heat and age, some types decay to a brown, conductive and/or corrosive material which can cause all sorts of problems including the creation of high leakage paths or dead shorts and eating away at nearby wiring traces.

The bottom line: Most of the time, this stuff serves no essential purpose anyhow and should be removed. A non-corrosive RTV or hot-melt glue can be used in its place if structural support is needed.

Repair parts sources

For general electronic components like resistors and capacitors, most electronics distributors will have a sufficient variety at reasonable cost. Even Radio Shack can be considered in a pinch.

However, for modern electronic equipment repairs, places like Digikey, Allied, and Newark do not have the a variety of Japanese semiconductors like ICs and transistors or any components like flyback transformers or degauss Posistors.

See the document: Major Service Parts Suppliers for some companies that I have used in the past and others that have been recommended. Also see the documents: Troubleshooting of Consumer Electronic Equipment and Electronics Mail Order List (this one is quite dated though) for additional parts sources.

Sources for adapters and cables

Office and computer supply companies like Inmac and Global may have some very common types like VGA switch boxes and extension cables - of unknown quality.

However, there are companies specializing in cables for computers, video, and communications. For example:

- Black Box Corporation. Check out their on-line catalog and other information.

Monitor replacement cables

Here is a company that will supply replacement cables for a wide variety of computer monitors.

- Interface 2 Ltd (UK) (formerlay A+G Computerware Limited)

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Performance Testing of Computer and Video Monitors

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

1.This notice is included in its entirety at the beginning.
2.There is no charge except to cover the costs of copying.

WARNING and DISCLAIMER

Attaching an incompatible video source to a monitor (i.e. the signals do not have the proper voltages as with digital or analog levels) or using the wrong scan rate are both potentially risky to the monitor.

- Incorrect signal levels or connections can damage the monitor's input circuitry and/or the output drivers of the video (or other interface card if you happen to accidentally plug it into an Ethernet or serial card by mistake!).

  Don't arbitrarily attach the monitor cable to a socket just because they physically mate or have the same number of pins!

- Setting the scan rate of a monitor outside its specified range may overstress components and can result in expensive damage to power supply and deflection components. Whether or not this happens with a given model depends on its design and there is no way to know beforehand which monitors are susceptible. Some monitors will be perfectly happy working beyond their published specs; others will politely shut down with a warning; but all too many will go up in smoke!

  It can be very risky to experiment with scan rate settings either because you have no idea of what is valid or to 'explore the envelope'. Either of these could result in expensive repairs. The only hint you may get just before the smoke comes out are unusually poor geometry or instability but it would be foolish to depend on these possible warnings.

We will not be responsible for any damage to your monitor or ego that may result from such experiments!

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Introduction

Scope and Purpose of This Document

This document provides a guide to the testing of computer and video monitors for functional characteristics like color purity, convergence, geometry, focus, resolution, Moire, switching between scan rates (where applicable), and acoustic noise. A subset of these tests apply to television sets as well.

Although flat panel monitors based on LCD and other discrete technology are increasing in popularity, their higher cost and spotty performance, especially when not used at their native resolution, means that CRT monitors will continue to be important for several years to come. And many of these tests apply to flat panel displays as well.

WARNING: No monitor is perfect. Running these tests on your monitor or one you are considering may make you aware of deficiencies you never realized were even possible. You may never be happy with any monitor for the rest of your life!

Note: the intent of these tests is **not** to evaluate or calibrate a monitor for photometric accuracy. Rather they are for functional testing of the monitor's performance.

Obviously, the ideal situation is to be able to perform these sorts of tests before purchase. With a small customer oriented store, this may be possible. However, the best that can be done when ordering by mail is to examine a similar model in a store for gross characteristics and then do a thorough test when your monitor arrives.

Comments on Monitor Performance and Sample-to-Sample Variations

(From: Will Nott (bnott@barngate.compaq.com).)

As with every piece of machinery built in mass production, monitors have performance specifications which define tolerances on performance, as well as operational limits. This has always been the case for monitors, and, in fact, front of screen performance specifications have not changed appreciably over the last ten years. Other items, such as for video & scan rate capabilities have changed, but those items do not appreciably affect the front of screen issues which most users find disappointing.

Most users never see the detailed specifications which the manufacturer works to, but may see a sub-set intended to "feature" the product's strong and/or competitive points. There are some variables which may be compensated for with more sophisticated circuits, but that usually results in higher product cost (*not* necessarily sales price; see below). There are other variables which are subject to normal state of the art production tolerances, and because of this, some units will actually come off the line looking better than others, even though they all meet spec.

For an example, misconvergence is a variable subject to production tolerances, and practically all monitors have similar spec's, even though most people would not like to settle for a unit which is at the limit of the spec. The typical spec. is 0.3 mm in the area within a circle equal to the height of the image, and 0.4 mm outside that area. That is actually more than the theoretical pixel size on a 14" monitor, and hardly anyone will want to use a display with that performance. However, the spec. allows such variations to exist.

An example of a feature which can be affected by additional circuit sophistication is Geometry, or line straightness - each manufacturer has specifications to meet, but here some units may allow as much as 6 mm of non-straightness, where other units may have the ability of being adjusted to a straightness of less than 1mm.

So, what the user runs into are variations of two kinds:

1. Normal manufacturing tolerances explain differences that may be expected among various examples of the same brand & model monitor.

2. Differences in design (circuits) which provide the possibility of adjusting out other kinds of distortion explain differences between different brands and models.

Of course, this probably has very little correlation with the price at which the product is being offered, because of other competing factors in the marketing game, so it's not really fair (although we all are likely to do it) to expect a more expensive product to perform better - maybe that company is doing better at "charging what the traffic will bear". That's why it's always advisable (within practical limits) to try and understand the spec's, and to try and examine the actual unit which you will be taking home, not a showroom example.

What About the New Flat Panel Displays?

The information in this document applies directly to the vast majority of CRT (picture tube) based equipment. However, what may be surprising, is that much of it also applies to the new generation of flat screen SVGA monitors based on LCD, plasma, or other discrete pixel based technology. Why? While these devices cannot suffer from some of the problems inherent with CRTs (like imperfect geometry, convergence, or non-linearity), many characteristics can still be quite variable from one design or even one sample to another. These include brightness, brightness uniformity, range of viewing angle), color rendition, flicker, and ghosting (if analog interface).

Furthermore, digital scan converters need to be built into autoscan (SVGA type) flat screen monitors since they are basically fixed format devices. These are needed to accommodate the multiple scan rates and resolutions produced by PC based video cards when used with DOS/Windows or any situation where the resolution does not match the native resolution (number of pixels and lines) of the physical display device. Problems can arise from less than optimal resampling or inadequate conversion speed where motion is involved. These include: reduced sharpness, Moire, flicker or limited frame rate of changing/moving images, stability, and more.

Therefore, much of the testing information provided below can still be used to at least provide guidelines as to what to look out for when selecting a flat screen display, and evaluating and comparing sample units side-by-side.

Comments on Selecting an LCD Monitor

As with virtually everything else, there is a lot of hype and specsmanship with respect to flat panel monitors. After screen size, native resolution, maximum refresh rate, the specification that many people consider most important is contrast ratio, loosely defined as the ratio of the brightest white to blackest black. Or, perhaps contrast ratio is the #1 consideration. All else being equal, a higher contrast ratio should result in better rendition of continuous tone (i.e., photographic) images. Photos without black blacks tend to look washed out or muddy. However, for much of what one does on a computer, this may not really matter.

So, don't base your decision only on the contrast specifications. Check out the monitors personally if possible and determine which you like best under a variety of viewing conditions and screen material (e.g., text, photos, graphics).

There are additional issues like maximum brightness and viewing angle which may be equally or more important.

A monitor with high brightness may also end up with a bright "black screen". Those with best contrast specs may have a mediocre viewing angle. The contrast ratio spec may only apply at maximum brightness.

One of the things I dislike about all LCDs is that remaining illumination even for a totally black display. Compared to a properly adjusted CRT, displays like the "Flowerbox" screen saver really look bad, especially in a dark room.

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Basic Monitor Performance Criteria

The following are among those characteristics of a monitor that should be evaluated:

- Screen size and general appearance.
- Brightness and uniformity, purity and color saturation.
- Stability.
- Convergence.
- Edge geometry.
- Linearity.
- Tilt.
- Size and position control range.
- Ghosting or trailing streaks.
- Sharpness.
- Moire.
- Scan rate switching.
- Acoustic noise - buzzing and whining.

For monochrome monitors, use the appropriate subset of these tests. The descriptions below usually assume an auto-scan SVGA type of monitor. Modify accordingly for fixed scan computer monitors and studio video monitors.

Note: we use the term 'auto-scan' to describe a monitor which accepts a wide (and possibly continuous) range of scan rates. Usually, this refers mostly to the horizontal frequency as the vertical refresh rate is quite flexible on many monitors of all types. Fixed scan or fixed frequency monitors are designed to work with a single scan rate (though a 5% or so variation may actually be accepted). Multi-scan monitors sync at two or more distinct scan rates. While not very common anymore, multi-scan monitors may still be found in some specific applications.

CAUTION: since there is no risk-free way of evaluating the actual scan rate limits of a monitor, this is not an objective of these tests. It is assumed that the specifications of both the video source/card and the monitor are known and that supported scan rates are not exceeded. Some monitors will operate perfectly happily at well beyond the specified range or will shut down without damage. Others will simply blow up instantly and require expensive repairs.

Note: throughout this document, the term 'raster' is used to refer to the entire extent of the scanned portion of the screen and the terms 'picture', 'image'. or 'display', to refer to the actual presentation content.

Test Patterns

Three kinds of test patterns will be needed:

1. Solid, saturated primary colors (R,G,B) and combinations of these (Y,C,M,W). These will be used for brightness and color purity tests. Total black will also be required to set background level and evaluate black level retention.

2. White cross hatch, fine dot, alternating vertical and horizontal line patterns and bounding box outline. These will be used for convergence, geometry, size, and position, focus, and Moire tests.

3. High quality graphic or photographic image for general color appearance and overall aesthetic tests. If no suitable material is available, a Windows desktop with a vibrant color scheme (computer monitors) or an outdoor scene on a sunny day (studio video monitors) may be used.

For computer monitors, software programs are available to conveniently generate the required test patterns. However, an application like Windows MSPAINT in conjunction with a picture with vibrant colors can be used to create anything that is needed. It just will not be quite as easy to switch between patterns. Video cards like those from ATI come with a software Install program which provides a bounding box pattern and at all (PC DOS/Windows) resolutions and scan rates.

Test pattern generators for TV monitors are readily available and relatively inexpensive. However, a camcorder viewing appropriate printed material or a prerecorded tape can be used in a pinch.

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Testing a New or Used Monitor

Before starting the series of tests, allow the monitor to warm up for at least 1/2 hour and make sure it is completely degaussed (see the document: Notes on the Troubleshooting and Repair of Computer and Video Monitors for details on degaussing techniques. Power the monitor up in the physical orientation you will be using it (front-back facing North-South if you do not know how your setup will be arranged) and don't rotate it on its tilt swivel base after degaussing and for the duration of these tests. Make sure the monitor is not near any sources of electromagnetic interference (i.e., other powered monitors, loudspeakers, motors, transformers, etc.). Subdued lighting is best.

Use only the original video cable that came with the monitor or high quality BNC cables as appropriate. If you have a choice, opt for a BNC cable - the quality at higher scan rates will be noticeably better. Do not use any extension cables, any video switch boxes, or excessively long BNC cables.

Obviously, if you can do any of this in a store at all, then you may not quite have the luxury to fully control your environment!

Note that for an auto-scan monitor, all tests should ideally be performed at several points including the extremes upper and lower limits of each scan range. Most aspects of a auto-scan monitor's performance are affected by scan rate.

Unless otherwise noted, all controls are those available to the user.

For each test, adjust the size and position controls so that the raster fills as much of the screen as possible or as appropriate for the particular test.

Screen Size and General Appearance

Screen dimensions are normally measured diagonally - corner to corner.

So you thought you were buying a 17 inch monitor, right? Wrong. A monitor that is advertised as 17" (or 15" or 21") will rarely give you anything near that viewable size. The specification is of the CRT - including what is covered up by the front bezel and not considering the actual maximum size picture that may be possible in all scan modes.

Easily, 1.5 to 2 inches of your valuable diagonal screen real estate may be lost to marketing hype. As a result, you might find as much as a 20% difference in usable screen area between monitors which claim to be the same size. This is like buying a 17" monitor and getting one that is only 15"!

At certain scan rates, it may not be possible to get a picture corner to corner so even more usable area will be lost. Check out the section: Size and Position Control Range.

Some advertisements now include actual viewable screen size. Hopefully, this will become a universal practice but I will not hold my breath.

Other aspects of the monitor to check out:

- Screen curvature - some are curved, others are nearly flat, Trinitrons are cylindrical. For the most part, this is strictly a matter of preference. However, if you intend to photograph (still or video) off the screen, a flatter screen (all other factors being equal like geometric accuracy) will result in less distortion.

- Screen surface finish - this may be highly polished resulting in annoying reflections or dull (flat) which if excessively graining will decrease the crispness of the display. A highly polished surface with an anti- reflective coating (see below) is probably best.

- Antireflective and/or black (smoked) glass - usually, a CRT with a dark appearance will produce a higher contrast picture but possibly at the expense of overall brightness. Antireflective coatings like on camera lenses help also but are easily smudged and may be damaged by excessive cleaning.

- Convenience of the user controls. Digital controls are nice in that the settings for each resolution and scan rate are stored in memory. However, knobs are much easier to adjust in many cases. I prefer knobs for at least brightness and contrast.

- The aesthetics of the case. While this is usually unimportant from a performance point of view, it could be of great significance to your happiness. However, I know of some incredibly ugly monitors with great performance!

Brightness and Screen Uniformity, Purity and Color Saturation

Display a black - totally blank screen (but don't just pull the video cable as the monitor will be running with the normal voltages and signals) so that the raster is just barely visible. This adjustment should be possible but as noted below, not all monitors have totally independent brightness and contrast controls - you may need to bring up contrast a bit also.

The raster should be of uniform intensity and neutral gray. If it is not of uniform intensity or has hum bars - full width areas of varying brightness - or full height vertical rippled areas, the monitor's power supplies may be defective or of poor design. The only way to be sure is to compare several samples of the same model.

If the raster is not a neutral gray but has a tint, the color balance may need to be adjusted. See the section: Brightness and Screen Uniformity, Purity and Color Saturation.

Make sure you can actually set the brightness for total black (turn out the lights and check). If not, you will never have truly dark shadow areas in your display. Blacks will never be black and the display will always look a washed out. This may be adjustable internally.

However, inability or difficulty in adjusting for a totally or nearly black raster and vibrant bright display - or if the background brightness shifts as the picture content changes - may indicate a deficiency or defect in the black level retention circuitry. Since video signals are usually AC coupled, a clamping circuit is needed to set the black reference. If this does not work correctly or is poorly designed, the black level may shift depending on the picture content. Modern monitors should be nearly perfect in this regard. This problem is still seen in some cheap TVs, however.

Now set brightness to make the raster just disappear. Set the contrast control all the way up. Display a pure red (R) full intensity raster. The entire screen should be a pure, fairly uniform fully saturated red. There should not be any areas that are not pure red. Repeat with the other two primaries - green (G) and blue (B). Follow this up with tests of pairs of primaries resulting in yellow (R+G), cyan (G+B). and magenta (R+B). Again, these should result in pure vibrant colors.

Finally, display a pure white full intensity screen. The raster should be pure white. There should be no patches of discoloration. It may be a warm white (somewhat redish) or a cool white (somewhat bluish) but not objectionably so. Some monitors permit this color 'temperature' to be adjusted by the user (e.g., NEC AccuColor models like the 4FG or 5FG). If the screen is noticeably colored and there are no user adjustments, then the internal video gain controls need attention - see the section: Brightness and Screen Uniformity, Purity and Color Saturation.

Note that the term 'vibrant' here is a subjective term but relates to the boldness, saturation, and, well, zappiness! However, this is affected both by the choice of spectral output of the primary color phosphors and to your perception. For a given CRT, the phosphors set the spectral characteristics of the display. Expensive studio monitors can be ordered with a specific CRT to suit the needs of the video standard. This is rarely an option with computer monitors. You probably do not have control over your visual perception (but do take off those autocompensating sun glasses!) In other words, your mileage may vary.

If any of these tests detect a problem, the color purity may need to be adjusted. (By you or by a professional as appropriate). A brand new monitor should not have purity problems unless it is near a source of magnetic fields like a loudspeaker or MRI scanner.

The pure white screen can also be used to evaluate the brightness uniformity of the CRT. Don't expect perfection. The actual quantitative measured brightness may vary quite a bit even with a high quality monitor. The corners and edges may be noticeably darker than the center even on the low deflection angle CRTs used in high performance monitors. With the high deflection angle CRTs in TVs and cheap monitors, this may be even worse.

However, local significantly darker or brighter areas could indicate defects in the CRT dot/slot mask or aperture grille or phosphor screen which should not be tolerated.

Should you see color or uniformity problems at full intensity, try turning down the contrast control. If the uniformity improves after a few seconds, the shadowmask in the CRT may be heating and deforming. This is not unusual with color monitors. One of the advantages of an InVar shadowmask is that it is less prone to these problems, however.

Also note if there is a brightness limiter circuit that is kicking in with the full white screen. As you turn up the contrast, is there a point where further increase has no effect on the intensity of the display or where the intensity actually decreases? These brightness limiters are designed to maintain the beam current at supposedly safe levels to minimize X-ray generation and/or to mimize the shadowmask heating effects. Is the maximum brightness adequate for you needs and viewing enjoyment?

Using the full white screen, adjust the contrast and brightness controls through their full range. The size of the raster should not change noticeably. A significant change in size - more than 1 or 2 percent - would indicate poor power supply regulation.

Examine the entire screen closely for blemishes both in the surface finish and for dead spots.

If you see any dead or darker spots, confirm that these are not due to the video source: if they are CRT defects, they will not move as you adjust the position controls.

There is a specification for the number and size of acceptable CRT blemishes so you may have to whine a bit to convince the vendor to provide a replacement monitor under warranty. Defects in the corners will likely only be noticed if if you are looking for them. However, dead spots in the central area of the screen will always be a distraction. Before the purchase is the time to find these.

(From: Jamie Carter (jacarter3@onebox.com).)

The specification for display brightness has always been subject to specsmanship. For example, a CRT or CRT based display will quote lux or lumens/m^2 based on a 10% white field which is a small square in the display set at maximum output. A CRT display cannot achieve the same current density on the phosphor with the whole screen being white and thus the full white screen will give a significantly smaller value not to mention that the resolution suffers significantly with the high electron beam density.

These effects are obviated for the most part with LCD or DMD displays because the brightness engine is decoupled from the resolution engine. But even in these cases, the color temperature of the white field, the color purity (saturation) of the color channels and gain of the screen (distribution of the luminous flux) all factor into the perception of display quality and image "goodness" (a very subjective quality at best). Your best bet is to compare the actual display units under your specific viewing conditions and intended display content. Note that the "Compu-Hut" will line up a whole bunch of displays for your comparison but only display photographic images with rather limited spatial bandwidth. This gives no indication of display quality when viewing 1 pixel wide strokes for desktop and application fonts. Make the sales ape show some of the GUI windows and a text file before you buy.

Then there's an industry term: "Market Comparable Lumens". I am sure that the real basis for this is to create a metric that cannot be disputed or independently tested by the buyer. :)

Stability

Display a picture having a complete range of colors and intensities.

At refresh rates beyond 70-75 Hz, even a very bright display should appear rock solid. Turn off any fluorescent lights (whose possible flicker at twice the power line frequency can confuse the test) and examine the screen closely. There should be no shimmering, wiggling, jittering, or dark or light flashes. Any of these would indicate either (1) external electromagnetic interference or (2) a poorly designed or defective power supply in the monitor. It is also possible, though less likely, that the incoming AC power is noisy but modern monitors generally do a decent job of filtering the power lines to eliminate most of this.

Convergence

Ideally, all three electron beams in a color CRT should be precisely coincident at every point on the screen. While this is never quite achieved, the degree of convergence even at the corners is generally quite impressive - less than .5 mm for many moderately priced monitors.

Display a white crosshatch pattern with boxes about 1/2 inch square. IF you do not have this, use a white-on-black graphics or text screen with a lot of fine detail - small fonts or intricate patterns.

The lines should appear white without excessive color fringing. The individual primary colors should not be visible at a normal viewing distance. First, examine the center. This should be nearly perfect. If your monitor has any user adjustable convergence controls, set these for best center convergence. Convergence will be worst in the corners but even there, it should not be objectionable.

A serious convergence problem in the center of the screen is definitely an indication of a defective monitor or one that needs internal adjustments. Slightly poorer convergence at the corners may be within specifications. A new monitor with significant convergence problems should be rejected.

Edge Geometry

Display a bounding box image - one that extends to the very edge of the raster on all sides.

Adjust any user pincushion controls (amplitude and phase) for minimum distortion along the vertical edges. Amplitude moves the sides in and out. Phase sets where, vertically, this effect takes place. If there are any other user controls that affect raster shape, optimize these for a perfectly rectangular display.

Now, examine all edges for curves, wiggles, dips, keystoning, or trapezoidal deviations from a perfect rectangle. These are all considered defects in the geometry of the raster. These will likely be more pronounced at high scan rates - near the limits of the specifications for the monitor. In particular, you may see a wiggle or wave on the left and right edges near the top of the screen which will be come more pronounced as you approach the highest scan rate (this is a deflection problem, however, not strictly a CRT geometry problem).

During manufacture, various magnets are strategically glued around the CRT or carefully positioned on rotating swivels on the deflection yoke frame or elsewhere. You need to decide if any remaining errors in geometry are acceptable or not because improving upon these settings is not something that is easy or fun to do - by you or a professional! As noted, if the geometry becomes noticeably inferior at high scan rates, this indicates a problem in the deflection circuitry - adjustments will probably not help. Consider another monitor if you intend to run at these rates.

Linearity

Display a crosshatch pattern of roughly 1/2" spaced lines. Take a tape measure and compare the exact spacing of vertical lines in the left, middle, and right areas of the screen. Do the same for the horizontal lines in the top, middle, and bottom of the screen. Modern monitors should have very little variation - probably undetectable using a tape measure.

Linearity may or may not be adjustable.

Tilt

Inspect the bounding box for tilt - is it perfectly aligned with the cosmetic bezel of the CRT? If the monitor has a tilt control, see if it will compensate. Few do. The only way to correct tilt on monitors without a tilt adjustment is to rotate the deflection yoke or entire CRT - not recommended. If the degree of tilt bothers you in the slightest and you are a perfectionist, reject the monitor or insist that the tilt be corrected - and be present if possible to make sure that the adjustment is done to your satisfaction.

Size and Position Control Range

Determine if the size and position controls have enough of an range to fill the screen totally (for computer monitors) or (possibly in conjunction with an underscan switch) allow for a suitable reduced raster size (studio video monitors).

For computer monitors, these tests may need to be done in conjunction with the video card you will be using and the software setup program for that video card. Ideally, all size and position adjustments can be done in software with the monitor's controls left at their center (default) setting. However, this is not always the case.

Some people want their computer monitors to extend to or past the edges of the CRT. Many monitors may leave a large border around the picture particularly at higher scan rates. Test at the resolutions and scan rates you expect to use. Obviously, a monitor that will not fill the screen is shortchanging you in terms of how much screen size you purchased!

Often, slightly reducing the scan rate at a given resolution will allow for a larger picture. This is one alternative if the flicker is not objectionable.

Ghosting or Trailing Streaks

Display a picture with a large number of high contrast vertical edges - a Windows desktop with many open folders, for example.

Vertical edges should be crisp and clear. Examine these for smearing, ghosting, or trailing darker or lighter lines. Any deficiencies will be most evident at high scan rates since these require the most bandwidth from the video card, cables, and monitor. Also, any ringing, undershoot, or overshoot, will extend for a longer space following the edge.

Without substituting video cards, cables, and monitors, it is not usually possible to determine which is the limiting factor.

The most common cause of these types of problems are inferior, defective, or excessively long cables; use of cable extensions or video switch boxes; or improper termination if there are termination options on the monitor.

Full brightness vertical edges should not smear or bloom to the right - possibly with a color change. This is due to the internal video gain controls being set too high and may be correctable but possibly with a reduction in maximum brightness.

There should also be no trailing lines to the right of long bright or dark horizontal areas. Similarly, the edges of the raster should not bulge out where the picture is very bright. These types of problems would indicate problems with the power supplies or just poor design.

Sharpness

Display a white screen at the highest resolution and scan rate your system is capable of (or the highest you ever anticipate using). See if you are able to make out the individual scan lines. Turn down the brightness - this will decrease the effective spot size and make the scan lines more visible.

Display a fine dot pattern. The individual dots should be tiny, crisp, and fairly symmetric. If the spot size changes drastically with brightness, focus may need to be adjusted or the monitor's power supplies or CRT may be mediocre or defective.

Note that it is not always best to have super sharp focus as long as the spot size is small enough. A slightly defocused spot will result in a smoother display and less likelihood of Moire effects.

Moire

Moire is caused by interference - beating - between the picture or raster and the phosphor dots or lines that make up the display. Technically, it is an aliasing artifact due to the relative sampling rates of these two structures.

There are several causes of Moire. The following will address two of these: scan line Moire and pixel Moire.

Try these tests with any 'Moire reducing modes' both off and on. However, the use of such 'features' may reduce the quality of the display in other ways like reducing sharpness or stability.

Display a solid white screen at mid brightness. Look for patterns that look similar to contour lines on topographic maps. Adjust the vertical size and position controls to see if these move around or change their severity and spacing. Repeat with a display of alternating black and white horizontal lines.

Now, display a pattern consisting of alternating black and white vertical lines at the maximum possibly frequency (alternating dark and light pixels for a computer display - make sure your software is not doing any dithering). Look for serious contour lines in this display. Adjust the horizontal size and position controls to see how these affect any Moire.

Try these tests at multiple resolutions including the highest you will ever use. However, the highest may not necessarily be the worst with respect to Moire.

Other than using any 'Moire reducing mode' provided by the monitor, there may not be anything you can do to reduce the severity of Moire other than running at resolutions which do not exhibit a serious problem.

Nonetheless, I think it is ironic that some people will end up returning otherwise superb monitors because of moire - when in many cases this is an indication of most excellent focus - something many people strive for! You can always get rid of it - the converse is not necessarily true!

Scan Rate Switching

When running Windows or DOS with a auto-scan monitor, switching scan rates may be done quite frequently. Some monitors take longer than others to perform this switchover. There may be clicks (due to relays) and other sounds. Better monitors will blank the video until the new scan rate has stabilized. On cheaper monitors, you may see the image as it locks in. Some monitors are very quick. Others can take several seconds - an eternity if you are doing this frequently. Try switching between scan rates at the limits of each scan range as this will be the toughest situation. While it is hard to pin down what makes for a suitable outcome of this test (unless there is an actual failure to properly sync), a monitor that appears to be struggling or which doesn't always make it may be trying to tell you something.

Note: there have been some monitors that blow up - fail completely and require expensive repairs - simply as a result of the video card initialization at boot time due to its power on self test when the video signal may be unspecificed and driving the monitor at an invalid scan rate. However, this is not likely to be a problem with any modern auto-scan monitor.

Acoustic Noise

Ideally, a monitor is seen and not heard. However, there are a variety of components inside that can vibrate and this may be quite annoying in a quiet room or late at night. A buzz may originate from the switching power supply or vertical deflection components. A high pitched whine, squeal, or twittering may originate from the switching power supply, flyback (LOPT) transformer, or horizontal deflection components. Some people aren't bothered by these sounds at all or cannot hear them. Others will be driven stark raving bonkers.

Listen carefully through the grille in the cover for any indication - even momentary - of annoying sounds. Try all scan rates - very often various resonances will only occur at particular horizontal or vertical scan frequencies. Even with high quality monitors, these problems sometimes occur erratically and no quick test will identify such faults. Obviously, doing this in a quiet location is best.

Note that any decreasing hum or buzz that may be heard at power-on is due to the internal degaussing coil and is usually normal and unavoidable.

Checking the Age of the CRT

This doesn't (or shouldn't) apply to a new monitor, but suppose you found this great deal on a used TV or monitor. How can you tell if the picture tube is about to die on you?

(From: Andy Cuffe (baltimora@psu.edu).)

The best way to tell is to look at the picture quality. There is no way to tell the exact number of hours. Also, the life of CRTs varies quite a bit. some will go down hill much faster than others.

- It should be sharply focused over the entire screen and all 3 colors should be equally sharp.
- Set the picture brightness and color to maximum. If you see any bleeding or smearing to the right of bright objects don't buy it.
- When you first turn it on the picture should look normal in well under a minute. If it is dim, tinted, or blurry for more than a minute or two the CRT is getting weak.
- A B/W picture should not be tinted.
- The picture should have decent brightness with the picture at about mid range.

Apart form that, if the overall picture is good the CRT is fine. CRTs usually fail very slowly. Even if it's starting to show it's age it probably has several years left.

(Portions from: Jerry G. (jerryg50@hotmail.com).)

You cannot tell the hours used by just looking or even measuring a tube. A tube can go at any time. There are no hour counters!

Turn on the unit and see if there is any unusual bleeding of the image in the picture at high contrast levels. When turning the brightness up and down, the color temperature should not change, only the brightness. When turning the contrast up and down, the focus at the center should also be very stable. It may change only a little bit. When turning on the set, the color temperature should be stable within about 3 to 5 minutes.

Look at the colors in the corners to see if the purity is good. Bad purity can be attributed to a miss-adjusted yoke assembly, to a bad shadow mask.

To know the manufacture date of the unit, it us usually on the back with the model and serial number. Most TV sets are on about 5 to 8 hours a day if it is a family TV. If it is a bedroom TV the hours may be 1/2 that amount. Monitors may be on 24 hours a day - or much less.

A good way to know if the emission of the CRT is up to specs is to get a CRT analyzer and measure the gun emission. Some service centers own one.

Specifically for Used Monitor Purchases

In addition to the previous tests, general condition may be a good indication of the future holds for the monitor. Aside from obvious damage from being dropped off a 10 story building, there can be scuffing, dings, and dents which may not affect performance but look bad. Equipment operated in dirty or dusty locations, among heavy smokers, or in or near greasy kitchens, may become coated and this can be difficult or impossible to clean up completely. The inside may be clogged as well which may ultimately affect reliability. Such monitors may also always smell bad.

When buying a used monitors, particularly sight unseen (as on eBay), asking the proper questions will be most important. Age alone isn't necessarily a reliable indication of performance or future reliability. I'm typing this on a 10 year old NEC 5FG which I still consider to be as good as any monitor sold today. However, a 2 year monitor run 24 hours a day could be ready for the dumpster. It's probably best to stay with a major brand name. If possible, ask about most of the items listed above, but particularly the brightness, focus, convergence, geometry, and overall picture quality.

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Final Evaluation

If after these tests, you determine that your monitor or the one you are considering is perfect - let me know as this is extremely unlikely. More likely is that you found a number of deficiencies. If this is a monitor you are considering purchasing, you need to decide if the benefits outweight the defects. For certain problems like color balance, the vendor may work with you to tweak the needed internal controls. Alternatively, using the information contained in the document: Notes on the Troubleshooting and Repair of Computer and Video Monitors, you may decide that you will be able to take care of the problem yourself. However, for problems like severe misconvergence, uncorrectable pincushioning, serious Moire, or audible buzz, there may be no easy solution and searching for another monitor may be the only option. If you inherited the monitor or are getting a really good deal, then many of these problems can prboably be dealt with but with some risk that significant improvement may not be possible.

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Monitor Testing Programs

There are a variety of PC compatible software programs for testing of SVGA computer monitors. These display various test patterns and color charts which are appropriate for the procedures discussed in this document.

Here are a few pointers:

- The monitor test program "NTest" is very often recommended on the comp.sys.ibm.pc.hardware.video Newsgroup. This was originally available from Nokia but since Nokia sold their monitor division to Viewsonic, it has disappeared so here is a copy. I'll be happy to link to the Viewsonic site if they replace it.

    - Nokia Ntest Monitor Test.

- ComputerCraft provides a shareware program for testing monitors and video cards. I have not tested it but as they say: "If you are aware of the dangers, Monitors 1.01 is a powerful tool." See the section: WARNING and DISCLAIMER for some of these. This shareware program can also test video cards for characteristics and graphic modes

    - Monitors 1.01.

  (From: Mark E. Nikl (markn3@infoave.net).)

  In the download section of the Web site, there is a file called monitors. It will give you all the test patterns and setups for gray scales, HV regulation, tell you about you video card and much more. I just ran across it the other day. You can even set up the pincushion and lots more.

- SONERA Technologies markets a set of programs called "DisplayMate" available for DOS and Windows/Win95. This is supposed to guide you through the monitor testing and setup process with a series of test pattern 'slides'. I have not tried it so I cannot comment on its utility.

  A demo version with a few test patterns, more information on their products, and some video tech tips, and some test patters are available at:

  - Display Mate Home Page and Demo.
  - Test Patterns.

- The following link provides some simple test patterns for color, focus, convergence, and black level, using just HTML pages which can be downloaded.

  - Various Display Tests.

- PassMark has a product that appears to have a fairly comprehensive set of features including 25 test patterns, display of monitor and video adapter information, and support for multiple resolutions, color depths, and display types. It can be downloaded for free with a 15 day evaluation, then costs $15:

  - PassMark MonitorTest.

- Here are a variety of common geometry and color test patterns for monitor adjustment.

  - Eric Richards' Web Site (Run on-line)
  - patterns.zip (Download Java applet)

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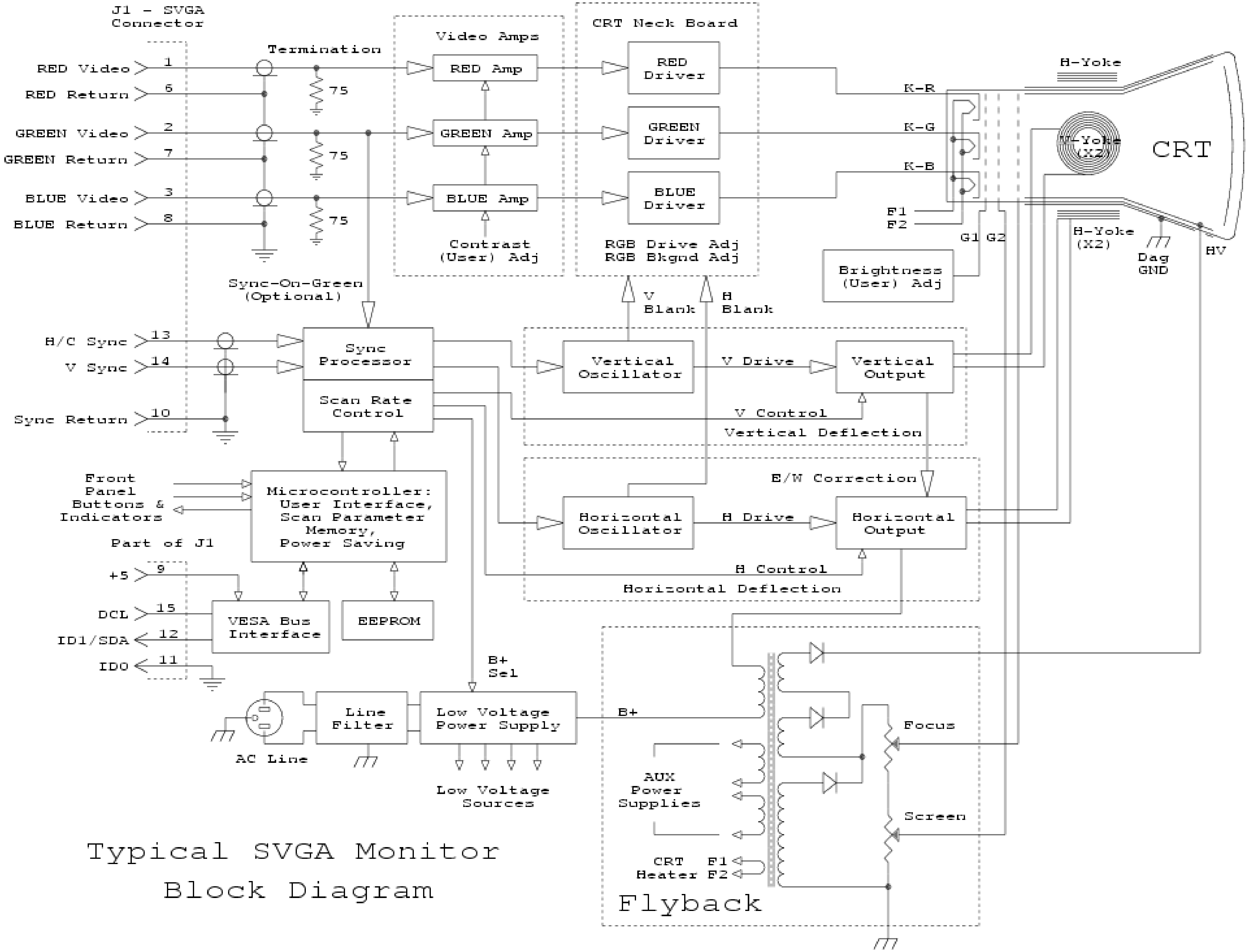
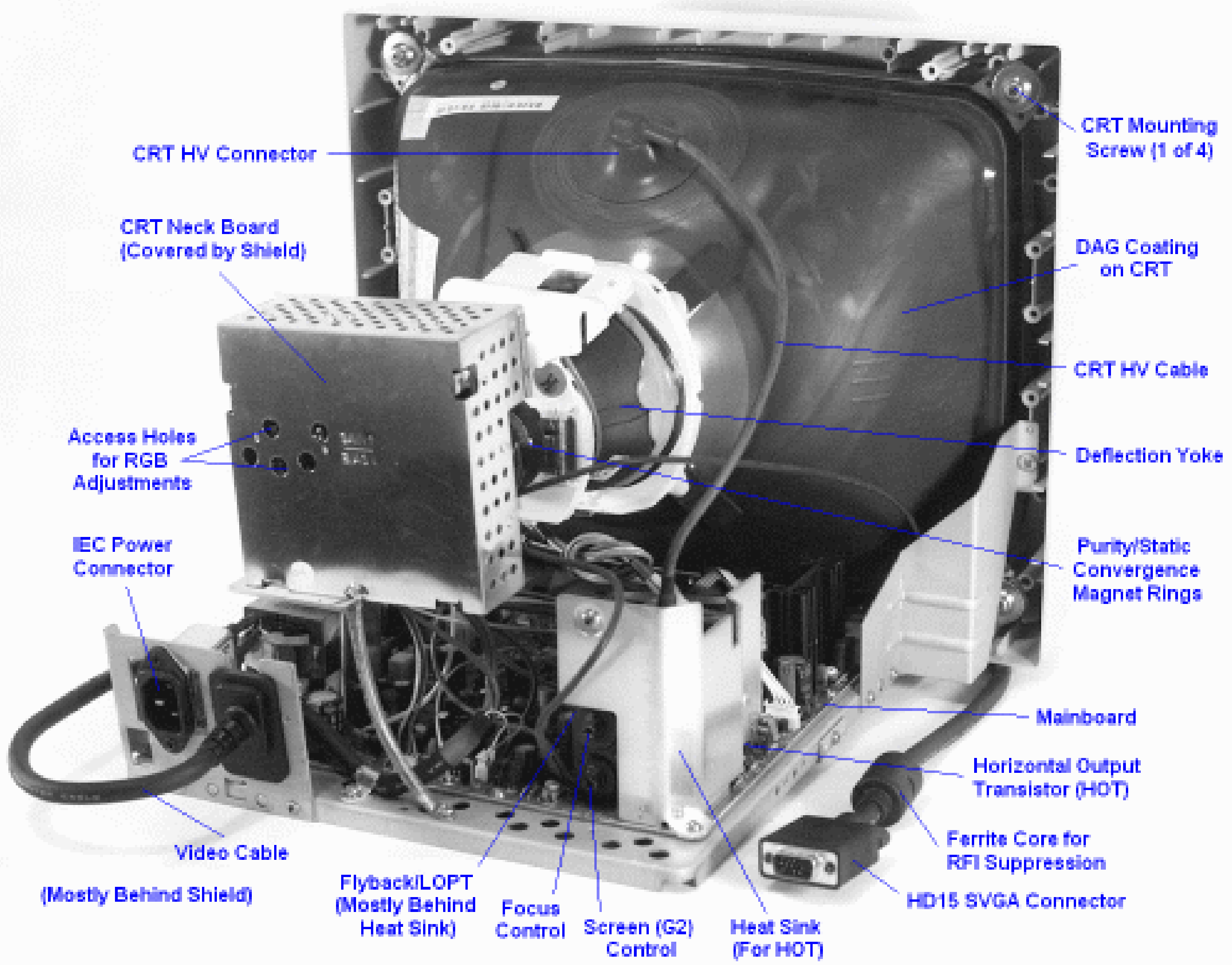
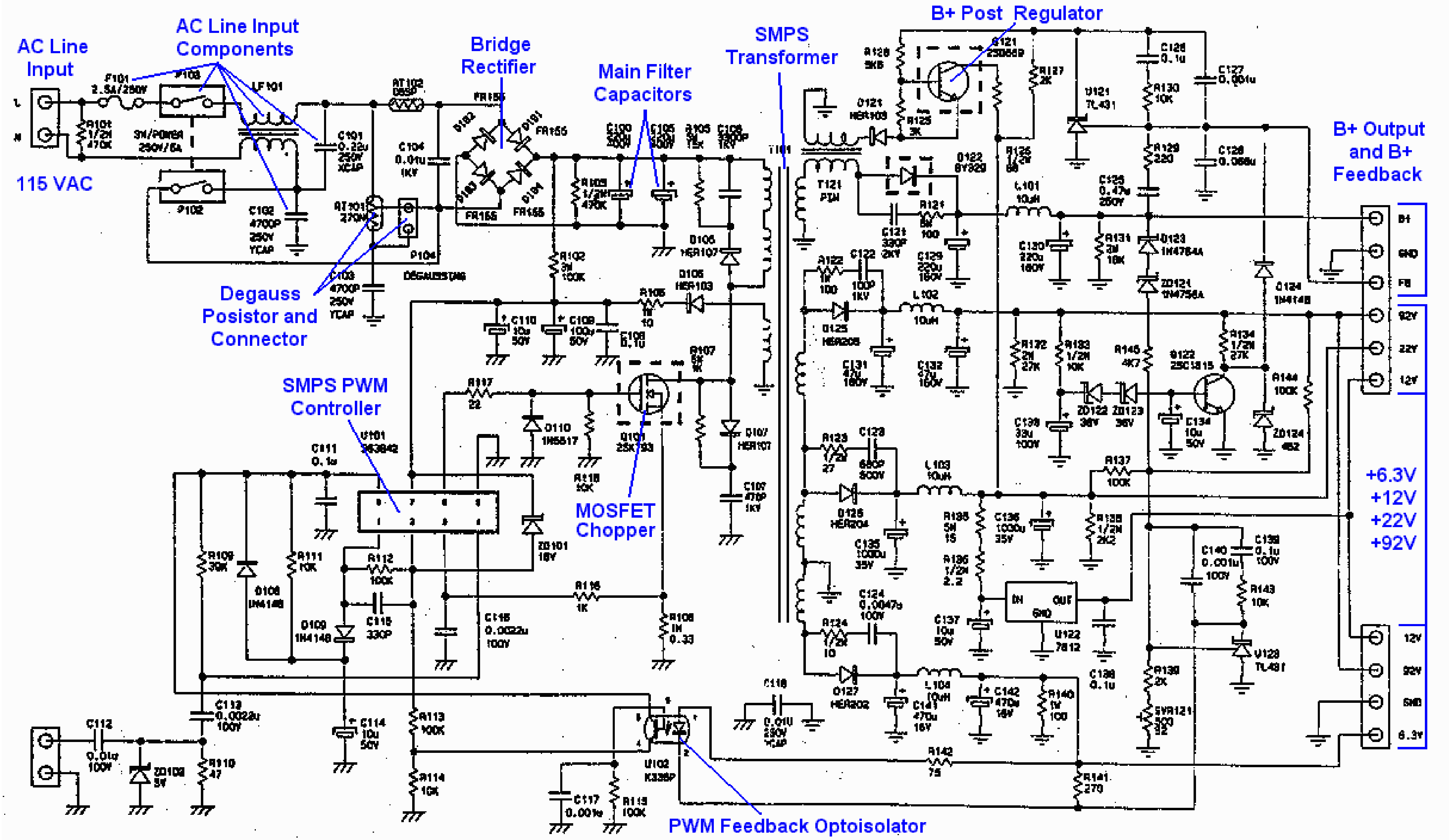
  -- end V1.45 --



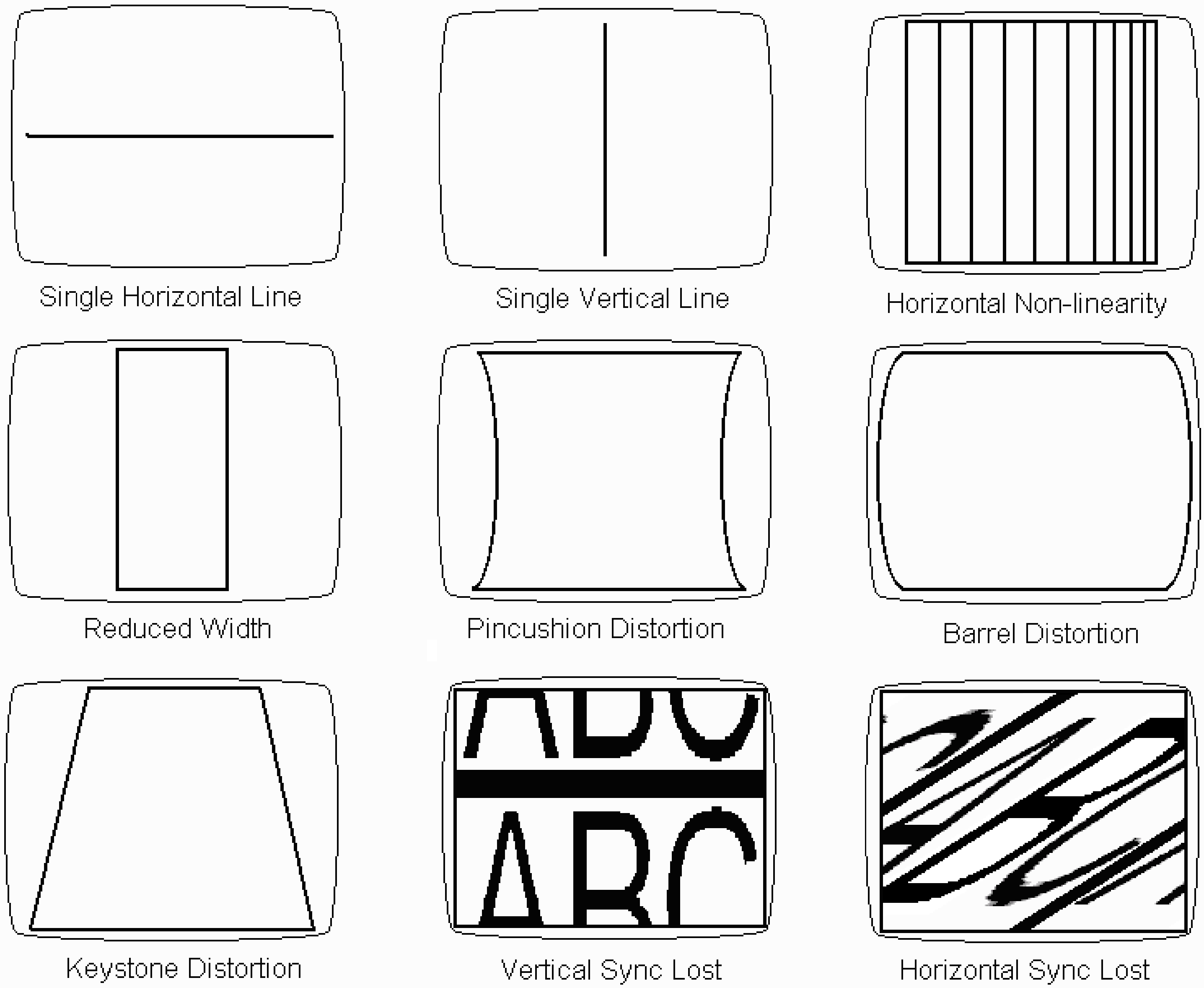
Typical SVGA Monitor Block Diagram



Major Parts of Typical SVGA Monitor with Cover Removed



Typical Switchmode Power Supply for Small SVGA Color Monitor



Symptoms of Some Common Deflection Problems

Approaches to Using Fixed Frequency or Non-Standard Monitors on PCs

Version 1.68a

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

Important Notice

The author of this document has absolutely no affiliation of any kind with any hardware, software, or service company which has a vested interest in advocating one solution over another.

The purpose of the FF Mon FAQ is to provide unbiased information to aid in making an informed decision when considering the acquisition of a fixed frequency monitor for use on a PC.

Contributions of a non-commercial nature to enhance this document are welcome.

WARNING and DISCLAIMER

Attaching an incompatible video source to a monitor (i.e. the signals do not have the proper voltages as with digital or analog levels) or using the wrong scan rate are both potentially risky to the monitor.

- Incorrect signal levels or connections can damage the monitor's input circuitry and/or the output drivers of the video (or other interface card if you happen to accidentally plug it into an Ethernet or serial card by mistake!).

  Don't arbitrarily attach the monitor cable to a socket just because they physically mate or have the same number of pins!

- Setting the scan rate of a monitor outside its specified range may overstress components and can result in expensive damage to power supply and deflection components. Whether or not this happens with a given model depends on its design and there is no way to know beforehand which monitors are susceptible. Some monitors will be perfectly happy working beyond their pusblished specs; others will politely shut down with a warning; but all too many will go up in smoke!

  The designers of fixed frequency monitors originally designed for specific workstation applications may very likely have taken even less care in dealing with unexpected scan rates as their environment is closed and such treatment isn't expected. Spectacular and expensive failure is quite possible.

  It can be very risky to experiment with scan rate settings either because you have no idea of what is valid or to 'explore the envelope'. Either of these could result in expensive repairs. The only hint you may get just before the smoke comes out are unusually poor geometry or instability but it would be foolish to depend on these possible warnings.

Some of the procedures described in this document may require going inside the monitor to make adjustments or add circuitry. There are both high voltages (25 kV OR MORE for the typical 19 inch workstation monitor) and AC line voltage all too easily accessible once the case is removed. Don't even think about doing anything inside a monitor unlil you have read and understood everything in the document: Safety Guidelines for High Voltage and/or Line

Powered Equipment. Something that looks innocent can really ruin your whole day!

We will not be responsible for any damage to your monitor or ego that may result from such experiments!

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Introduction

That Bargain Monitor

So, you have got the deal of a lifetime - a brand spanking new (or at least low mileage) high resolution 21" computer monitor that came from a DEC Alpha Workstation - or a Sun or HP - or Macintosh. Or, perhaps an IBM 9517 which you were told has a super sharp bright picture. The cost to you: $1 or you haul it away. Is this really and truly a good deal if you use a PC?

Questions like this come up all the time on comp.sys.ibm.pc.hardware.video.

These are either fixed frequency monitors or are incompatible with the common VGA/SVGA 'standards' in some other ways.

This document provides unbiased information on the problems and possible solutions to dealing with these monitors on PCs (where the term 'PC' mostly refers to DOS/Windows based x86 and Pentium boxes but may include Macs and Linux based systems as well).

Note that some/many/most newer workstation monitors may indeed NOT be fixed Therefore, before spending a lot of time, effort, and money to adapt a fixed frequency monitor that isn't, attempt to determine its specifications from the manufacturer - all you may need is a cable! That workstation monitor may be identical internally to a one sold for PCs but with a different model number and video caonnector. Why is this now the case? Simple: Because it is cheaper for a monitor manufacturer to produce a single standard model rather than a one for the large PC market and another for the much smaller workstation market - even if it is somewhat simpler with a lower parts cost.

Fixed Frequency Monitor Basics

A fixed frequency monitor is designed to operate at a single scan rate which usually means a single resolution such as 1280x1024. (Strictly speaking, the horizontal resolution is determined by the number of pixels sent on each scan line by the video card but this is a detail.) PCs running DOS, Windows 3.1, WFWG3.11, and Win95 generally require the monitor to run at multiple scan rates - one for each corresponding resolution. For example, boot at 640x400, VGA at 640x480, Windows at 1024x768 - and each one may have a correspondingly different horizontal and vertical scan rate. (Some workstation monitors are actually dual frequency but this does not really help since neither of the supported scan rates are what a PC wants.)

Monitors like the IBM 9517 are not fixed frequency but are XGA compatible. This was an IBM abortion and not compatible with VGA/SVGA even for booting your PC.

These types of monitors are generally manufactured by the best names in the industry such as Hitachi, Mitsubishi, Philips, Sony, etc. - and are thus often of very high quality. The specifications of these monitors may exceed those of any but the very top-of-the-line monitors used on PCs. The origianl cost of these monitors was probably much higher than an equivalently sized PC monitor as well. They become available as high performance workstations (whose technology advances nearly as quickly as that of PCs) are decommissioned or upgraded. The cost to you now is usually very low since they just take up space and you know how bean counters at big companies like to have all their beans lined up in a nice neat row :-)

Some fixed freqeuncy monitors may be from Apple Macintosh computers as well.

It would be nice if all you needed was a cable to use one of these beauties on a PC. Unfortunately, there is often much more involved in making these freebie monitors conveniently usable on a PC under DOS, Windows, or Win95.

Some of these comments - a la scan rates - may not apply to PCs running oprating systems like Linux where scan rate switching isn't required (at least after boot).

And, just because a monitor has BNC connectors (or does not have a VGA/SVGA connector or cable) does not necessarily mean that is is a fixed frequency monitor and therefore a problem. Many top quality monitors only have BNC connectors and might be fully compatible with most video cards running PC/DOS/Winddows. The only way to be sure is to obtain the detailed video, sync, and scan rate specifications.

Are you totally confused yet? :-) The purpose of the FF Monitor FAQ is to try to sort through all the confusing compatibility issues and alternative solutions to enable you to use that fabulous monitor.

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Problems with Fixed Frequency Monitors on PCs

While workstation monitors look like PC monitors - they have a CRT and a power cord, after all - there are generally significant differences that prevent these from being a 'drop in' solution.

The following are the principle difficulties in using a fixed frequency monitor on a PC:

- Scan rates. PCs particularly with DOS/Windows/Win95 may require a number of different resolutions and scan rates during any work or play session. Workstations use one scan rate and resolution at all times including during boot. That is why the monitors are called fixed frequency. The video source must match the parameters of the monitor withing a few percent, not enough variance for typical PC applications.

- Sync. PC VGA and SVGA video cards generate separate horizontal and vertical sync signals. Some may be programmable to generate what is known as composite sync. Workstation monitors may require composite sync or sync-on-green (this will be explained later). They rarely use separate H and V sync like a PC. Many PC video cards can only provide separate syncs. Some workstation monitors are already set up for various sync schemes but not all.

- Video connectors. PCs nearly always have a miniature DB15 VGA/SVGA type connector. Workstation monitors may use separate BNC connectors (3, 4, or 5 depending on sync options), a 13W3 Sun style connector, or something totally non-standard.

- Plug-and-play. The newest PCs and video cards expect to determine the capabilities of your monitor (to a greater or lesser extent) by either reading the monitor sense lines on the VGA connector or interrogating the ACCESS.bus. Neither of these will be present by default with a workstation monitor. The PC may come up in glorious black and white or refuse to operate in all modes.

Scan Rate Issues

A workstation runs at a fixed resolution and scan rate. All software is written to interface to the screen via a windowing system like X-Windows. PCs, on the other hand, must be able to drive a monitor at several quite different resolutions and scan rates:

- DOS - 640 x 400 default boot screen.

- DOS programs - 640 x 400 (EGA compatible), 640 x 480 (basic VGA), etc. (Note: CGA resolutions like 320x200 are emulated by modern video cards by running at 640x400 (for this example) and replicating pixels and lines.)

- Windows/Win95 - 640x480, 800x600, 1024x768, 1280x1024, 00x1200 etc. depending on your hardware and software. Normally, the highest resolution that the video card/monitor combination supports with good quality will be used most often. Some options like a larger desktop than the physical display with dynamic resolution switching require multiple scan rates, however.

Therefore, a fixed frequency monitor driven from a typical video card (e.g., ATI GPT) running under DOS/Windows has a problem. For a typical workstation monitor with a resolution of 1280x1024 operating at 78 kHz horizontal scan rate and 72 Hz vertical scan rate (fixed frequency), you only have one option - and that precludes the display of the DOS boot messages or running DOS applications or games.

Note: for the remainder of this document, I use the term 'Windows' to refer to MS Windows 3.1, WFWG 3.11, and Win95/98 interchangeably.

If all you run is Windows - never any DOS games or other applications that require you to suspend to a full screen DOS shell or run in native DOS mode - then you can always use a second VGA monitor for booting and then just switch over to the high resolution monitor once Windows comes up. Or, just assume your system **will** come up and forgo a display until the Windows desktop appears.

Unfortunately, there are a lot of DOS applications still used so this not a solution for everyone.

However, if you mostly use your PC for Autocad or Lotus, then this is a perfectly reasonable option if you have a suitable video card. (However, read on).

Sync Options - Separate, Composite, Sync-On-Green, Sync Polarity

In order for the monitor to display a picture, it must know where the lines and frames begin. The synchronization signals - sync for short - are pulses sent for each line (horizontal sync) and each frame (vertical sync). There are 3 common schemes for doing this:

- Separate horizontal and vertical sync signals. Individual wires are used for the H and V sync. This is the scheme that has been used for most PC video cards including MGA, EGA, VGA, and SVGA. It makes for easier hardware - particularly in the monitor.

- Composite sync signal. The H and V syncs are logically combined (usually either OR or XOR) and sent on a single wire. This is used by Macintosh computers and Sun workstations, for example. Basically, it saves a wire.

- Sync-on-green. The composite sync signal from (2) is combined with the green video signal (it actually goes on the bottom, from 0 to .3 V or so). The Red and Blue video signals usually do not have sync added to them but this is not always the case. Note that theoretically, (1) or (2) are best as there is no interaction between the digital sync signals and analog video signals but in practice, the difference is usually undetectable.

The users manual for your monitor will identify which options the monitor supports. OK, so you don't have a users manual:

For monitors with BNC connectors, it may be possible to determine capabilities by counting them:

- 3 BNCs - Sync-on-green only (Red, Green+Sync, Blue).

- 4 BNCs - Composite sync (R,G,B,CS) and possibly sync-on-green.

- 5 BNCs - Separate syncs (R,G,B,HS,VS) and possibly composite or sync-on-green as well.

Where: HS=Horizontal Sync, VS=Vertical Sync, and CS=Composite Sync.

Monitors with a 13W3 connector will generally accept composite sync though the other options may be possibilities as well.

Some video cards (like the ATI GUP, GPT, and others) can be programmed in their SETUP or INSTALL program (or possibly from a command line option) to generate composite sync on the H or V sync wire. These will then work (at least with respect to sync) with a monitor requiring either separate or composite syncs. A few high-end cards can generate sync-on-green as well.

Sync polarity (whether the pulses are negative or positive going) may be an issue depending on the design of the monitor. However, most suitable video cards can be programmed for either polarity.

Therefore, depending on your video card, the sync issue may be a non-issue.

Otherwise, an adapter will be needed. Unfortunately, this is not just a cable as circuitry is required to combine the signals. If you are electronically handy, it is a simple matter to construct a suitable circuit but if you are not, this may be a show-stopper unless you can locate a commercial product. Note that the term 'electronically handy' means a bit more than knowing how to read the resistor color code. The circuits are very simple. However, for the adapter to work well at the very high video bandwidths of the typical (1280x1024) display, you must use the proper 75 ohm coax and connectors, and assemble the circuitry itself in a shielded metal box, if possible. Otherwise, there could be degredation of the displayed video - ghosting, ringing, and less than optimal image sharpness. If you will be making a cable from scratch, there will be some precision (very tiny pins) crimping or soldering needed to construct the VGA and/or 13W3 (typically) connectors as well.

Video Connectors

Most common are BNCs - individual coax connectors for each signal - and 13W3 which combines 3 coax and 10 normal signal pins in a single shell. Except for some really strange custom connectors, adapters are available:

- VGA to 3, 4, or 5 BNC (might as well get the 5 BNC as the increased cost may not be that great and it is the most flexible should you come across another 'bargain'.

- VGA to 13W3. (e.g., Sun monitor).

- VGA to MAC (regular DB15). (e.g., Macinstosh monitor).

Plug-and-Play

When your PC boots, it may interrogate the monitor to determine what its capabilities are. With BNC or 13W3 connectors, the needed signals are generally not present. Some manufacturers are addressing this by providing little widget boxes that plug in as part of an adapter cable to provide these signals but these are not common at the present time. Therefore, you may need to take steps in hardware or software to get around this deficiency.

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Alternatives to the Dumpster

Perhaps that deal-of-the-century doesn't sound so great at this point. Don't give up yet. There are several possibilities.

- High-end video cards with compatible scan rates. As noted above, for use with applications that run entirely in windows and/or at a single resolution and scan rate. A separate monitor (or no monitor in case you trust your setup) is used for booting.

- Special fixed frequency monitor video cards. These emulate VGA and SVGA video cards as far as the PC's software is concerned but drive the monitor at a fixed (high) resolution and scan rate even when booting (in most cases).

And who knows? Sometimes you can get lucky with your $20 bargain basement video card!

High-End Video Cards

If you already have an investment in a good video card (not a $29 K-Mart special), then this may be a possibility.

- Advantages: you may already have one and it will be good for a PC compatible multiscan monitor in the future.

- Disadvantages: Not usable for booting and DOS applications. It may not be capable of generating composite sync or sync-on-green (if needed) without an adapter.

(From: Royce Liao (liaor@uci.edu).)

ALL modern video adapters (PCI/AGP) incorporate programmable dot clock generators. So *any* decent video card should be able to output the necessary scan-rate video signal. Unfortunately, unless you have access to a special refresh-rate utility, and you *know* the precise frequency, this info still won't help your situation.

Scitech Display Doctor has a Windows based display utility which works with majority of contemporary video cards. The control center lets you tweak video refresh rates down to 0.1Hz, and adjust H/V sync polarity.

Special Video Cards for Fixed Frequency Monitors

These are special video cards. You remove and mothball your current video card (if you already have one) and replace it with one of these. You then install the special video drivers (where required) supplied with the card.

Some models appear to be quite competitive in terms of graphics performance (Windows accelerated, etc.) so these may represent an attractive alternative even for high performance applications like Autocad.

After specifying the monitor type and/or scan rate parameters for your monitor, the behavior of the card should be essentially transparent to your software. That is, programs think they are talking to a VGA/SVGA card but the output of the card drives your fixed frequency workstation monitor properly at all times - including booting, DOS games, Windows, etc.

- Advantages: full DOS/Windows, possibly high performance (some models claim Windows accelerated video performance), drop-in solution (no adapters, circuits, cables, etc.).

- Disadvantages: cost if you already have an expensive video card, possible lack of wide or long term support (these are not exactly Fortune-500 companies).

Mirage and Photon appear to be the most well known of the companies providing fixed frequency video cards. However, there are others. The listing below is in alphabetical order and may change without prior notice :-). In other words, the position of any given company doesn't represent any sort of recommendation.

1. MaxVision
   Phone: 1-800-533-5805 ext. 202

2. Mirage Multimedia Systems, Inc.
   3457 A W. El Segundo Blvd.
   Hawthorne, CA 90250
   Phone: 1-800-228-3349, fax: 1-888-816-8324
   Email: info@mirage-mmc.com
   Web: http://www.mirage-mmc.com/

3. Mobius Trading Company
   Web: http://www.ioa.com:80/users/mobius/monitor.html

4. PCG Corporation (Photon)
   Phone: 1-800-255-9893
   Fax: 1-310-260-4744
   Email: sales@photonweb.com
   Web: http://www.photonweb.com/

5. Software Integrators Inc.
   851 Bridger Drive
   Suite 4

Bozeman, MT 59715
Phone: 1-800-547-2349 or 1-406-585-8866
Fax: 1-406-586-9145
Contact: Joe McCarthy
Email: mccarthy@si87.com or sales@si87.com
Web: http://www.si87.com/

6. STB Systems, Inc.
   Web: http://www.stb.com/
   FTP: ftp://ftp.stb.com/

7. UltraSpec Cables, Inc.
   Phone: 1-800-622-2537
   Web: http://www.ultraspec.com/

   Cables and adapters in addition to a PCI card for using a fixed frequency monitors on a PC.

8. Worldwyde.Com
   Phone: 1-248-473-1182
   Email: sales@worldwyde.com
   Web: http://www.worldwyde.com/

Then Again, Maybe it Will Work

Having been told by all the experts that his monitor was fixed frequency and a pain to use:

(From: Malik (psxpic@malik.eng.net).)

Against all odds i thought what the hell and tried it anyway... And hey, presto! it works perfectly, no problems.

I had to feed a vertical sync into the monitor which would not have been possible because the feed for this was not present on the plug. However it was possible to remove one of the unwanted wires in the RGB lead and reconnect it to the unused Vsync input.

It appears Sony just fit the appropriate lead/connectors to the monitor depending on its purpose then badge it for Sun, etc.

The model number is GDM-17E20 its absolutely a superb monitor... If you can get one I suggest you do.

I know there is a 17E10 and 17E11 that are older.... the situation maybe the same with these.

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Web Information

General Video Card and Monitor Information

Here are some on-line sources of information relating to monitors, video cards, and fixed frequecy monitors issues:

- The Fixed frequency monitor FAQ and Sync-on-green FAQ are available at:
  - The Sci.Electronics.Repair FAQ
- Some other sites with information and links relating to fixed frequency monitors (in no particular order):
  - http://saturn.tlug.org/sunstuff/ffmonitor.html (Using a Fixed-Frequency Monitor on a PC)
  - http://www.devo.com/video/ (Fixed Frequency Video FAQ).
  - http://www.sunhelp.org/ (SunHELP)
  - http://cvs.anu.edu.au/monitorconversion (Use your old Workstation Monitors with Linux/XFree86)
  - http://sdss.ucsd.edu/~jesus/ibm.htm (Fixed frequency Monitor Info)
  - http://www.geocities.com/SiliconValley/Foothills/4467/fixedsync.html (Connecting the SONY GDM-1960/GDM-1961 to a PC)
  - http://wmad95.mathematik.uni-wuerzburg.de/~buckel/projects/schalt.html (How to Connect a Fixed Frequency Monitor to a PC Running Linux)
  - http://www.llamacom.com/~joebuck/c2746a.htm (Using a Hewlett Packard C2746A workstation monitor with a PC)
  - http://grafi.ii.pw.edu.pl/gbm/matrox/nonvgamon.html (Using Matrox cards with non-VGA monitors)
- The Comp.sys.ibm.pc.hardware.video FAQ includes a lot of general information as well as some directly related to fixed frequency monitors:

  The FAQ has received news.answers approval, so it should be archived at rtfm.mit.edu and all mirrors, as well as in news.answers and comp.answers. There used to be a Web site with the FAQ but it appears to have vanished.
- The following company sells various inexpensive fixed frequency monitors and video cards. I have not dealt with them so I have no idea of their quality or customer service.
  - Machias Computer Systems
    Phone: 1-207-546-3030
    Web: http://www.nemaine.com/~jims
- Ian's Fixed Frequency Monitor Conversion Page for the Sony GDM 1660 fixed frequency monitor. However, I wonder about the operation of this circuit and part values, particularly for the R and C on the V-Sync input.

Web Sites with Monitor Specifications

Check out the following when you have an SVGA, MAC, or workstation (possible fixed frequency) monitor and need to know its specifications (sites listed in alphabetical order):

- Computer Shopper (1994-1996)
- Griffin Technology
- Monitor World
- Rasterstone
- Table of monitor specs
- Linux/XFree86 Monitor Database
- Links (mostly the same as those above)

Some of these are companies that sell various video products that may be useful. However, I am only recommending these sites for the information on monitor specifications. Note that since this data comes from undetermined sources, it isn't always to be accurate - check with more than one site to see if they agree. And, these Web sites come and go - I apologize for the likely broken links but believe it or not, I am not usually informed when any particular company goes belly-up or their Marketing department decides that fluff is more important than substance and they pull the plug on the pages with useful information. :(

Additional Fixed Frequency Monitor Information Links

(Some of these may be listed elsewhere in this document as well.)

(From: Tony Chau (tonychau@netcore.ca).)

- http://www.devo.com/video/
- http://www.nemaine.com/~jims/index.htm
- http://www.mirage-mmc.com/sony/
- http://www.mirage-mmc.com/leader.htm
- http://www.si87.com/
- http://www.ioa.com/users/mobius/monitor.html

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Miscellaneous Monitor Information

Tweaking the Deflection Rates of a Fixed Frequency Monitor

Pulling a fixed frequency monitor by more than a few percent will likely be a problem. I know this is not the answer you were looking for but getting a new inexpensive video card, video card designed for fixed frequency monitors, or new monitor, may be a better solution.

If you insist, the adjustment would be called something like horizontal oscillator, horizontal frequency, or horizontal hold. If you do tweak, mark everything beforehand just in case you need to get back to the original settings.

WARNING: Make sure you understand the issues involved in working inside a monitor! See the document: [Safety Guidelines for High Voltage and/or Line Powered Equipment](). Something that looks innocent can really ruin your whole day!

There is also some risk to the monitor - changing it too far may result in damage either immediately (the horizontal output transistor or power supply may blow) or increase component stress reducing reliability and shortening its life. There is no way to know without looking at the design.

IBM 6091 Monitor Information

(From: Richard Shima (RShima@att.net).)

The IBM (Sony?) display 6091-19 is a 5-BNC type, and is, indeed, a fixed frequency type. Therefore, you'll need certain special modes available in a display adapter to accommodate it, beside the correct cable, of course.

I'm pretty certain that IBM 6091 was actually made by Sony, and, in their better displays, they still use the 5-BNC (separate signal) video cable, i.e., on their current SE series, etc. I'm certain you could buy a Sony (or other) replacement cable that would do the job, tying your display to a PC-type 15-pin VGA/SVGA "D" video connector, once you know you have a video card that will support it.

(From: Justin Thiessen (thiessen@physics.arizona.edu).)

I *know* the officially sanctioned video modes for my version (the 6091-19 (_not_ the 6091-19i)) limit the refresh rate to 67 Hz, but the one I have happily syncs to quite a few non-standard modes:

```
#
# Following modelines are for linux and work under XFree86 3.3.6
#
# H - 69.84 kHz; V - 61.37 Hz; Pixel Clock 138 Mhz
# Generated by Colas XFree Modeline Generator
Modeline "1464x1098" 138 1464 1524 1844 1976 1098 1100 1112 1138 -hsync -vsync

# H - 71.15 kHz; V - 79.58 Hz; Pixel Clock 108 Mhz
# Borrowed from somewhere
Modeline "1152x864" 108.00 1152 1156 1300 1518 864 865 868 894 -hsync
-vsync

# H - 72.76 kHz; V - 59.84 Hz; Pixel Clock 78 Mhz
# Thrashed out on my own - small black space at sides of screen
Modeline "768x576" 78.00 768 792 888 1072 576 579 585 608 -hsync -vsync
DoubleScan

# H - 66.67 kHz; V - 66.14 Hz; Pixel Clock 64 Mhz
# Thrashed out on my own - almost fills screen
Modeline "640x480" 64.00 640 728 856 960 480 482 484 504 -hsync -vsync
DoubleScan
```

Note the use of the DoubleScan parameter on the last couple of modes, which just (as I understand) draws each scan line twice, allowing the use of (much) lower apparent modes than the 6091-19 is technically capable of displaying.

Also, if I'm clear on what's happening here, then the "real" pixel clocks for the last two modes are twice the number listed in the modeline. (Each line is drawn twice, therefore there are twice as many pixels actually being plotted as the modeline indicates, yielding double the clock.) Please correct me if I'm wrong on this. This indicates, however that the monitor is capable of handling signals with bandwidth up to 156 Mhz, quite a bit higher than its official rating.

And, truthfully, as much as I relish the real estate of the higher resolution modes, the actual dpi of the monitor combines with the relatively low refresh rates to make them a bit harder on the eyes than I'd prefer. The 1152x864 mode is (by my guess) probably the one best-suited to the actual physical limits of the monitor. If I manage to get 2nd monitor hooked up and running under X I'll probably drop both of them down to this relatively eye-friendly mode.

I still don't get a boot-up screen, nor do I ever expect to without some hardware hacking. The low-end modes are just fun for trying out games. Since my video card (ATI Xpert98) has an apparent text-mode dot clock limit of 60 Mhz (according to the SVGATextMode documentation), I haven't been able to get a text screen yet, although exploring the DoubleScan parameter in that context may eventually yield results.

Now I take no responsibility for just how strangely I have all the pots inside the monitor tweaked. I never use anything that doesn't function in "Mode 3", and if I do happen to flip the switch to Mode 1/Mode 2, any signal that actually resolves is, at best, displaced and suffers severe fish-eye effects, but in mode 3, my monitor looks pretty good for being 10 years old. I also have no idea how much I'm shortening the life of the monitor by running it at these scan rates, nor do I have any clue as to just how far over actual spec I'm pushing it. (Who knows what the internal Sony/IBM engineering specs were for this beast?) I'd give a lot for a manual, but such seem to be scarce for most of the old workstation monitors available.

As a side note, a great deal of info is available on the 6091-19 on a few web sites:

- Jonas Svensson's IBM 6091-019 FAQ or Info Page
- Joakim Wallman's IBM 6091 19" Color Monitor Page
- Sven Koelsch's IBM 6091/19 Fixed-Frequency Monitor Page

I also found the Colas Modeline Generator useful, although I created most of the modes I use by hand with the Xfree video timings HOWTO.

- Colas Modeline Generator

Well, I can't stop tinkering.

I still have a IBM 6091-19, though now it's the 2nd head of a dual-head setup, and in an effort to match up the capabilities of my two monitors, (gdm20e20 rebadged by sun + the 6091-19) I've scraped out a few more modelines to fit the VESA-standard resolutions.

Here are some more:

```
# V - 64 Hz
ModeLine "ibm1400x1050" 133.38 1400 1480 1800 1912 1050 1052 1064 1090
 -hsync -vsync

# V - 71.21 Hz
ModeLine "ibm1280x960" 122 1280 1324 1716 1720 960 963 974 996 -hsync -vsync

# V - 79.58 Hz
```

```
ModeLine "ibm1152x864" 108.00 1152 1172 1316 1518 864 865 868 894 -hsync -vsync

# V - 86.26 Hz
ModeLine "ibm1024x768" 103 1024 1124 1364 1500 768 770 782 796 -hsync -vsync

# V - 59.90 Hz
ModeLine "ibm800x600" 81 800 804 908 1080 600 604 622 626 -hsync -vsync
 DoubleScan
```

Including the modeline above for 640x480, these cover the VESA standard resolutions (though not at the suggested refresh rates) from 640x480 to 1152x864. Also included are a nice 1280x960 mode (with a desirable 4:3 pixel ratio) and a large but very readable 1400x1050 mode.

Note that all these modes fill the screen, with the exception of 1024x768, which has some (quite small) black space on the left and right, and 800x600, which has a slight bit more black space on the left and right, but is still quite usable.

I am now using a Matrox Millenium II to drive the monitor, if it is of any concern.

Using the IBM 6091 with Standard Video Cards

Using the IBM 6091 with the Cornerstone ImageAccel

(From: Helmut P. Einfalt (hp.einfalt@t-online.de).)

The IBM 6091-xx series can be driven by Cornerstone ImageAccel cards, at least by various ImageAccel 1 cards, including the MCA version MC1608C/11. And, above all, there are drivers for DOS, WfW, Win9x, NT3.51, *and* NT 4.0. A detailed account on how to install the MC1608C/11 and a 6091-19 (the procedure being the same for all other 6091s) can be found at

- Helmut's Cornerstone ImageAccel MC1608C/11 and the IBM 6091-19 Monitor Page.

Cirrus BIOS Modifications to use the IBM 6091-19i Monitor

(From: u1061771156@csi.com)

I've gone through the more interesting task of adjusting the BIOS ROM on my video card so the boot screen and DOS work nicely as well. (It's a Cirrus 5429 based card). I still have the Vesa modes to fix, next weekend maybe. ;-)

The IBM 6091-19i has 4 modes of operation (1-4). The first three are based around 1024 lines of vertical resolution and are good for "desktop" use (I'm using the 1024x1024 mode under X as you can't get much more that 1024 Pels across with a 5429 since it's limited to 85MHz clock. As I currently only have 1M ram that fits neatly with 8bpp too.)

Mode 4 (the mode that was introduced new with the 6091-19i and was not supported in the old 6091-19) is more interesting for VGA use. It runs 63 kHz horizontal rate, and 120 Hz vertical rate, with a vertical total of 528. This is a similar geometry to the VGA modes, except about twice the rates. In practice I find the monitor will sync quite happily with vertical frequencies of 120 to 140 Hz and a bit beyond. (Incidentally this mode was originally intended for 3-D viewing with LCD shutter glasses synced to the vertical, and left/right images displayed on alternate frames by software.)

So the first step was to double the Pel clock (and hence all timings). After some serious disassembly, I found the first three PLL multiplier/divisor values for the Pel clocks are in a little table. The table contains the six values: 4A 2B 5B 2F 42 1F. For the particular BIOS version I have (CL-GD5429 Bios Version 1.00a) this is at BIOS address 0812, on an older BIOS, I found the same table with the same values at a slightly different address. If you do a search in any Cirrus 542X rom it's probably there somewhere. Paraphrasing a little (see the .pdf on the Cirrus Website) the Pel clock is generated by taking a 14.318 MHz crystal, and multiplying it by the first value and dividing by the second (ignoring the bottom bit) e.g. the first is 14.318*74/42 = 25.22 MHz and the second is 14.318*91/46=28.32 MHz. The bottom bit of the denominator byte is a "divide by 2" bit, if cleared the frequency is doubled. That's so convenient!! Hence step one is to clear these bottom bits, making the table into 4A 2A 5B 2E 42 1E and magically the monitor syncs up in all VGA modes!

(There are a few peculiarities to note when actually editing the EPROM. Firstly, like all Bios extension ROMs, there is a checksum at the end so the sum of all bytes in the rom is zero. Hence you have to add 3 to this to make the checksum correct. Secondly, the EPROM is a 27C512-150 which is 64Kx8 when the Bios is only 32K. There are two identical copies in it, only the later one is used as the A15 pin is wired high on the adapter card. Thirdly, and most annoyingly, the PC address line A0 is connected to eprom pin A14, and all the others shift down one. So Bios location 0812 (hex) is in the eprom at address 8409 when it's on the programmer. Why on earth did they do that?!)

If all you want is to be able to see your boot messages, this could be enough. However the image is a few columns too wide for the screen so you can't see both sides at the same time (the front panel control lets you move it side to side a bit.) So I've increased the frequencies a little more to make the Pels closer together. The table I'm currently running with contains 51 2A 62 2E 47 1E To maintain the correct scan rates and centering one has to increase the vertical total (CRTC register 0) as well as these frequency tweaks. This meant finding the VGA CRTC mode tables, a search for 2D 27 28 90 2B A0 finds the first one (mode 0 40x25 text). Each mode table (there are 1D of them) follows in steps of 40 hex bytes. Some experimentation showed that there are 3 different timings to change:

```
Modes starting 2D xx xx xx xx A0   I changed to 31 xx xx xx xx B1
Modes starting 2D xx xx xx xx 80   I changed to 32 xx xx xx xx B1
Modes starting 5F                  I changed to 66
```

With these changes, all VGA modes produce a nicely centered image that is close to filling the screen (about 1cm black top and bottom).

There are a few mode tables that didn't start 2D or 5F which I have left alone for now, and affect Vesa modes, and there are other vesa tables elsewhere in the eprom that ought to be changed one day.

Note: I've been working on a Cirrus 5429 chip. Doing the same with a 5428 gave somewhat erratic results (shimmering characters) sometimes. I think this is due to the Sequencer(0x1F) register which sets the memory clock rate being initialized slower on the 5428 (1E versus 22 hex) so it's failing to get enough bytes out of ram in time to display. 22 is out of spec range for the 5428 but putting it up to that as an experiment seemed to fix it. ;-) I didn't find where that register is loaded in the EPROM though, but that fix is fine for a little DOS program to fiddle the modes. As I intend using the 5429 I haven't pursued it any further.

The only obvious side effect I'm left with is that the cursor flashes too fast. I can live with that! ;-) Maybe there's a register somewhere to fix that too?

Of course any noxious game that meddle with the registers direct may well screw up (but note that the Pel divisor registers are not part of regular VGA so may survive.)

I note that sync polarity doesn't affect the monitor at all. I guess its circuits accept either polarity and invert if necessary. Also, sync rates out of range don't appear to damage the monitor, it just loses sync quietly and the picture goes haywire. ;-)

I have the original "User Guide" and "Maintenance Guide" books which makes life a lot easier.

P.S. I see that the IBM 9517 can do 1024x768 if you can get to 85Hz vertical interlaced, maybe starting with a 1240x768 interlaced mode and fiddling the frequency up in a similar way that I did would work for the original question? Of course interlaced modes are yucky unless you're viewing images...

Comments on IBM 9515 Monitor

(From: Peter Duck (pduck@zetnet.co.uk).)

This monitor is not VGA/SVGA but XGA2, as used in IBM PCs with the short-lived MCA bus.

There are said to be ISA (PCI?) cards that drive them, but a friend (ironically, ex-IBM, but not the 'toy computer' end) who bought a stack of the monitors cheap never found any.

It is near-enough to impossible to convert 'properly' and can't be made to run at the 31.5 start-up scan-rate without the HOT (Horizontal Output Transistor) dropping dead.

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Complete Plans for Sync-on-Green Adapter

Sync-on-Green Adapter Description

Here, courtesy of Berg Hawkins, are complete plans for a cable adapter to convert separate H and V sync to the requirements of many common fixed frequency monitors. This approach uses a programmable logic device (GAL) to implement the function. For an alternative using discrete logic, see the document: Notes on Video Conversion in the section "Notes on VGA to RGB Conversion".

Note that he also sells both the cable as well as just the required GAL (CMOS programmable logic device) already programmed so providing this information is truly in the spirit of these FAQs and the "open source movement". Thanks. However, purchasing the completed unit may indeed be the best use of your resources.

(From: Berg Hawkins.)

I sell a sync-on-green cable for single frequency monitors. It is $75 and will run any of a half dozen monitors from most standard video cards on the PC and Macintosh G3/G4. The cable contains a chip, a CMOS GAL programmed with the appropriate equations. It fits in a plastic housing that goes over/around a 15 pin VGA connector which plugs into the video card. A source of +5 VDC from a Molex connector tied to one of the power supply outputs on the PC drive it.

I have been selling it for about 7 years and have done hundreds of monitors. The equations are free, so is the schematic. I will even mail the programmed chips to anyone who does not have a GAL programmer for a small fee.

The best is to buy the whole cable since it takes me about 45 minutes to make one and involves some close-in soldering work.

I have done Sony GDM1950s, Hitachi 4119s and CM2086s, IBM 6091s and other monitors.

Important note: This setup WILL NOT allow DOS full screen or most video games or DVDs to be played, all other Windows applications will work with most any video card.

The equations are included in the .PDS file, they go right into the AMD PALASM compiler and have been tested. The output of the compiler is in the .JED file, this is what is fed to the PAL programmer. It has also been tested. Note that ONLY CMOS GALs such as 16V8s are to be used since the circuit needs to SOURCE a few milliamps into the GREEN color output. This is done by means of an approximately 330-360 Ohm resistor (1/4 Watt) connected between pin 12 of the GAL and the GREEN video signal. One weakness of this circuit is that power from a 4 pin Molex connector on the PC's power supply output needs to be applied to pin 20 of the GAL. Also note that power to the chip MUST be applied BEFORE a signal is input, otherwise the chip can latchup and be damaged. This is accomplished by connecting the power Molex connector while the PC is powered off, then plugging in the VGA connector at any time.

Any speed 16V8 can be used, down to -25 parts, speed is not critical.

A crude diagram showing the chip, the VGA connector and the BNCs is included in the file diagram.txt.

It is best if all unused GAL inputs are connected to ground. I can program and mail the 16V8 chip and the 330 Ohm resistor for $5. I sell the complete cable for $75 (recommended since it takes me about 45 minutes to make one - I have been making these for 7 years and have some experience in this. It involves some close-in soldering work.

I also sell 20" single-frequency monitors, refurbished and tested for $200 to $250 with 6 month warranty.

The chip can be used without the resistor if composite sync is needed (a small minority of monitors will not sync-on-green, in this case connect pin 12 directly to the horizontal sync input of the monitor. Some monitors need POSITIVE composite sync, in this case pin 13 can be output to the composite sync of the monitor. In either of the 2 above cases, 4 BNCs will be needed instead of 3.

I have also successfully used this circuit to connect to monitors under Linux. Macintosh PCs also work, including PowerMacs, G3s and G4s. Over 8 types of 17" and 20" single-frequency monitors have been successfully driven by this circuit.

Send me email if you have problems syncing up a monitor. My phone number is 1-310-839-6430 in Los Angeles.

Sync-on-Green Adapter Schematic

```
VGA Connector                                                    Coaxes
from PC video card                                               to Monitor
Pin

 1 -------------------------------------------------------------> RED
 2 ---------------------------------------------------+-----------> GREEN
 3 ---------------------------------------------------|-----------> BLUE
 4 NC                                                 |
```

```
 5 ---------+                                       |
 6 ---------|---------------------------------------|-----------> RED RETURN
 7 ---------|---------------------------------------|-----------> GREEN RETURN
 8 ---------|---------------------------------------|-----------> BLUE RETURN
 9 NC       |                                       |
10 NC       |                                      / 330 Ohm to
11 NC       |                                      \ 360 Ohm
12 NC       |                                      / 1/4 Watt
            |              To +5V from PC >----+   |
            |              4 pin Molex conn.   |   |
            |                     +----U----+ |   |   Top of chip
13 --------------------------------|1      20|-+   |   has notch
14 --------------------------------|2      19|- NC |   indicated by U
 To Pin10 (+sync) OR Pin20 (-sync) -|3   1  18|- NC |
 To Pin10 (+sync) OR Pin20 (-sync) -|4   6  17|- NC |
15 NC       |                 GND -|5   V  16|- NC |
            |                 GND -|6   8  15|- NC |
            |                 GND -|7      14|- NC |
            |                 GND -|8      13|-    | Use pin 13 for +Csync
            |                 GND -|9      12|-----+ Use pin 12 for -Csync
            +-----------------------|10     11|- GND
                                    +---------+
```

Sync-on-Green Adapter GAL PALASM File

```
;PALASM Design Description

TITLE    HVB2G2.PDS
PATTERN  A
REVISION 3.0
AUTHOR   Berg Hawkins, 1-310-839-6430, Los Angeles.
COMPANY
DATE     8/21/96

CHIP VIDEO_SYNC PAL16V8

; POS/NEG SEPARATE INPUT(selected with POL).
; SYNC ON GREEN OUTPUT, connect to the GREEN video output
; (pin 2 on VGA connector) through a 330-360 Ohm 1/4 watt resistor.
; Pin 12 can also drive separate/composite sync input directly, i.e.
; Hitachi 4119
;
; Histor
; HVB2G0.pds:   Initial design
; HVB2G1.pds:   removed extra 3 outputs, added LED output to pull down LED
; HVB2G2.pds:   Added separate sync polarity control for H/V sync this takes
                care of NEW Cirrus Logic CLMODE (i.e., H- V+)

PIN  1    HSYNC     COMBINATORIAL  ; Horizontal sync input from VGA pin 13
PIN  2    VSYNC     COMBINATORIAL  ; Vertical sync input from VGA pin 14
```

```
PIN  3    POLH      COMBINATORIAL  ; Polarity control for horizontal sync
PIN  4    POLV      COMBINATORIAL  ; Polarity control for vertical sync
PIN  10   GND                      ; Connect to pin 5 of the VGA connector

PIN  12   SYNC_ON_GREEN1 COMBINATORIAL  ; composite sync or sync-on-green out,
                        ; OUTPUT can also drive a composite sync input on the
                        ; monitor directly

PIN  13   LED       COMBINATORIAL  ; drives LED, active low when OK, can also
                        ; be used to sync monitors that need POSITIVE composite
                        ; sync input

PIN  20   VCC   ; Connect +5 VDC from the PC's power output (red cable) INPUT

;------------------------- Boolean Equation Segment ------------------

EQUATIONS

SYNC_ON_GREEN1 = /HSYNC*/POLH*/VSYNC*/POLV + /HSYNC*/POLH* VSYNC* POLV +
                 HSYNC* POLH*/VSYNC*/POLV +  HSYNC* POLH* VSYNC* POLV

LED            = /SYNC_ON_GREEN1

;----------------------------------- Simulation Segment ------------
SIMULATION
TRACE_ON SYNC_ON_GREEN1 HSYNC VSYNC LED POLV POLH

SETF   /HSYNC /VSYNC POLH POLV
CHECK  /SYNC_ON_GREEN1 LED

SETF    HSYNC /VSYNC POLH
CHECK  /SYNC_ON_GREEN1 LED

SETF   /HSYNC VSYNC=20
CHECK  /SYNC_ON_GREEN1 LED

SETF    HSYNC VSYNC POLH POLV
CHECK   SYNC_ON_GREEN1 /LED

SETF   /HSYNC /VSYNC /POLH /POLV
CHECK  SYNC_ON_GREEN1 /LED

SETF    HSYNC /VSYNC
CHECK  /SYNC_ON_GREEN1 LED

SETF   /HSYNC  VSYNC
CHECK  /SYNC_ON_GREEN1 LED

SETF    HSYNC  VSYNC
CHECK   /SYNC_ON_GREEN1 LED

TRACE_OFF
```

Sync-on-Green Adapter GAL JEDEC Fuse Map

PALASM4 PAL ASSEMBLER   - MARKET RELEASE 1.5a (8-20-92)


```
TITLE   :HVB2G2.PDS                  AUTHOR : Berg Hawkins, 1-310-839-6430
PATTERN :A                           COMPANY:
REVISION:3.0                         DATE   :8/21/96

PAL16V8
VIDEO_SYNC*
QP20*
QF2194*
G0*F0*
L0000 00000000000000000000000000000000*
L0032 00000000000000000000000000000000*
L0064 00000000000000000000000000000000*
L0096 00000000000000000000000000000000*
L0128 00000000000000000000000000000000*
L0160 00000000000000000000000000000000*
L0192 00000000000000000000000000000000*
L0224 00000000000000000000000000000000*
L0256 00000000000000000000000000000000*
L0288 00000000000000000000000000000000*
L0320 00000000000000000000000000000000*
L0352 00000000000000000000000000000000*
L0384 00000000000000000000000000000000*
L0416 00000000000000000000000000000000*
L0448 00000000000000000000000000000000*
L0480 00000000000000000000000000000000*
L0512 00000000000000000000000000000000*
L0544 00000000000000000000000000000000*
L0576 00000000000000000000000000000000*
L0608 00000000000000000000000000000000*
L0640 00000000000000000000000000000000*
L0672 00000000000000000000000000000000*
L0704 00000000000000000000000000000000*
L0736 00000000000000000000000000000000*
L0768 00000000000000000000000000000000*
L0800 00000000000000000000000000000000*
L0832 00000000000000000000000000000000*
L0864 00000000000000000000000000000000*
L0896 00000000000000000000000000000000*
L0928 00000000000000000000000000000000*
L0960 00000000000000000000000000000000*
L0992 00000000000000000000000000000000*
L1024 00000000000000000000000000000000*
L1056 00000000000000000000000000000000*
L1088 00000000000000000000000000000000*
L1120 00000000000000000000000000000000*
L1152 00000000000000000000000000000000*
```

```
L1184 00000000000000000000000000000000*
L1216 00000000000000000000000000000000*
L1248 00000000000000000000000000000000*
L1280 00000000000000000000000000000000*
L1312 00000000000000000000000000000000*
L1344 00000000000000000000000000000000*
L1376 00000000000000000000000000000000*
L1408 00000000000000000000000000000000*
L1440 00000000000000000000000000000000*
L1472 00000000000000000000000000000000*
L1504 00000000000000000000000000000000*
L1536 11111111111111111111111111101111*
L1568 00000000000000000000000000000000*
L1600 00000000000000000000000000000000*
L1632 00000000000000000000000000000000*
L1664 00000000000000000000000000000000*
L1696 00000000000000000000000000000000*
L1728 00000000000000000000000000000000*
L1760 00000000000000000000000000000000*
L1792 01010111011111111111111111111111*
L1824 01101011011111111111111111111111*
L1856 10010111101111111111111111111111*
L1888 10101011101111111111111111111111*
L1920 00000000000000000000000000000000*
L1952 00000000000000000000000000000000*
L1984 00000000000000000000000000000000*
L2016 00000000000000000000000000000000*
L2048 11111111000000000000000000000000*
L2080 00000000000000000000000000000000*
L2112 00000000111111001111111111111111*
L2144 11111111111111111111111111111111*
L2176 111111111111111110*
C1C97*
0D34
```

(Checksum may be incorrect - a character was included that doesn't display properly.)

- Back to FF Mon FAQ Table of Contents.

Case Studies - Using, Modifying, Adapting Fixed Frequency Monitors

Steve's Experience With a Special Video Card

As noted below, this is an experience with one particular video card - I don't even know which one or how old it was. Thus, these comments should only be used as an indication of what kinds of questions to ask when selecting a card and the possible problems you may encounter.

(From: Steven Leinwand (steve_leinwand@hp.com).)

It is true that the most expensive solution (a special video card) is usually the best solution. I bought one a while back, and in the interest of 'truth in advertising' let me describe some of the drawbacks you will experience. In all fairness, I will mention that I haven't tried all the video boards out there, and am basing my comments entirely on my experience. Your mileage may vary.

Fixed frequency monitors like those commonly supplied with Sun workstations cannot change video modes like multiscan monitors. In order to get them to work in DOS modes, video card vendors like Mirage and Photon modify the VGA bios on their cards to 'emulate' *some* DOS modes at a fixed scan frequency. This works well in *some* modes, works poorly in others, and doesn't work at all in some.

These BIOS mods interfered with motherboard timing on two VLB motherboards. I tested it with four video cards, the problem was the VGA BIOS). Video wouldn't sync after warm-booting. I had to shut the machine off, and wait about 10 minutes. In all fairness, I have not heard of similar problems on ISA and/or PCI cards, so that problem may be on that vendor's VLB boards only.

It usually works best in Windows, where the display is always in the same graphics mode, and mode switching isn't an issue. It works for *some* DOS programs, depending on what video mode they try to put the display in. It works poorest on games, which seem to insist on using weird and/or undocumented VGA video modes. At least half my games either wouldn't work, or their image was so small, as to negate any benefit of having a large monitor.

** Modes less than the monitor resolution will usually be displayed at 1/2 the screen size of the monitor **

This was a surprise to me, and was never mentioned in any of the ads for video boards. I've been told this is a fact of physics, and cannot be overcome in fixed frequency monitors. (Editor's note: it can be overcome using a scan converter but this is much more complex than a BIOS change! See the "Notes on Video Conversion" document for further information on scan converters.)

I finally sold both monitor and video card, bit the bullet, and bought a 17" SVGA monitor and card. If I didn't have the VGA BIOS timing problems with the VLB version, I might have been able to re-use the video card, but was tired of the hassle. Since I got the monitor for free (obsolete product destined for the dumpster), it wasn't that bad. My advice is ask detailed questions before you buy, get a money-back guarantee, and test with all your applications. If you can't live with the results, exercise your guarantee.

Also check out support capabilities. One of those vendors I mentioned was very responsive and helpful. The other one started out awful, but made some progress in responsiveness over time.

Check and Dirty Way to Display Lower Resolutions on Fixed Frequency Monitor

(From: Karl Ivar Dahl (karl_ivar.dahl@capgemini.no).)

I have a SONY GDM-1961 (a.k.a. VRT 19-HA) fixed frequency (sync-on-green) monitor. This monitor displays 1280x1024, but I have recently been able to tweak it to display 1024x768, 800x600, and 640x480!

So now I can play Quake full screen under NT and Linux :-)

The clue is to reduce the visible resolution and add the missing pixels to the front and back porch. The image of course doesn't fill the entire screen, but it's a *lot* better than having none at all.

I have made a page with my experiences with making a fixed-sync monitor work on linux, NT and win95 to help others with access to these extraordinarily cheap and large workstation monitors:

- Connecting the SONY GDM-1961 to a PC

Using IBM 6091 Monitor on PC

(From: Wayne Rothermich (wayne@utilicom.com))

I had to learn what signals my IBM 6091 monitor wanted versus what signals my video card provided by experimenting with a scope and a pulse generator for a day or so. In my case, the monitor wanted inverted polarity on the horizontal sync line. I found that I could provide this by triggering a lab pulse generator from the video card's horizontal sync output, and using the resulting (inverted) pulse to sync the monitor. Fortunately, the timing jitter in the pulse generator was low enough that no horizontal jitter was noticeable on the display.

I used the monitor this (rather nerdy) way for a while, and then I noticed a small ad in Nuts and Volts magazine for a moderate cost ($200) translating video card made by a company called Ming. I ordered one, and it turned out to be a modified (new video BIOS chip, a few wire jumpers) Jaton 58P card, which uses the Tseng Labs ET6000 chip.

This has proven to be a good solution to my fixed frequency monitor problem. I ran comparative benchmarks using the Landmark PCPRO test program, and the speed of this card - when writing to video RAM - is similar to other high performance (Matrox Millenium 2, Diamond Stealth 3D 2000), cards I have tested recently. Ming makes cards for several different fixed frequency monitors, so they could be a viable choice for many of your readers. You can check their web page at http://www.riverside.quik.com/ming for more details. (From: Fabio Quenel (info@tesitalia.it).) I've managed to get this monitor to work in Windows98 at 1152x864, 76 Hz, in true color (24 bit) with a 4 MB Matrox Mistique card (170 Mhz RAMDAC). I had tried with the 1280X1024 resolution but the refresh was 67 Hz and it really was straining for my eyes (also the definition lacked a bit). In DOS mode the monitor doesn't work and I don't know if thare is a way (if you know please tell me).

(From: Sam).

> Since the 6091's lowest horizontal scan rate is 63 kHz, you would need over a 120 Hz vertical scan rate for the 640x400 boot screen. Even if you could set up your video card for 120 Hz or more refresh, the 6091 almost certainly won't work at too much beyond its 67 Hz vertical scan rate specification.

Here is what my mga.mon file of the Matrox seems like:

```
[User-Defined.Customized IBM 6091 Mode 3 new]
1280X1024 = NI, *User-Defined_Customized_IBM_6091_Mode_3_new_,(1280X1024)
1152X864 = NI, *User-Defined_Customized_IBM_6091_Mode_3_new_,(1152X864)
1024X768 = NI, *User-Defined_Customized_IBM_6091_Mode_3_new_,(1024X768)

[*User-Defined_Customized_IBM_6091_Mode_3_new_,(1280X1024)]
PIXEL_CLK = 119089
H_DISP = 1280
H_FPORCH = 16
```

```
H_SYNC = 160
H_BPORCH = 240
H_SYNC_POL = 0
V_DISP = 1024
V_FPORCH = 3
V_SYNC = 3
V_BPORCH = 18
V_SYNC_POL = 0
INTERLACE_ENABLE = 0

[*User-Defined_Customized_IBM_6091_Mode_3_new_,(1152X864)]
PIXEL_CLK = 112064
H_DISP = 1152
H_FPORCH = 72
H_SYNC = 96
H_BPORCH = 288
H_SYNC_POL = 0
V_DISP = 864
V_FPORCH = 2
V_SYNC = 15
V_BPORCH = 36
V_SYNC_POL = 0
INTERLACE_ENABLE = 0

[*User-Defined_Customized_IBM_6091_Mode_3_new_,(1024X768)]
PIXEL_CLK = 94252
H_DISP = 1024
H_FPORCH = 32
H_SYNC = 192
H_BPORCH = 128
H_SYNC_POL = 0
V_DISP = 768
V_FPORCH = 11
V_SYNC = 15
V_BPORCH = 33
V_SYNC_POL = 0
INTERLACE_ENABLE = 0
```

Modifying an IBM 9517 XGA Monitor for SVGA Operation

(From Arnoud van der Wel (a.p.vanderwel@student.utwente.nl).)

Well, I did this to two of them about a year ago. Of course I wrote down what I did, so I'll try to reconstruct for you what I did.

There are two modifications, one is the H-FREQ control, the other is the H SHIFT VGA control.

To boot, you need it to display the standard 31.5 kHz VGA text mode.

Turning the H FREQ pot (on the rear edge of the PCB) will eventually give you a display, but it is off-screen to the right. You then adjust the H SHIFT VGA pot (on the right of the PCB) and find that this pot has insufficient range to center the display. The H FREQ pot is 4.7K from the factory. It is in series with an 18K SMD resistor on the solder side of the PCB. I found that I had to turn the 4.7K pot to max resistance to move the display to the left, so I removed the 18K resistor and the 4.7K pot, and replaced them with a 22K resistor and a 10K pot.

I was then able to center the display for text mode. The only problem is that the horizontal linearity in text mode is now off. The letters near the right of the screen are narrower than elsewhere. The problem is not serious (a casual observer does not see it) so I can live with that. Moreover, I never use text mode anyway (except during booting and for BIOS setup, etc.) The 320*200 mode (games) also works correctly after this modification.

Now, we want it to sync to highter refresh rates, specifically, 1024*768. That is the mode I adjusted it for. All the 1024*768 parameters are separately adjustable from the ones for the other modes, except the H FREQ. The pots that govern this mode are all labeled "4,5", meaning, I presume, that they govern the operation of what the monitor manufacturer calls mode 4 and mode 5. I found these to coincide with H frequencies of over approximately 50 kHz.

I found that by tweaking the H freq, I could get the text mode to be all right, *or* the 1024 mode, but not both at the same time. (BTW, I run 1024 with a pixel clock of 77 MHz, H freq. of 57.63, and V freq. of 68.13 Hz. I don't know what the specs for this monitor are, so I thought it was prudent to stay on the low side.)

So I needed two instead of one H FREQ pots. I also found that there is a relay click if you throw something over 50 kHz at this monitor. Hence, I tapped the relay coil to give me the 0/12 volt signal to tell me what mode the monitor is displaying. This signal I take to a little PCB that holds my two H FREQ pots, an inverter, and two NPN transistors that switch in one or the other pot instead of the original one.

The schematic is shown in ASCII below. Or, see the Gif version provided by: Puiu Chiselita (puiu@microinfo.logicnet.ro).

```
                                           TO H-FREQ
                                               o
                                               |
                              +12 VDC   +------+-----+
                                 o      |            |
                                 |      /            /
                                 |      \ 680    680 \
                                 |      /            /
               100K  1N4148    |/ E     |            |
  RELAY o---+--/\/\--|<|--|<|--|    PNP +--+      +--+
            |          1N4148  |\ C     |  |      |  |
            |                    |      /  |      |  /
            |                    / 2.5K \<-+      +->\ 2.5K
            |              100K \      /            /
            |                    /      |            |
            |                    |    |/ C          C \|    1N4148 100K
            |                    +----|    NPN   NPN   |---+--|<|--/\/\--+
            |                    |    |\ E          E /|   |             |
            |                    /      |            |     /             |
            |              100K \      |            |     \ 100K        |
            |                    /      |            |     /             |
            |                    |      |            |     |             |
```

```
|                              +------+------+-----+-----+                |
|                                           _|_ Gnd                         |
|                                            -                              |
+---------------------------------------------------------------------------+
```

Transistors can be any general purpose type:

- Typical NPN: 2N2222, 2N3904, BC547.
- Typical PNP: 2N2907, 2N3906, BC557.

I added the diodes to make sure we have a real OR circuit here, not a bit of AND left in it, since that would (albeit momentarily) drive the H FREQ up way too high and send the monitor into its OV protection.

Now I can tweak the H FREQ pot for both modes separately. To sum up, my 9517 now displays VGA text modes, 320*200, and 1024*768 in approx 70 Hz. When it is warm, I can also get it to display 640*480. I could probably do a fix for that too, but haven't bothered since I don't need that mode. Moreover, I don'thave schematics, so I'm a bit hesitant to continue modifying it, when it already works adequately for my use right now. The H linearity in the 320 and 1024 modes, by the way, exhibits no problems.

This solved monitor number one, and oddly enough, when I did monitor number two. I was able to get it working after installing only mod number one. A little help from the VGA card (Diamond Speedstar if I remember correctly) did the rest. So maybe you are in luck and need only one mod. A flexible VGA card definitely helps. (Or good setup-software for the VGA card.)

When you are turning all the little presets, be careful not to short the wipers to the chassis... use a plastic tool! The wipers are not insulated from the screwdriver slots. You can easily destroy some of the SMD transistors by doing that. That's what I did, and I had some VERY lucky guesswork in unsoldering them and replacing them by normal transistors (that is what I tend to do when I find a dead SMD transistor...)

These are beautiful monitors and well worth modifying. Fortunately, not a lot of people are able to do this, and this means that they are available rather cheaply. :)

SVGA to Sun Fixed frequency Monitor - Complete Solution

Here is a success story for the Sun 21" fixed frequency color monitor. The only active part in the circuit is a 74HCT86 quad XOR chip. Only one XOR gate is used - to combine H and V sync. All the other signals are wired through to the monitor (using RG59, 75 ohm coax for each of the RGB videos.)

(From: Ken Jones (k.jones@coastlight.com).)

Disclaimer: I will not be responsible for any damage to your monitor or ego that might be caused by the use of this circuit.

I don't know if this works with all VGA Cards. I've tested this with my Matrox Millenium and Mystique VGA Card, and it worked well. But there is a tricky part!!! For all those, who are trying this circuit with their Matrox Card, be sure to accomplish the following steps:

1. Buy all the needed hardware parts - 74HCT86 (TTL-XOR), 0.1uF Capacitor, Print, HF-Box - and assemble it. I use a small HF-Box, to eliminate interference problems. Be sure to make all wires as short as possible!

2. In Win95, go to the Display Properties:

    - Select MGA-Monitor Panel.
    - Choose a Monitor which can Display 1152x864. (Hitachi CM2111 for example)
    - Select this Monitor, and press 'Properties'.
    - Now select 1152x864x256 or 1152x864x65535 (as you like) and press 'Apply'.
    - Select the MGA-Settings Panel and increase the Display-Area to 1152x864 too. Press 'Apply' and reboot Win95.

    Now, your Monitor could work. If not, (as it happened to me...) do the following:

3. Go to the Display-Properties again:

    - Select MGA-Monitor Panel.
    - There is a Button named 'TEST!'. (First it was grayed out). Press it. (What for?.. Well, read on)
    - A Monitor Test-Pattern should appear, nothing special, but there is a small Button, called 'DETAILS'. This is the key for all...
    - Press 'DETAILS' and a new form appears. Now you can choose Sync-Negotiation, Vertical, and Horizontal, Refresh-Rates, etc., etc... (AHA!)
    - Set all you need to get your Monitor running. (In my case I changed the horizontal refresh rate to 71 kHz)

Using a Sony GDM-1950 Monitor on a PC

(From: Ross (rross@hotkey.net.au).)

I've had one of these working on a PC. From memory, the refresh rate is 1280x1024 at 60 Hz (therefore pretty crappy). You can either use a fixed frequency video card (expensive) or as I did, a Matrox Millenium which allows custom refresh rates in 1 Hz increments. Simply set up the computer on another monitor, and plug in the GDM-1950. The cable should not be a problem, easy to get here in Australia, so no problems in the states.

(From: Bill (bill_h@azstarnet.com).)

I have one - seems to me it was around 72 kHz/75 Hz refresh, but I'd have to check to be sure. I use a Quantum128 (costs around $150) but comes with a $30 adapter (Griffin Technologies) that makes the sync_on_green (this would be for 3 BNC type monitors) AND Composite sync (for the 4 BNC type monitors). You don't need this adapter if you're planning to use only the GDM-1950. If you buy the board, I'd be sure to get this adapter anyway. It comes in handy for checking the 'other' types of fixed frequency monitors.

The cable you need is pretty simple - just 'normal' VGA to the 5 BNC's.

This same cable is/was used on some sort of MAC's, and I found one in the close-out pile of a retailer dropping MAC's (for ten bucks).

(From: Joe McCarthy (mccarthy@si87.com).)

The GDM-1950 was sold by Sony to many different OEMs. The standard GDM-1950 is a 64 kHz, 60 Hz monitor designed to run 1280x1024 resolution. Radius bought a lot of these monitors and tweaked them to the MAC frequency of 63 kHz, 75 Hz, at 1024x768.

SVGA to Sun/Sony GDM-1960

(From: Flupke ut Warns (P.O.Langemeijer@student.utwente.nl).)

The most important thing is to get the sync pin(s) connected and the horizontal scan rate as close to the required value.

There is much more info and links at:

- http://www.geocities.com/SiliconValley/Foothills/4467/fixedsync.html

(From Paul Langemeijer).

If you have a GDM-1960, you can make an even easier modification to the monitor. A thing I might add to the problem of the sync-on-green, is the 'modifying' of your monitor. Well actually it isn't that hard. If you remove some of the panels (the one near the connectors with the monitor turned off!), I found holes for two more BNC connectors. You can put them in, attach a bridge and put in two resistors (the holes for these are obvious, the numbers are above them). And you've got a 5-BNC monitor (and it works). You should use 75 Ohm resistors and the monitor syncs perfectly at 1024*768 at 85 Hz (Standard VESA videomode).

(From: Pascal Specht (specht@roguewave.fr).)

I'm now running the GDM-1960 from my DECstation 5000 on my PC.

I found an even easier way (if you can live without the three VIDEO OUT BNC's). Simply reuse two of them for H and V-sync - No resistors, no holes to bore. This applies to my Digital GDM-1960 D3. Simply follow up the cables going from these 'video out' BNC's and take them off at the other end. Put these ends now into the obvious holes for the two predesigned places intended to take in the missing BNC connectors. Add the bridge to make the HSync connected. That's it. It perfectly works on my nVidia RIVA 128 with 1024x768 at 85 Hz, but also 1280x1024 at 60 Hz.

Sun 365-1335 or Sony GDM-20E20 monitor on PC

(From: Anders Stenkvist (Anders.Stenkvist@uab.ericsson.se).)

I just wanted to share some info about a Sun monitor I recently acquired. It's one of the new 20" multisync monitors you get together with Ultras with part number 365-1335 or GDM-20E20 made by Sony. Searching the net told me it should be possible to connect it to my PC but gave no info on how. So, armed with a screwdriver, an soldering iron and a lot of curiosity a started to investigate my new monitor, and after some iterations I got the following "new" pinout of the 13W3 connector.

```
    Analog:  13W3 connector:

          +-----------------
          |   +-------------
          |   |   +---------
          |   |   |   +-----
          |   |   |   |   +-   horizontal sync (new multisync only)
          |   |   |   |   |
          |   |   |   |   |  grey
    red   |   |   |   |   |  green blue
     |   1o  2o  3o  4o  5o    |     |
    (O)                       (O)   (O)
       6o  7o  8o  9o 10o
       |   |   |   |   |
       |   |   |   |   +---   sync common (gnd)
       |   |   |   +-------
       |   |   +-----------
       |   +---------------   vertical sync (new multisync only)
       +-------------------
```

The monitor works with a PC driver from Sony named "SONY Multiscan 20SE" and is able to do at least 1280x1024 @ 75Hz, that's at least what my video card is capable of.

Looking inside it I also found markings for one of the PC-monitor buses used for autoconfig but I have not bothered to get that to work. Any info on that would be appreciated but it does work nicely without it. Converting Sun Workstation Monitors for use on MACs (From: Phil Lee (plee@orbis.net).)

Here is a cheap, less than $300 total, solution for converting legacy Sun 20" workstation monitors for Macintosh use. Over the summer, there were large batches of Sun OEM Sony monitors, model GDM-20D10 being auctioned by ubid.com for about $225. They were being bundled with a Mirage Diablo 3D AGP, mirage-mmc.com, board and the package was advertised as compatible with PCs only.

The Sony 20D10 is a "limited multi-sync" monitor which is still satisfactory for the standard Mac two page display resolution 1152 x 870 @ 75 Hz (horiz=68.7KHz) for desktop publishing. Two cable related add-ons was required to convert it for Mac use.

1. DB13W3 female coupler, PI Manufacturing P/N 000-530, $14. 1-909-598-3718.
2. DB13W3 to DB15 cable with Mac sense switches, PI P/N 530-BNC-Mac, $28.

The 4 sense switches was set to all on, similar to using a Griffin MacSync griffintechnology.com , for legacy monitors. Was attached to a Mac IIfx using a SuperMac Thunder 24bit large screen Nubus card. Using the monitor controls, was able to center the image nicely. The Trinitron display was nice, sharp, and bright for light DTP and CAD use.

Not bad for repurposing legacy equipment.

There were other Sun (Sony OEM GDM-1962b) monitors also being auctioned. Other WS mfgrs such as HP, DEC, and IBM have similar monitors. They may work as well. I chose the 20D10 as they seemed to be newer.

Also see the section: Sun 365-1335 or Sony GDM-20E20 monitor on PC and the following for more technical info:

- Hiroaki Kobayashi's Resource
- Monitorworld
- http://saturn.tlug.org/sunstuff/ffmonitor/GDM-20D10.html">Sony GDM20D10 Monitor Specs

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- Monitorworld
- Sony GDM20D10 Monitor Specs

Mitsubishi HL7965 Workstation Monitor on PC

(From: Wong Sy Ming (simingx@yahoo.com).)

The SGI (Mitsubishi) HL7965KW-SG monitor is widely advertised as a Fixed-Sync, Sync on Green monitor in the workstation world. Well, most people know that this is actually a multisync monitor but not many people may know that it actually has inputs as well!

I don't know if they appear on the video input board, but if you remove the board where the 13W3 connectors are on you can actually see, beautifully silk-screened on the main PCB, near the connectors that once went to the input board, pins labeled: R G B and HSYNC, VSYNC!

So this is actually NOT a sync-on-green monitor as everyone says. It's a separate sync monitor! (Yes I have this and it works beautifully in Windows up to 1600x1200x60hz. At 1280x1024 it does 75Hz.

However, the pincushioning will need adjustment (I don't know how) but if you are willing to live with a little distortion at the sides it's perfectly OK. You'll also need to solder in some 75 ohm resistors where the RGB goes in (conveniently, there are SMT pads there!) otherwise you'll get extremely severe ghosting. You might also want to replace a new 13W3 plug to cover up the rather unsightly holes left from removing the input board, although these can get *very* expensive and *almost impossible* to get.

And this is a monster of a monitor, weighing more than a 21" Sony CPD-G500! There's actually a warning label at the back saying "Caution: 23kg" with a picture of those "10 ton weights" that you see so much in cartoons :) All that said, the video amps look like miniature tanks, they're fully encased in shiny aluminum blocks and there are a ton of ferrite blocks and shielding screens inside.

Although mine was manufactured in 1993, it still gives a better picture than a slightly-less-than-new Philips monitor.

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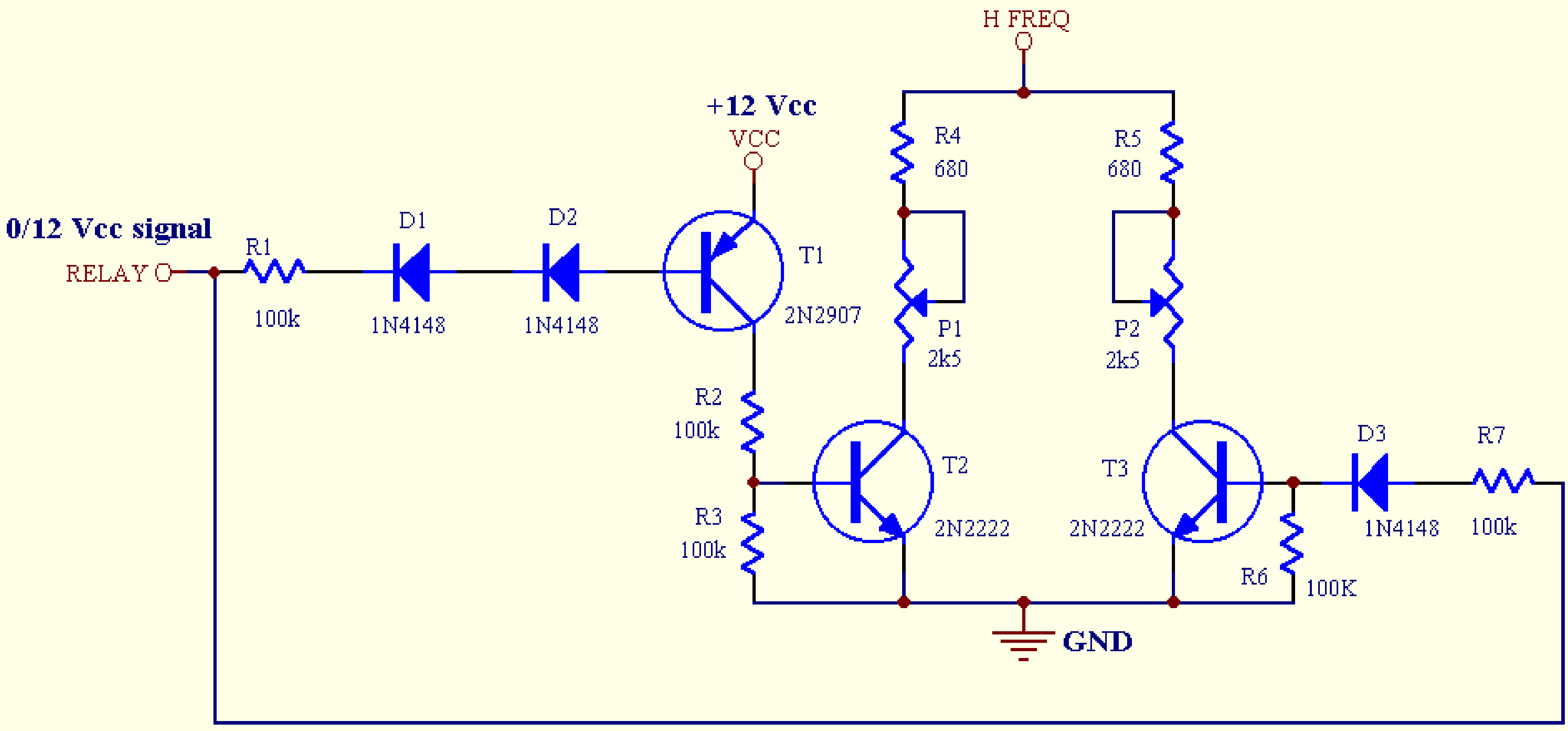
-- end V1.68a --



IBM9517 Monitor Modifications for use with PC VGA/SVGA

Notes on Video Conversion

Version 1.94

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Interconnecting a video source and display device that are not compatible can potentially result in expensive damage to either or both pieces of equipment. While this isn't that likely with just a bit of care, it cannot be ruled out.

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

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Introduction

Scope and Purpose of This Document

Questions relating to various aspects of converting one video format (like PC SVGA) to another (like NTSC) are very common.

Most of the articles in this document have been compiled over the last two years based on replies from myself and others to postings on the USENET newsgroups comp.sys.ibm.pc.hardware.video and those of the sci.electronics hierarchy. I apologize if your response is not here - it could have been that I missed the posting and will welcome contributions.

As always, comments, suggestions, and corrections are welcome.

Note: in this document, the terms 'VGA' and 'SVGA' are used somewhat interchangeably. However, strictly speaking:

- VGA refers to the basic original IBM VGA standard of 640 x 480 at 60 Hz.
- SVGA refers to scan rates greater than and including the basic VGA rate.

Commercial Solutions

A number of companies offer adapters to handle many of the problems discussed below. They may advertise in the backs of electronics/hobbyist magazines (many are not exactly large companies!) or turn up with a Web search. One example is Magenta Research. Look under: "Video Adapters, Cables, Accessories". (I have absolutely no affiliation with this company nor do I have any first hand knowledge of their products.)

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TV (NTSC/PAL) to RGB

Watching TV on a VGA/SVGA Monitor

Depending on the monitor, you may need a lot of electronics. VGA uses a 31.47 kHz horizontal scanning frequency - twice NTSC.

1. If it is auto-scan and goes down to 15 kHz horizontal, then you need an NTSC to RGB converter. There are chips from companies like Sony, Signetics, and others that will do this without too much pain.

2. If it will not sync at 15.734 kHz, you will need a real time digital scan converter consisting of a video digitizer and a full frame buffer with suitably fast I/O, For the special case of basic VGA, a subset of this called a line doubler or scan doubler will also work but there are some problems with this approach. See the section: What is a Scan Doubler?.

For PAL (625/50) the relevant resolution is closer to 800x600.

There are boards for your PC that will take NTSC/PAL and put it into a window.

There are also stand-alone boxes that will allow you to view NTSC/PAL on a VGA computer monitors. One example is the Z64 V-Box. I have no idea how well it performs. However, from the specs, it would appear to have a limited color resolution (only Y:U:V 4:2:2) so while adequate for some games, it may display annoying contours for continuous tone images. And since it only generates a resolution of 640x460, there may be serious artifacts when driving a higher resolution flat panel display.

What you may find in the end is that your $150 TV gives you a better picture.

(The following from: Stan Rohrer)

For cards as well that take NTSC and put it into a window on your PO:

Check in the PC mail-order catalogs and your local PC parts outlets. There are a number of TV boards and frame grabber boards that do what you want. Prices start (I think) around $150. Professional level conversion boxes soar above there somewhere.

I've just started investigating such devices. PC Zone (800-258-2088 for orders/catalog) and MicroWarehouse (800-367-7080) carry Computer Eyes and TelevEyes by Digital Vision. Prices here range from $300 to $600 with the highest reported to include genlock and overlay capability.

PC Zone has an AITech TV board for $150. I don't know if it will take NTSC video input or not. One of the guys I work with just bought an (unknown brand) TV board that takes NTSC but he doesn't have it installed yet.

SCART to VGA

This will only be possible without a lot of work if the VGA compatible monitor or video projector can sync at the PAL (or whatever) scan rate. If so, this may be possible with just a special cable. If available, use an oscilloscope to confirm that your equipment produces the relevant signals (not all SCART connectors have all the signals). See the document: Pinouts for Various Connectors in Real Life(tm) for the SCART pinouts.

While VGA usually expects separate H and V sync - it looks like SCART has them only in combined (composite) form but many monitors and video projectors will accept either.

(From: Someone who wishes to remain anonymous.)

I just bought a box that lets me view PAL/NTSC output from a VCR or DVD player on an old (but big) VGA monitor I had spare.

It's called the Gamars V-box. (Gamars and Gamars Europe) Inside it has a Philips SAA7111 and an Averlogic AL250 IC. Inputs are composite video and S-video, autodetecting PAL or NTSC. Output is VGA.

The quality is great. The only problem is that playing an NTSC disc in my PAL DVD player causes the DVD player to output PAL at 60 Hz. This fools the V-box into engaging NTSC mode, which results in a black and white picture.

The box was inexpensive, about $40 or so. Cheap importer: Golden Shop VGA Box Page.

(From: Mike Deane.)

I have played with the V-Box unit, and it's pretty good considering it = wasn't really meant for converting monitors into TVs. However, it only = produces 640 x 480 resolution, which is not so great if you were = planning to use a 1024x768 TFT display with it. The screen syncs up OK, = but cannot do a decent job of multiplying up the resolution, so the = result is fairly nasty.

TV to Fixed Frequency Monitor

The hardware needed to watch TV on a typical high resolution fixed frequency monitor would cost more than a nice large TV. In two words, forget it! In addition to decoding the NTSC/PAL to RGB, the scan rates are SO different that the only hope would be to build a full blown scan converter.

TV to MGA

> "How hard would it be to make my amber Hercules monitor display the output from my VCR? the VCR has a RCA video output and a coaxial RF output and I want to use the monitor as an orange TV."

This is almost certainly not worth the effort as the monitor accepts TTL (2 bits) and can display at most 4 gray (well, amber) levels without extensive modifications. In addition, the scan rates differ substantially between NTSC or PAL and the Hercules standard. As noted below and elsewhere in this document, a CGA monitor with a composite video input would be a better choice.

(From: Jerry Penner (jpenner@sentex.net).)

You want to connect a Herc Mono TTL monitor to a composite video signal? Can you say 'Big Waste of Time and Effort'? If you want a black and orange or black and green TV screen, connect your RCA video output on your VCR to the input of a composite CGA monitor. These monitors were used on Sanyo MBC computers, and early Apple clones as well as some XT's. Colour composite CGA monitors used to be used on C-64 and Vic-20 computers. Their usefulless as TV/game monitors is legendary, and you'll be lucky to find a used one for under CDN$80.

TV to CGA

> "I have a RGB CGA monitor and would like to use it to display a composite or S-video signal from a VCR. I was wondering if anyone knows how to accomplish this or knows of any economical products that will be able to do this. Any info on S-video pinouts would also be greatly appreciated."

Is it strictly CGA? If so, that is TTL and you can forget about displaying VCR S-video without extensive and not worth-it modifications. Some CGA monitors have composite inputs or analog RGB inputs. With analog RGB inputs, you need an NTSC to RGB converter. These can be built with a single chip and some discrete components. There are probably converter boxes available as well. If it accepts composite, then just use the normal video out from your VCR. S-video won't gain you anything unless the monitor has separate Y and C inputs as well. If all it has is S-video in, then you can combine the Y and C signals with a resistor and capacitor. See the section: S-Video to Composite.

I have a Magnavox CM8762-074T RGB Color Monitor which accepts both CGA TTL and NTSC color composite video inputs. Locating monitors of this type may be an alternative to video format conversion. These may be available for next to nothing as the owners have upgraded and are often not interested in (or aware of) their present utility. They are often of relatively high quality and display a very nice picture since their original intended resolution is similar to that of NTSC. I use the Magnavox CM8762-074T for testing of VCRs and other baseband video sources.

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PC VGA/SVGA to/from TTL

VGA to TTL (MGA, CGA, EGA)

Both the signal format and scan rates are incompatible. Therefore, simple conversion between analog VGA/SVGA and any of the TTL formats - Mono, CGA, and EGA - is generally not realistically possible.

Some (mostly older high-end) monitors will accept multiple input types like VGA, EGA, and composite. Some examples are: Mitsubishi AUM1371/81, Tatung CM1495, Princeton Ultra-14, and NEC MultiSync. These can select between VGA and EGA input (either a switch or cable) and the Mitsubishi (at least) will also accept composite (NTSC) video.

VGA to CGA1

The following applies with minor changes (scan rates, number of bits) to MGA, CGA, EGA, and most other TTL video signal formats as well.

> "I am trying to use an old Sony monitor, (PVM-1342Q), which only accepts a CGA video signal through a 9 pin connector. My output is SVGA via a HD15 pin connector. Any suggestions on pin assignments or existing converters to do the job?"

Assuming the monitor is actually CGA, it is probably not worth it. CGA is TTL and SVGA is analog - you would need a converter and then only end up with CGA's 8 colors or whatever.

The scan rates differ by a significant factor. If you can program your VGA card for the monitor's horizontal scan rate (around 15.734 Hz - similar to NTSC in the case of CGA), then the remaining problem is converting from analog to TTL. This will require some high speed comparators and logic.

VGA to CGA 2

For the general case of desiring to drive a true CGA-TTL monitor from a VGA card, there are three options:

1. Replace the monitor with a VGA monitor.

2. Replace the video card with a CGA card if you can find one.

3. Completely redesign the CGA monitor to accept the VGA scan rate and analog video input. Neither of these is easy or necessarily even possible and the resolution of the CRT may be inadequate in any case.

If the monitor accepts analog RGB, it may be possible to program you VGA card to put out the CGA (15.734 kHz) horizontal scan rate to be compatible with a CGA monitor of this type. Your hardware and software may or may not support this easily or at all.

If it's a true CGA monitor, there simply is no practical way to use it with a VGA card. Period. If it's one of the original multisyncs that happens to work with CGA, then there's some hope. However, these weren't so common: Sony 1302, Mitsubishi AUM1381 or Diamond Scan, plus a few others). In this case, you just need the proper cable and the appropriate switch settings for the monitor.

VGA to CGA 3

> "We are trying to upgrade our print servers and have a lot of CGA monitors and a lot of PS2 computers with VGA cards. We don't need more than 2 colors (mono) but when we make an adapter to connect the R to R, G to G, B to B, H to H, V to V, Ground to Ground and the rest NC we don't really get what is wanted.
>
> Well, what happens is that the display is quite acceptable other than the fact that there are two of everything on the screen indicating timing problems. Covering the right side of the screen with a sheet of paper works to cure the problem but a more acceptable solution is needed.
>
> Adjustments to the monitor frequency, width, phase, H-hold, etc. don't help."

This is not surprising as the horizontal scan rates for VGA and CGA differ by about a factor of two. This is much too large change for the monitor to accommodate.

Note that CGA outputs TTL level signals (0 to 3-5V) and VGA outputs analog levels (.7 V p-p). Therefore, what you have done may not work in any case if the monitor expects strictly a TTL input. However, your monitor must be compatible with the VGA levels.

The monitor would have to sync at double its normal scan rate for the picture to properly fill the screen. First, it would be difficult to modify the monitor for such a substantial change in horizontal scan rate. Second, and more importantly, any such change could compromise the safety - stressing the monitor's circuitry - increasing the risk of failure and the possible fire hazard. Therefore, I would not recommend even making the attempt unless you are quite knowledgeable in the design of monitor deflection circuits and power supplies.

One other option other than replacing the video card or the monitor would be to determine if your PC is capable of putting out CGA scan rate video. Many video cards do have this capability not so much for CGA as for NTSC/PAL compatibility. However, some programming or use of special video drivers (software) may be required.

Alternatively, you may be able to find an inexpensive card that would be able to provide the correct timing or even some old CGA cards that no one wants anymore. Also, monochrome video rates are 18.43 kHz. If you can find some MGA cards, you may be able to tweek the monitor that far.

Actually, for your intended application, painting over one half of the screen isn't such a bad idea. :-)

TTL to VGA/Analog

This requires matching the scan rates and implementing a suitable digital to analog converter to take the TTL data and produce analog signals.

A scan converter can be used on the analog signals once they are generated to adapt the video to your monitor. However, I don't know if scan converters with suitable input and/or output capabilities exist.

The digital to analog conversion can be done with a few resistors if you are not terribly fussy about the quality. For example, the following circuit should be able to generate a reasonable VGA signal from a 2 bit input (e.g., MGA or one of the EGA color channels):

```
                     450 ohms
  Bit 1 (MSB) o--------/\/\/------------+
                                        |
                     900 ohms           |
  Bit 0 (LSB) o--------/\/\/------------+-------+----o Analog video signal
                                                |
                                                /
                                                \ 75 ohms (termination, may
                                                /           be inside monitor).
                                                \
                                                |
  Ground o--------------------------------------+----o Monitor Ground
```

This assumes the H and V sync are separate signals. If this is not the case, these will need to be combined into this signal (at least one of the channels) as well.

I have not tested this circuit. Using low value pullups on the TTL signals (say 220 ohms) should help improve the high level consistency.

CGA to VGA

There are two problems:

- CGA is TTL; VGA is analog. Relatively simple circuitry can deal convert the TTL levels into the .7 or so V signal.
- CGA scan rate is approximately 15.75 kHz; VGA is 31.4 kHz. Therefore, unless the VGA monitor can scan at the lower rate (some early multiscan monitors like the Mitsubishi AUM1371/81/91 can do this), a scan doubler will be needed. See the section: What is a Scan Doubler?.

In general, where only 1 (or a few) of these are needed, locating true CGA monitors at used computer stores or thrift shops is definitely the easier way to go!

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VGA to Analog RGB

Note that in some cases, no actual hardware is needed - the video adapter may be programmed to do what you want either using existing or special driver software or at a low level by directing controlling the video chipset:

(From: Jack Schidt (jack@wintel.net).)

Most questions regarding changing or using VGA signals in non-standard (PC) methods, is answerable only by consulting either:

1. Graphics adapter manufacturer (if known) of the VGA adapter, or integrated motherboard. They may have the information you need.
2. Graphics chip manufacturer. They will have programming information or books you can read to change the device programming. NTSC mode set commands are sometimes on the graphics chip mfg's Website or BBS.

   However, this is not always simple!

If you are lucky, you can reach an apps engineer in either case who has knowledge of your requirements, and has the means to supply you a solution. Otherwise, you need to write a short assembly language program to stuff the VGA controller registers with the correct parameters for what you are trying to do.

VGA to Fixed Frequency Monitor (3, 4, or 5 BNC Connectors)

Questions about this specific problem are among the most common as low cost fixed frequency monitors become available when their workstation hosts are decommissioned due to the march of progress.

You will have to obtain the specs to have any idea of whether what you want to do is possible. These are very often high resolution with a typical horizontal scan rate of 64 kHz.

There are several issues:

- Video compatibility - here is the one area where you are likely fine - your monitor is probably compatible with VGA analog video levels - .7 V p-p.

- Scan rate - your horizontal and vertical refresh rate. I would expect that the monitor is not auto-scan and probably not compatible with VGA or SVGA. Please check the specs if you have them or post a message so that someone else can identify it. You need to know its horizontal and vertical scan frequency range.

  If it is fixed frequency, you will be able to use it only in your high resolution (probably) applications. Booting the PC will require a normal VGA monitor for the messages to be seen.

Assuming you are willing to use something else to boot and only run at a single resolution, then the last hurdle is sync:

- Sync. You have 5, 4, or 3 BNC (coax) connectors on the back of the monitor.

  - 5 BNC connectors - this means that your likely have separate horizontal and vertical (H and V) sync inputs - just what your VGA card wants. In this case, as far as sync is concerned at least, all you need is a VGA-to-5 BNC cable.

  - 4 BNC connectors - this means that your monitor requires composite sync. The H and V sync signals must be combined into one TTL level signal. Some cards like those from ATI will probably drive it with just a VGA to 4 BNC cable since they can be programmed to generate composite sync with no additional hardware. (Actually, get a VGA to 5 BNC - you just won't use one of the syncs and this may come in handy at a later time).

    You need to determine what its expected H and V rates are to see if they fall within the range of the video card. Some internal twiddling may be possible depending on the monitor. Also, the software size adjustment in the ATI Install program also affect rates so that adds another couple of degrees of freedom.

    If you need to combine the H and V sync, a TTL gate, single transistor circuit, or sometimes just a couple of resistors will do it.

    For example, if you are able to program your video card for negative sync polarity, then an AND gate (which will act as an OR for negative logic) should do it. For positive sync polarity, a NOR gate or NPN transistor will work. It is also possible to build an auto-polarity switching circuit to accommodate any combination of positive and negative sync polarities. In some cases, just using a resistor in series with each sync line will be enough.

  - 3 BNC Connectors - these monitors need what is known as 'sync-on-green'. This will require some circuitry to combine the H+V+video into one signal. The circuitry is quite simple if you are electronically handy. Commercial boxes to do this are also available.

    (From: Exar (exar@aol.com).)

    For any type of video converters call ALTINEX,INC. in California 714-524-5400 they make a device that will combine sync, separate sync, put it on Green, shift image left or right. Product name is

DA1910SX. I have several of them for my PC, MAC SGI and SUN.

See the documents: "Fixed Frequency Monitor FAQ" and "Sync-On-Green PC Video FAQ" for details.

Some monitors have the required circuitry to accept separate sync internally that is not brought out for a particular model. In this case, some careful exploration may reveal hidden treasures.

So, check your scan rate. If that is not compatible, then you will need a new display board anyway. If it is compatible, then you will just need the sync combiner. Then there is the problem of booting DOS or Windows - these usually want 640x400 at boot.

There are video cards designed for just this purpose. Whether the investment is worth it compared with a new PC compatible monitor is questionable IMO.

See the document: Notes on Approaches to Using Fixed Frequency Monitors on PCs for additional information and names of companies who manufacture the special video adapters.

VGA to Apple RGB

> "Is there any way to modify an Apple 12-inch RGB color monitor so that it can display 640x480 (instead of 512x384)?
>
> Has anyone ever managed to do this? Any opinions on whether or not it is possible?"

I assume you want VGA resolution - 31.4 kHz horizontal.

This would require changing the horizontal scan rate by a large amount and is unlikely to be easily accomplished without extensive modifications to the monitor's circuitry. This should not even be attempted unless you are knowledgeable in the design of monitor deflection circuits and power supplies.

For other Apple (MacIntosh) monitors, see the section: VGA to Fixed Frequency Monitor (3, 4, or 5 BNC Connectors) as most of these run at a fixed frequency. For example, the Mac II rate is 35.0 kHz H and 66.67 Hz V.

VGA to Mac (Monitor) Conversion

I have no idea of what this gadget actually does but it may be worth checking out:

(From: James Willcox (jwillcox@spitfire.net).)

Boca makes an adapter. I have one and it works fine. It has little switches on it to select resolution and refresh rate.

VGA to Sun/Sony GDM1960

(From: Flupke ut Warns (P.O.Langemeijer@student.utwente.nl).)

The most important thing is to get the sync pin(s) connected and the horizontal scan rate as close to the required value.

There is much more info and links at:

- http://www.ifi.uio.no/~karld/fixedsync.html

VGA to Amiga 1024

From: jcaldwel@iquest.net (Mr. Caldwell)

It is a CGA frequency only monitor. It has an 8 pin analog jack on the back and may have a 5 pin ttl jack and ttl to analog converter inside for standard CGA, you can use a cable for the analog plug to a 9 pin d plug for MCGA and get 320 x 200 by 16 Million colors. Some IBM cards will put out the correct frequency and analog signal, most won't. I used an ATI Wonder VGA card that would work correctly *if* manually configured.

Otherwise you need a VGA to NTSC converter. See the section: VGA to TV - NTSC or PAL for more information.

VGA to SCART

SCART is basically an analog RGB + composite sync interface found mostly on PAL (and maybe other European standard) TVs but rarely on TVs in the U.S.

Signal conversion from VGA to SCART is straightforward - just a matter of generating composite sync and making the proper cable. However, it has the same problems as the others with respect scan rates unless you are running an O/S like Linux or an X-server - for the latter case, see: X on TV.

Notes on VGA to RGB Conversion

See the document: Approaches to Using Fixed Frequency Monitors on PCs for an adapter using a programmable logic device to implement conversion from separate H and V sync to sync-on-green. Or, here is a solution using discrete logic:

(From: Jon Jenkins (jenkinsj@ozy.dec.com).)

I use standard 74HC DIP gates available from any electronics store. I use a 14 pin DIP socket originally so that I could change gate types (OR/XOR/AND) easily. 74HC86 (XOR) works just great with the VR320 (I am using it now can also use OR, don't understand why ??).

The VN10KM is a small signal N channel enhancement mode MOSFET also available from most electronics store.

If the video card you are using is a standard VGA output (I'm using a diamond stealth 64 VRAM):

Pin 1: Red video
Pin 2: Green video
Pin 3: Blue video
Pin 4: Monitor ID bit 2
Pin 5: Ground
Pin 6: Red return
Pin 7: Green return
Pin 8: Blue return
Pin 9: NC
Pin 10: Sync return

Pin 11: Monitor ID bit 0
Pin 12: Monitor Id bit 1
Pin 13: H sync
Pin 14: V sync
Pin 15: NC

I join all the "returns" together with the ground on the small PCB and use that as a common ground for the RGB cable to the monitor. You can use separate if you want to but you should join the green return and sync returns together. I did find some small shadowing if I didn't group them all together.

Just a note, when you set up your video card in Windows (or Win95) set it to 1280x1024x72|66 or whatever is closest. I use a VR260 (1024x864) at 1027x768@66Hz (check with your manual DA or D4 are 72Hz) your VGA will not like this frequency so either disconnect it quickly or before you actually set the video card to this mode (i.e. put the OK as the active control in Windows and then connect the VR320 and hit return) My diamond setup gives me 10 seconds to do this adjustment When you exit you will probably have to select the 1280x1024 mode with your old VGA connected again and from then on every time you start Windows you will be able to view it in "big" colour mode. Note the vr320 will not work in DOS mode as it is not an auto-scan monitor so all you see when you boot up is garbage until Windows starts, I put "win" in my autoexec.bat file.

Note there is a danger here: I had set up the monitor and for some reason it did not work so I couldn't see what was going on: my old VGA wouldn't work and the VR wouldn't work either so I had to find the cards .ini files and edit by hand to get back to usable video!!

For FreeBSD/XF86 the lines are:

```
#VR260 monitor is 70MHz 1024x864
#VR320/319 monitor is 130MHz 1280x1024
Modeline "1280x1024" 130.81 1280 1312 1472 1696 1024 1027 1030 1063 +hsync +vsync
Modeline "1024x864" 69.2 1024 1040 1168 1272 864 864 867 904 +hsync +vsync
```

The circuit to do this is as follows:

Notes:

1. You may be dealing with 135MHz square waves so there are lots of high frequency stuff around; use good RF practices.
2. The coupling capacitors are a safeguard to start with. I don't use them because they caused shadowing around sharp colour changes (the old RC effect).
3. Use the XOR gate first as a test but you may need other gates to actually get it working.
4. An oscilloscope will be handy for final adjustment.
5. Make the device is as close as possible to the video outlet on the VGA card.
6. Take the 5V from the PC power supply inside the box. I just hooked one of the spare connectors which I also use for an external fan (Pentiums being the heaters they are!). Make sure (check it again!!) (and again!!!) you don't get the 12V one!!

7. You must use a VN10KM or other small signal N-channel enhancement mode MOSFET. Others will not work!!

```
                         +5 V
                           o
                           |
                           /
                           \ VR1 (1k carbon mini pot)
                           / (Warning: don't let this go near zero!)
                           \
           33uF tantalum   |   ~0.3V DC in porch area
    GREEN o----+----||-----+----------------------+---o GREEN to monitor
               +----||-----+                      |
           .1-.01uF ceramic                       |
                                                  |
           Gnd                                    |
            o                                     |
            |                                     |
            /                                     |
            \ 47k                                 |
            |                                    _|
    HSYNC o-+----|-------\                      |
                 | GATE   |------CSYNC----+----||   VN10KM or similar small
    VSYNC o-+----|-------/                |     |_  N channel enhancement MOSFET
            |                             \       |
            \                             / 47K   o
            /                             \      Gnd
            \ 47K                         /
            /                             |
            |                             o
           gnd                           gnd
```

HSYNC, VSYNC and CSYNC are grounded with 47k carbon resistors

Gate type=LS or HC types, HC preferred:

- OR: for -ve logic sync and no hsync during vsync.
- NAND: for +ve logic sync and no hsync during vsync.
- XOR: for -ve or +ve logic sync and hsync during vsync.

Capacitors are optional, I don't use them.

Use XOR gate with DEC monitors and as a first shot with others, then OR gate then NAND gate.

Get an oscilloscope and adjust porch levels to 0.3V and 0 level (sync level) to 0.0V

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VGA to TV - NTSC or PAL

> "I am interested in converting a signal from my video card to a signal that can be taken into the video in on my vcr. I realize that it is not going to be easy. Still I would appreciate how to do it."

You are correct - this is not easy.

1. You need to convert RGB to NTSC or PAL - there are single chips for this. Try Sony, Philips, Motorola, and others. These will combine the R, G, B, Hsync, and Vsync into a single composite video signal using a minimum of additional components. The same part can usually do either NTSC or PAL by changing a jumper and possibly some of the external components.

   For example:

   (From: Brian B

   > "In the July 1996 issue of Electronics Now, a MC1377P (Motorola) is used to convert RGB to NTSC/PAL. The chip can be purchased through the Newark catalog. This chip is very easy to use and should make your circuit simple." (See the wiring instructions, below. --- sam.)
   >
   > Some other possibilities may be: ADV7175/ADV7176, UPC1352 (ECG/NTE1416).

   (From: Quick Fix (iradg@guru.nu).)

   > "The MC1377 is a 20 pin all-in-one chip. Connect the following: +12 VDC to pin 14 and ground to pin 15, composite sync to pin 2, RGB to pins 3, 4, and 5, respectively. Put a 3.58 MHz xtal between pins 17 and 18. Optional Y delay pin 6 to 8. Video output at pin 9. I have made and sold many of these. If you have any more questions, you can visit the Motorol Website and search for: "MC1377".

2. You need to match the horizontal scan rate to NTSC (15.734 kHz) or PAL (15.625 kHz). Even basic VGA is roughly twice this - 31.4 kHz. If your video card can be programmed to put out interlaced NTSC or PAL rate video then this is easy. If not, it is more difficult. If you want to use any higher resolution than basic VGA (640x480) for a 60 Hz system or 800x600 for a 50 Hz system, it is a very non-trivial problem requiring a scan converter which includes a video A-D, full frame store, interpolator, readout timing, and video D-A. Unless you are an experienced digital and analog designer, you really really do not want to tackle this.

For the special case of VGA to NTSC or PAL, you may be able to get away with something less than a full blown scan converter. See the section: What is a Scan Divider?".

You can also buy little boxes to do this. Quality is general not great as you are seriously limited by the NTSC/PAL standards. Even with S-video inputs to a TV or and S-VHS VCR played on a high-end TV, don't expect to be able to throw away your computer monitor!

Here's one link to check:

- RAM Electronics Industries, Inc. SVGA to Video Adapter

I have no idea of whether this devices works as advertised.

(From: Tomi Holger Engdahl (then@neppari.cs.hut.fi).)

There is all sorts of information relevant to video at:

- http://www.hut.fi/~then/electronics/video.html

There is collection of links to RGB to NTSC/PAL converter and other video chips at:

- http://www.hut.fi/~then/electronics/video.html#chips

or

- http://www.hut.fi/Misc/Electronics/videochips.html

For more detail on this, check my circuit and related software at

- http://www.hut.fi/~then/circuits/vga2tv/

Probably the most complete VGA to TV conversion pages in the web can be found at:

- http://www.hut.fi/Misc/Electronics/circuits/vga2tv/

There you can find schematics, drivers, tips, ideas, documents, links to commercial products and much more. It does not have everything you need but it is a good start. Going to composite video or RF is more complicated as there are three composite video standard NTSC, PAL and SECAM in use in the world and there are also some small differences in modifications of those used in different countries) which is the reason why there are not much of this kind of project. VGA to TV conversion is not simple technology either (the circuit can be simple but there are quite many things to consider when designing such circuit).

Homebuilt circuit persons should take a look at:

- http://www.hut.fi/Misc/Electronics/circuits/vga2tv/

There you can find my design of VGA to TV converter which outputs RGBS signals suitable for TV SCART RGB input (I have also designed one with composite video output, but that's for a commercial application). At the same page you can find a PAL composite video output version of the circuit designed by Paulo Coelho.

For introduction to scan conversion, check

- http://www.extron.com/

Specifically:

- http://www.extron.com/product/scanconv.html

Flickering is a problems always when yu do graphics to TV systems. The graphics material must be designed so that flicker is not noticeable or the scan converter box must include some kind of filtering to do the job.

NTSC/PAL system limit the bandwidth which makes picture to loose some details. The picture is usually even worse than that, because of the cheap video encoding chips used in many converters.

(From: Bill Sloman (sloman@sci.kun.nl).)

Try the Analog Devices AD721 and AD722. When I used the AD720, I had to add a National Semiconductor LM1881 sync separator, and black-level clamps on the red, green and blue inputs to get the right DC levels.

Check them out at Analog Devices.

(From: Leon Heller (leon@lfheller.demon.co.uk).)

Raytheon has a chip which produces broadcast quality PAL/NTSC from VGA. I think that Harris does one, as well.

VGA to TV Converter Boxes, Adapters, and Boards

(From: Kevin Centanni (kpc@panix.com).)

There are a couple of VGA-to-TV converter boxes that also output an NTSC RGB signal. I own one from UMAX - I think it's called the TV-Mini. I bought it from Global Computer Supplies for about $175. I also think that MicroWarehouse sells this product. There's a model sold by AVer also that has RGB out... but it's over $300.

The UMAX TV-Mini is a small box that plugs into your VGA card... it also has a female VGA connector on it so you can display images on your computer monitor and television monitor at the same time. The TV-Mini is powered by the PC's keyboard connector. It has an RCA jack for composite NTSC, an S-Video jack for S-video output and a Mini-8-DIN for RGB output... if you go to UMAX's web page, they'll talk about how the TV-Mini comes with an RGB SCART cable (SCART is a strange looking connector that's used on many European televisions) - but it doesn't come with this cable.

I was able to build a small adapter cable with some parts from Digi-Key. The TV-Mini manual provides the Mini-9-DIN pinouts.

(From: Jerry G. (jerryg@total.net).)

I have played around with a few. The ones in the upper $300 to $400 are not too bad. You will get a reasonable picture. I found the cheap ones are extremely poor.

The best way to do it is with a video display card that has it built in. These cards are expensive because the scan rate must be changed. There is a lot of high speed ram and processing involved to do it right.

It is not a question of movement involved. It is a question of scan rate conversion that makes things complex. With this conversion there is the requirement of some complex quantizing to also convert the characters to match as well. In a lower priced card that I have seen good results is the ATI card with the NTSC output. I don't know the price of the card, but it is not cheap...! There is a Targa card that is excellent, but the price is too high unless you are in the business... But like I said, the higher the price, I found the pictures get better.

Also, the bandwidth for the fonts, and data comming through the conversion is extremely wide. It is wider than off of a conventional TV broadcast, or what comes out of a VCR. The TV set that you use must have a Video Component input, and be able to handle at least 600 lines resolution or better. If not, you will be cutting the performance of the signal right at the end! If your TV has S-Video capability, get the card with that option. It is better than using encoded NTSC or PAL. The S-Video mode keeps the color information separate for processing. This allows for a better signal to noise in the luminance signal, thus rendering cleaner pictures.

Please note, that you will never get the same picture out of a TV video monitor as your computer monitor. They are based on very different processing and CRT design. There are VGA Monitor projectors on the market, and I would consider renting one for the casual use. It will certainly do a much better job. This is what I recommend and do for my clients. Don't even think about buying such a projector unless you have a lot of use for it. They are extremely expensive, and require periodic maintenance.

(From: E. Abel (EugeneA1@worldnet.att.net).)

I've used an ATI 3D Expression+ PC2TV. The S-Video output is not bad, although text is really not very crisp.

Surprisingly, the TV output from the Canopus Pure 3D card is much better. Text is actually readable. (this is on a 27" Sony trinitron TV.) The Canopus card uses a Chrontel chip to do the conversion.

Of course, at $190 the card is a little pricy.

VGA to NTSC/PAL Chips

> "I am trying to build a circuit to convert the RGB output of a video game to my large screen TV."

(From: Leon Heller (Leon@lfheller.demon.co.uk).)

If the game outputs VGA, Raytheon has a chip, the TMC2360, which converts it to broadcast quality PAL/NTSC video.

Another IC that does most of the required functions is the Analog Devices AD725 "RGB to NTSC/PAL Encoder".

(From: a-freak@freenet.de.)

A very nice IC is the TDA8501 which converts RGB or YUV to Y/C and FBAS signals, needs very few external parts ana can be switched between NTSC and PAL with a single jumper. See TDA8501 Datasheet for more details.

Together with a sync processor like the TDA2579 and a colour decoder like the TDA4650 it gives a very simple color standard converter. Also the fast input switch allows one to build a very simple video genlock for home computers.

Questions and Answers on VGA to NTSC Considerations

This dialog resulted from the desire to construct a VGA to NTSC converter to output PC video to a TV or VCR.

"I managed to construct a VGA to RGB converter so far, so I'm almost halfway there, all I believe I need now is an RGB to NTSC converter circuit, although i was trying to avoid the cost of buying one they sell in the PC catalogs."

Can you program your video card to output 15,734 Hz H interlaced scan? If so, you will have a lot less hassle.

> "I figure the odds are in my favor by creating one myself, and as far as I know, no harm could come to my computer by attempting it since the VGA/RGB is and output only and not and I/O. Now since I

> already manged to convert my VGA to RGB, hopefully you might be able to answer some specific questions for me?"
>
> "Is there a minimum & maximum resolution for a TV , or does that depend on the size of the TV?"

If you mean resolvable spots on the TV screen, realistically, it is about half VGA horizontally and perhaps a little more than half vertically or about 320x300 give or take.

If you mean scan lines, that is pretty much fixed at 525 total interlaced 2:1 at 60/30 Hz (625 at 50/25 Hz for PAL 50 Hz systems) with about 420 (540) actually visible on a typical TV. TV's are not auto-scan - they are designed to run at a single scan rate.

Therefore, even displaying easily viewable VGA resolution will be tough. A TV with an S-video input may do somewhat better.

(Remember when you had at most 40 characters across on a Commodore?)

> "Assuming the construction of this circuit would only allow a maximum output from my VGA card, what resolution would that be? 640x480 or 800x600? (I have no expectations of anything higher)"

As noted, for a regular TV, you can send it 640x480 but it will be somewhat fussy. 800x600 is really out of the question. A high quality TV-monitor might do VGA ok. The actual number of lines on a TV is, of course, only about 480 active with perhaps only 420 visible due to the CRT bezel. Unlike an auto-scan monitor, you don't get easy control of this and no control of the number of lines.

> "Finally, taking into consideration the limitations of such a device, I only intend for this to be used for full motion video playback, as my current video capture card, as well as all other cards currently on the market, lack the ability to output the video back to the original source (i.e. a VCR or camcorder)."

Unfortunately, even expensive solutions are still limited by NTSC. However, since your playback is often at reduced resolution (e.g., MPEG) to begin with, this may be acceptable.

(From: FoulDragon (fouldragon@aol.com).)

I'll warn you: You can get a box that will make your PC display on a TV, but it will not be worth your while. We use them at our school, they cost from US $100 and up, and the picture, even on a good TV is very poor. If you can afford one of those boxes, buy a used VGA [even monochrome] and use that as you will be much happier.

(From: Terry Lin (tlin@servtech.com).)

I find that with the ATI PC2TV, on a S-Video hookup on a Sony XBR, the image quality is pretty decent. The flicker removal makes even a full white screen easy to look at (provided you have the contrast turned down, which should be done on every set). I have seen what poor external boxes can do, they give me adaches with the flicker and blurriness. Just make sure your setup is right before evaluating the entire PC to TV monitor thing.

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VGA to Composite Video

Realize that no matter what you do, the quality you get on the TV/VCR is not going to be anywhere near what you see on the computer screen. You must keep this in mind when designing layouts, selecting text fonts and font sizes, etc. The new video cards with on-board NTSC/PAL output should be better than your average cheap converter but don't expect miracles.

> "I need a bit of advice on converting VGA or SVGA to output suitable for a color composite monitor and/or a regular NTSC standard television. I have seen add on cards or outboard boxes that will convert VGA to standard TV but I am not sure if this will have the same effect on a Color Composite Monitor. You see I am wondering if it would be more cost effective to keep my old Apple Color Composite Monitor and buy the necessary hardware to convert VGA output from my IBM clone or to just go ahead and buy a bottom end 14" VGA monitor? Can I even get true 24 bit 800 x 600 color performance out of a TV or a color composite monitor?"

A color composite monitor may be somewhat better than a good TV but it is still limited by the NTSC standard - mainly horizontal resolution but color rendition as well. There is no way to get even basic VGA performance (640 x 480) from a TV or composite monitor.

You are much better off getting a bottom-end SVGA monitor for your PC. As noted, the resolution of a TV or composite monitor is not even good enough to do justice to VGA (640x480) when using the composite video input. Direct RGB can be better but the pitch of the CRT relatively coarse dot or slot mask or aperture grill is then likely to be the limiting factor. A composite monitor or TV will give you approximately 480-490 lines vertically but 10 to 15 percent of these may be hidden by the CRT bezel due to overscan. However, horizontal resolution is much worse. You will be lucky to get half the VGA resolution (300 to 350 lines). For SVGA, there is simply no way to display 800 x 600 without expensive scan conversion on such a tube and you will not be able to read text or display clear graphics. In addition, since the composite monitor or TV is interlaced, there will be annoying flicker of graphics with thin horizontal lines.

Save your pennies - prices for basic monitors are dropping. Your Apple monitor may work fine on your VCR, however.

(From: Jerry Roush (roush_jerry@htc.honeywell.com).)

There is an "inexpensive" device available from JDR Microdevices that works fairly well, called the AVerKey (JDR part no. VGA-NTSC) They are about $100. It also has S-video output.

VGA to Grayscale Composite Monitor

This will only work if you can program the video card to produce a compatible resolution and scan rate.

If you would like to experiment, here is a really simple circuit that may work well enough for combining Hsync, Vsync, and one of the VGA color signals, say green, into a composite video.

If the monitor sense lines on the VGA connector are tied MS1 (pin 12) = GND, MS0 (pin 11) = no connect, then some programs will default to monochrome and use a reasonable color map. I don't know how you will get a reasonable mapping to monochrome for the others.

All you will need are 4 resistors.

I am calling your connector on the monitor 'Composite Video In'.

- Hsync through 500-1K ohm (R1) to Composite Video In.
- Vsync through 500-1K ohm (R2) to Composite Video In.
- Green Video through 200 ohm (R3 - variable) to Composite Video In.
- Green Video side of R3 to Ground through an 82 ohm (R4) resistor.
- Tie this ground to the BNC or RCA connector ground.

```
                         R1
        Hsync o--------/\/\/------------+
                                        |
                         R2             |
        Vsync o--------/\/\/------------+
                                        |
                         R3             |
  Green Video o----+---/\/\/--+---------+--------o Composite Video In
                   |     ^    |                    (Termination = Hi Z)
                   \     +----+
                   /                    +--------o GND of monitor
                   \ R4                 |
                   /                    |
                   |                    |
 GND (shield) o----+--------------------+
```

It is essential that all this be built as close to the monitor as possible for best signal quality.

Set monitor video termination for Hi-Z. R4 provides the cable termination to minimize reflections and ghosting of the green video signal.

Set your video card for negative sync polarity.

You may need to tweak these values for best results. This will depend on your actual signals. The variable R3 may provide enough range for this.

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TV or Composite Video to RGB (Analog or Digital)

NTSC to CGA

> "Does anyone know how to convert a video out signal into a signal usable by a CGA monitor (RGB + H and V sync)?"

If your CGA monitor is TTL, then it may not be possible, at least not without modifications to the monitor. You need to convert from NTSC to RGB. There are single chips (with a few external components) solutions to this. Try Sony, Philips/Signetics, and Analog Devices (I think) as well as others. These take NTSC (or PAL) and output RGB and sync. CGA is not analog (continuous range of video values). It is TTL with Red, Green, and Blue signals as well as a separate Intensity signal. Unless your CGA monitor can take analog video (.7 V p-p) inputs, you will still only be able to get 8 or 16 colors - not a normal TV picture. (And even for that, you will need external circuitry to convert the analog output of the decoder chip to TTL.)

However, some CGA monitors have internal NTSC composite inputs and in that case, it is simply a matter of flipping the appropriate switch.

Composite Video (NTSC/PAL) to RGB

Several companies provide single ship solutions requiring only the addition of a few discrete components to convert NTSC or PAL to RGB and H+V or C sync. Some have options for YIQ, S-Video, and other formats at the input or output in as well.

See: Tomi Engdahl's (then@neppari.cs.hut.fi) Video chips and circuits page:

- http://www.hut.fi/Misc/Electronics/videochips.html

for an extensive list of video encoder, decoder, sync, and other chips with links to their datasheets. Also, check out the web sites or databooks of Sony, Philips, Brooktree, Motorola, Linear Technology, etc.

One example is the Motorola MC44011. (However, it would appear to not be a currently available part as of Summer, 2001, as I could not find it on either the Motorola or On-Semi Web sites).

This part can be used without an external delay line (for PAL to RGB) but a delay is recommended. The chip also provides an A/D sampling clock output for video digitizing applications.

(From: Julie Porter (Julie.Porter@efi.com).)

I was able to get my Sony PVM Monitor to successfully take a YC input on the RGB port. I used the MC44011 and it worked! However be advised. The MC44011 has just been announced for last buy this month! March of 1999. There are no other non digital solutions. The TDA3330 has been unavailable for some time. There is some additional information on my Video Animation Web site. I urge people to call Motorola and ask that this component, not be discontinued as there are many web references designs that use it. There are no substitutes. It should also be noted that if people are considering these designs then they should get the parts soon. The part will go out of production this fall (1999).

(From: Jeremy Todd (bulb@cix.compulink.co.uk).)

Sony makes at least two PAL decoder chips - CXA1621S and V7021.

It looks like you'd need a separate sync stripper (LM1881 or EL4581CN)

Brooktree's Bt812KHF is a much fancier thing for video processing and multimedia stuff.

From RS(UK) both the Sony chips are 10UKP each for 1 off's. The Bt812KHF is 107UKP!!

(From: Sam).

Also, some questions are along the lines of the following:

> "I looked at several chip manufacturers. Most have extensive documentation on their chips in PDF format. Again, most of the chips currently available convert Y/C to digital RGB, and have a lot of extra brightness/sharpness control built in. Too complex- the simplest chip I came across was 18 pins and still required two dozen external components."

(From: Eugene (eugenek@istar.ca).)

The answer is: MC44011 by Motorola, cost $28(Can). It requires some sort of a micro to program it (PIC or the like will do).

There is no external critical components except for a 14.318MHz crystal (found on any PC motherboard).

About the old TV single-chip decoders. This is not true, I've been working with those things for 15 years, and in 70-80s the decoders were much more complicated than they are now (each decoder, actually, requires a delay line (sometimes more than one) and a bunch of various filters). Yes, you had one chip and half a dozen of coils, trim-caps to tune (that required some equipment and knowledge).

Sorry, the chip I suggest has 44pins :-(but little hassle :-)

Watching TV on a PC Monitor - NTSC/PAL to VGA

Questions are along the lines of the following:

> "I'm wondering whether I could use my NEC Multisync as a TV. Long ago I had a Mitsubishi Colour Monitor which could also be directly connected to the videorecorder. Sure, I could use cards in my PC like "WIN/TV", but then every time I want to look TV I have to switch on the PC as well.
>
> Is there the possibility to convert a video to a VGA signal? My NEC has only a VGA input. Or: Are there any monitors available which have both inputs (like my old Mitsubishi)?"
>
> "I have a VGA monitor That I want to use to watch TV. I want to be able to maybe build a box that will let me plug a vcr video out into the monitor. I do not want to spend tons of $$$$$. Can anyone tell me if there is a way to do this??"
>
> "I have a HI-FI VHS that is attached to my stereo. Therefore, my audio needs are well taken care of. I now need the video. I had to sell my TV a little while ago so I do not have a T.V. at this point. I have recently acquired a 20" monitor for my PC (DFI brand.) It has the RGB (red-green-blue) connectors on the back along with a Horizontal and Vertical cable connections. So I have a cable that plugs into my video board on my PC that turns into 5 connectors at the end that connects to the monitor."
>
> "Does anyone have any information on viewing composite video on SVGA type monitors. I have a MAGNAVOX SVGA monitor and if possible I'd like to feed composite video from my VCR and Sony PSX and PANASONIC 3D0 to it. Rather than getting a Toshiba TIMM monitor there has to be some kind of blackbox that will allow someone to do this...Please send info to the address provided or post here."

It depends on your monitor:

1. The monitor needs to support the NTSC scan rate - 15,734 H, 60 V. Some NECs do (like the 3D) but others do not (like the 2A).

2. You need to convert NTSC to RGB. There are boxes on the market for this or if you are handy with electronics, single chips to do this. Check out Sony, Philips, Analog Devices, Motorola, and others for NTSC/PAL to RGB decoder chips.

For PAL (625/50) the relevant resolution is closer to 800x600.

If your PC monitor scans down to 15.734 kHz, then all you need to do is convert the line level NTSC composite to RGB and sync. Some older auto-scan monitors like the Mitsubishi AUM1381 even have a composite NTSC input jack. Conversion requires a single chip and a few discrete components. Commercial converter boxes are also available.

However, if it is a modern SVGA/auto-scan that does not go below 31.4 kHz, then it is a non-trivial problem requiring a video A/D, frame memory, readout electronics, video D/A, etc. This is called a scan converter and is not an afternoon project even for an experienced design engineer.

You can of course buy PC cards that will enable you to watch TV in a window on you PC.

There are also external boxes that will accept antenna/cable or NTSC/PAL composite input and drive a VGA monitor. One such unit is the 'Proview' (Proview Technology, Garden Grove, CA). This is reviewed in Popular Electronics, June, 1997. It appears to be quite capable with its own internal 181 channel tuner and IR remote control. It accepts both RF (antenna or cable) and composite inputs and can select between the video source or computer to drive the monitor (but does no processing of the computer's VGA signal - full screen only). With a suggested list price of $119, the Proview could represent a cost effective alternative to a new TV if you have a VGA monitor sitting around collecting dust.

Some others can be found at:

- http://www.aver.com/lite/products/avertvgenie.html
- http://www.aimslab.com/home.htm

(I have no personal experience with any of the above products --- sam).

In any case, a $150 TV may actually produce a better picture. This is because the CRT/electronics in a computer monitor is optimized for focus at the expense of brightness. Therefore, sharpness may actually be excessive and brightness may be inadequate except under subdued lighting conditions (especially on a well worn monitor!).

(From: Helmut Weber (Helmut.Weber@hamburg.sc.philips.com).)

There are some companies that have boards ready, which you only have to buy and plug into your PC. Try:

- http://www.como.com
- http://www.miro.com
- http://www.2fast4u.com

(From someone else. --- sam).

> "I want to display output of VCR on my computer monitor. Is there a video card that has Video In (such

as RCA in)? Would you tell me which video cards they are? Or does anyone know any other way to display VCR out on a computer monitor? Or Is there a PC monitor exist that has RCA input jacks?"

(From: Todd McCormick (todd@galstar.com).)

There are lots of video cards that have video capture and real time display from RCA phono and S-Video inputs, Matrox Rainbow Runner (which requires a Matrox Millenium/Mystique 220/G200) or the upcoming Marvel, the ATI All-In-Wonder and it's decendents.....

There are several other cards that fill this bill. There are external devices that attach to your parallel ports, or USB port, or Firewire port which can also do this. Some of the older Diamond monitors also had video input as well as a computer input but they were quite expensive.

Comments on TV to VGA/SVGA Conversion

You need a lot more than cables. Here are some comments:

1. Your SVGA monitor must be able to sync down to 15,735 Hz Horizontal - the NTSC scan rate - this is CGA speed and few modern monitors go this low. You thus need a scan converter - not cheap.

2. You need to convert the composite video or S-video out from your VCR into separate RGB and possibly H and V sync. This means electronics not just wires.

3. You will need a good switchbox to select between the sources, you cannot just hook them together.

4. The quality of the TV video on your expensive SVGA monitor will likely be worse than on a $150 TV due to the fine focus of the monitor and the possibly lower brightness. To put it simply, the monitor is too good for NTSC video.

5. Why tie up your computer system watching TV? The other alternative is to get one of those TV tuner and/or frame grabber cards for the PC.

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Video Standards Conversion

NTSC to PAL

"Does anyone know of a simple way to convert NTSC signals produced by American video equipment to UK PAL signals."

If you simply mean the color conversion, then a couple of chips will do it.

There are chips to do RGB to NTSC or PAL color encoding but not, as far as I know, scan conversion. For your needs, look into Sony, Philips, and Analog Devices, Motorola, and others.

See: Tomi Engdahl's (then@neppari.cs.hut.fi) Video chips and circuits page:

- http://www.hut.fi/Misc/Electronics/videochips.html

for an extensive list of video encoder, decoder, sync, and other chips with links to their datasheets.

As has been pointed out, using the strict definition of NTSC to PAL as referring only to the color encoding, all you need is a couple of chips for NTSC to RGB and then RGB to PAL, maybe even a single chip. However, for the very common interpretation of NTSC to PAL (IMHO, maybe a little USA-biased) is with respect to US NTSC 525 line 60 Hz systems to PAL 625 50 Hz systems which is where the non-trivial part comes in.

If what you really mean is NTSC 525/60 Hz to PAL 625/50 Hz, it's not trivial.

- The horizontal and vertical scan rates differ 15734 vs. 15625.
- The number of lines/frame differ 525 vs. 625.
- The color encoding differs.

If you simply want to watch an NTSC tape on a PAL TV it may work but not with proper color if the vertical has a wide enough range to sync or you have a vertical hold control with enough range. If your intent is to put it into a VCR, you can safely forget it.

The usual way is to use a scan converter. Essentially, an NTSC color decoder/A-D feeds a frame buffer (approximately VGA size). The frame buffer is then read out at PAL rates and the necessary interpolation is performed using digital processing to go from 525 (480 or so active) to 625 (580 or so active) lines. The output is sent to a video DAC and then color encoded for the PAL system. Everything all happens in real-time.

Needless to say, this is not your basic hobbiest afternoon project.

Here are some additional comments:

(From: Clive Tobin (tobin@nwus.com).)

Conversion is not a trivial matter, involving interpolating scanning lines, changing the field rate, and changing the color encoding scheme. I am not aware of a simple chip set that will do it. There are several ways of doing it with bought equipment, listed in order of increasing price:

1. If you can stand to look at it on your computer instead of your TV, you can buy TV tuner cards with video input jacks, that will display NTSC on your VGA computer screen. I think I have seen these for around $100.

2. Buy a multistandard TV, which are becoming increasingly popular and don't cost much more than single-standard ones. You would not need an NTSC tuner if it has a video input jack. (I don't know if your camera has an RF modulator as well as a video output.)

3. Buy a standards converting VCR, such as Aiwa HV-MX1, Samsung SV-4000W, or similar. These can be used as a stand-alone converter, or to convert the video to record tapes in a different standard. These sell for around $600 and up. I think they all have RF modulators to feed your TV set if it is lacking a video input jack. If you get one of these you could go into the standards conversion business, converting home tapes of overseas relatives.

   Editor's note: Not all multi-standard VCRs do what you want. Some/many simply convert the color encoding between NTSC and PAL without affecting the scan rate (which is much more difficult/expensive). A wide vertical range TV or monitor might produce a viewable picture with these but at the wrong speed (off by 5/6 or 6/5 including the sound)! Unless the product specifications clearly state 'full conversion' or 'scan rate conversion' or something similar, you can probably assume they take the cheap way out! Make sure you can return the VCR if it doesn't meet your needs! --- sam.

The cheapest of all, if you can stand to see the image in black and white with the vertical size off, would be to plug it into the video input jack of a PAL monitor that has a wide-range vertical hold control. Don't use the RF (antenna) input of a regular TV as it may not work at all because of the different carrier frequencies. (You did buy one with video and audio jacks, didn't you?)

(From: Geoffrey S. Mendelson (geoffm@pita.cs.huji.ac.il).)

There are digital converters that do this "on the fly". Akai (and Radio Shack in the US) sell a VCR for $500-600 (US) that works well. Panasonic sells the AG-W1 (NV-W1) that is an excellent VCR and a much better converter for about $1800.

You can also buy just the converters.

Avoid VCR's that claim to play PAL tapes on NTSC TVs. They convert the color signal from PAL to NTSC (well enough for the kiddies to watch tapes), but assume you can "stretch" the sync of your tv to work with 50Hz video.

(From: Tim Jacobs (timothy.jacobs@gecm.com).)

The output from these PAL VCRs won't always record properly, because they take advantage of the fact that the TV can put up with some signal variations that a low-bandwidth VCR (such as an ordinary VHS machine) can't.

The other big problem is the higher frame rate of NTSC as opposed to PAL. In NTSC you have 30 frames per second against PAL's 25. PAL frames have 100 more lines than NTSC frames. So to convert, you have to drop 5 frames each second, add 100 lines every frame, and then you have to worry about the Colour!

This is very complicated if you want good quality.

Here in the UK, there is a VCR available from, IIRC, Panasonic, that will convert between PAL, NTSC, and SECAM (French system). You chose your input system which is either from socket inputs or the tape play-back, and your output system which is to socket outputs or tape record. The machine then does the conversion for you.

The only problems I see with this VCR are, no TV Tuner, and they cost around 1000 UKPounds.

(From: Chris Hall christopher.hall@bbc.co.uk).)

At a broadcast level, probably the best known TV standards converters are made by Snell and Wilcox. I have also used a Barco unit. At a PC level, Vine Micros made a number of boxes for much less money than broadcast kit which do the conversions between PC (and Mac) video standards and broadcast ones. (From: Steve Darsey, N5PMB (sdarsey@yahoo.com).) We use a Sony DSC1024G everyday, does what you ask. Up to 1024x768 to NTSC or PAL video in composite, component (RGB or Y,RY,BY) and S. It will also go the other way. NTSC or PAL to a computer monitor. Also does NTSC to/from PAL. It will also do aspect ratio conversion. Did a letter box from a 16x9 source, no sweat. I have also seen it used to down-convert HD to SD TV.

The Hyperconverter is very comparable, at the time of our purchase, it did not do much more than pure scan conversion from the PC to video. I have no knowledge of their current model.

If price is no object, look for the Fulsom 9000 series boxes. Those machines can deal with much larger (over 1600x1200) pixel rates and will probably walk your dog and water the plants. :)

Find an AV rental or convention show production facility and see if they rent one. We use Alford Media, they have a few locations around the country.

What is a Scan Converter?

A scan converter accepts video of one format - say SVGA - and outputs it to some other format - say NTSC. Some are designed for fixed input format while others can adapt - possibly automatically like an auto-scan monitor - to a wide range of input scan rates and resolutions. Output format is most often selectable between NTSC and PAL scan rates (or those of other TV formats) with a variety of output options such as composite, RGB, SCART, and S-Video.

The typical scan converter must implement the following functions. (This example applies to a unit designed to convert from SVGA or workstation video format to NTSC):

1. Analog to digital converter (A-D or ADC). In the case of VGA/SVGA or workstation video, there will be 3 video signals - R, G, and B - and each of these must be digitized separately. The A-Ds used are generally single chip 'flash' types using a bank of voltage comparators (e.g., 255 compares for 8 bits of output precision) or similar technique to achieve the high speed conversion needed in modern video applications. These may be able to convert up to 135 M samples per second or more as they must run at the dot clock rate of the RAMDAC of the input video source. A filter (input anti-aliasing) may be needed to limit the bandwidth of the input signal. Ideally, the sampling will be adjusted to occur at the center of each pixel but this is not always possible.

2. Full frame store. The resulting digitized data - usually 6 to 8 bits for each color - is stored in a frame buffer generally constructed from DRAM or VRAM. This memory must be capable of being written to and read out effectively at the same time - dual port or pseudo-dual port. In some special cases, less memory is needed but these are the exceptions. With VRAM, the input may use the serial port since it is strictly sequential (and very high speed) and the readout can use the random access port for interpolation (since its rate is lower but multiple pixels and lines may need to be accessed, see below).

3. Readout and interpolation. Hardware must be able to access the frame store without conflict at the desired output scan rate. Since the output video format has a different (generally fewer) number of pixels per line and total scan lines, some means must be provided to combine multiple pixels and lines into the output video stream. For interlaced output (as used by most TV standards), some amount of interpolation between lines (in the vertical direction) is desirable to reduce the flicker of fine horizontal lines (in graphical material) which would otherwise fall in a single output video field. For RGB full color, there is a separate interpolator for each color channel.

    - Nearest neighbor interpolation simply uses the closest sample from the stored data. This is very easy to implement since it is just a matter of computing a memory address - often by just truncating bits. However, quality is poor - pixelly - and usually unacceptable for all but the least critical and cheapest applications.

    - Bi-Linear interpolation takes pairs of input pixels in the horizontal and vertical direction and combines them to form an output pixel that is their weighted sum. This results in a much smoother and more pleasing display. Since two pixels on each line and and two lines are required for the computation of each output pixel, the bandwidth requirements of the frame store and processing complexity are greater resulting in a more expensive system. However, this is the minimum level of interpolation required to produce decent quality output video.

  - Cubic or higher order interpolation uses more than two points in each direction resulting in somewhat better results at greatly increased cost. This is likely to be found mostly in the high performance professional equipment used in television studios and production houses.

   The output of the interpolator is typically 6 to 10 bits of data for each color channel.

4. Video digital-to-analog (D-A or DAC) converter. A high speed DAC (three for RGB) converts the each of the interpolated data streams to an analog signal. A filter (output anti-aliasing) may be needed to smooth edge transitions.

   - For driving RGB monitors, this is the final output.

   - For NTSC or PAL, RGB along with H and V sync are further processed by an RGB-to-NTSC/PAL encoder. It may output be composite video as well as separate Y and C to provide for various output connector options: RCA or BNC, S-Video, SCART, etc.

5. Microprocessor control. Most modern scan converters use sophisticated computer control to provide for advanced levels of auto-scan, many user conveniences, stored setups, and so forth. Features may includes various amounts of user or RS232 (PC) controlled pan, scroll, and zoom; control of sampling times and speeds; and selectable levels of interpolation to control smoothness or sharpness.

However, in the end, no matter how the scan converter is implemented, if the ultimate destination is an NTSC or PAL TV, the resulting picture quality will be very limited. Even a $20,000 professional scan converter may not be able to display fully legible VGA on an NTSC or PAL TV.

For more information on features and selections of scan converters, try:

- http://www.extron.com/scancon.htm

(I have no affiliations with this company and am in no way necessarily endorsing any of their products or claims.)

Implementing a system of this type is a challenging task even for an experienced engineer with extensive design experience with both analog and digital systems.

(From: Derek Roberts (der@cam-orl.co.uk).)

If you really want to do this properly, check out the Genesis Microchip gmVLD8 which uses DSP techniques to do the un-interlacing. Of course you need to add an A-D, field or frame store and some control, But this is the basis of a decent quality scan converter.

What is a Scan Doubler?

This is a special case of a scan converter where the output format has roughly twice the number of lines as the input format and runs at twice the horizontal scan rate. Various scan doubler boxes are available commercially. For example, check out the offerings from Harmonic Reseach. (I have no idea of whether they are any good - just an example.)

The following is described for NTSC; A similar approach can be taken with PAL 625/50 to SVGA at 800x600, 50 Hz.

To convert NTSC interlaced at 30 frames/second 60 fields per second to VGA which is at 60 complete non-interlaced frames per second requires a simple scan converter. This is basically an NTSC color decoder and video A/D feeding a full frame memory storing RGB (probably at 24 bits), and VGA video D/A. I say simple to compare it to the general case where in addition to frame store, you need a high speed interpolator to convert between resolutions. VGA is close enough to NTSC resolution (at least in terms of the number of active video lines) that no interpolation is needed. See the section: What is a Scan Converter?. In either case, this is a non-trivial project. IMHO, this is a poor use of an expensive monitor. A $200 TV will likely look better.

An even simpler approach is possible as well which only requires a one or two line buffers instead of a full frame store. Each input line is read in and reformatted to the appropriate VGA line (even or odd) depending on which field is being displayed. The other lines are blanked (i.e., display even lines and blank the odd lines during the even field display). This would only require enough buffer memory for one or two scan lines (depending on whether the implementation uses a double buffer or more sophisticated write and read timing) which would be a significant cost and complexity savings compared to a full frame store. The disadvantage is that since half the lines are by necessity left blank, the maximum possible brightness of the display will be reduced. It is not possible to use the blank lines as the interleaving of the even and odd fields will be incorrect and result in a poor display.

Inexpensive scan doublers do exist. For example:

(From: Jeffrey Kessler (kessler@fas.harvard.edu).)

I picked up a device called the "Video Cheese Box" from a company called TVOne. This is a $70 box that acts as a rudimentary line doubler. It takes a composite or S-Video input and outputs a 640 X 480 60 Hz VGA signal.

The picture is dramatically better than on a regular TV.

I'm in no way affiliated with this company except for having purchased one of their products.

Scan Doubler Chips

Several companies now provide single chip (or minimal chip) solutions to a major part or all of this problem. For example, Siemans has just announced the SDA9400 Scan Rate Converter which appears to includes nearly everything required - even the buffer memory - to convert from interlaced to progressive (i.e., non-interlaced) scan in Y-U/V format.

(From: Richard Birchall (birchallr@aecl.ca).)

AverLogic has a chip that makes the task of implementing a scan doubler almost trivial. From their product description: "The AL250 is a 64 pin single chip scan doubler/de-interlacer. It converts interlaced TV signals (e.g., NTSC or PAL) into non-interlaced RGB format for output to a PC monitor or LCD panel. The single device also corrects color accuracy on different types of CRT and removes jagged edge artifacts from motion pictures. To allow a regular PC monitor to display television or video input you just need to add a de-coder and the AL250."

What is a Scan Divider?

For the special case of converting from VGA at 640x480 (31.4 kHz H, 60 Hz V) to NTSC or SVGA at 800x600 (31.4 kHz H, 50 Hz V) to PAL, something simpler than a full blown scan converter may be satisfactory. In this case, it is only necessary to provide storage for a single scan line (rather than an entire frame store) since the input horizontal frequency is (almost) exactly twice that of NTSC (15.734 kHz) or PAL (15.625 kHz). A double buffer where one buffer is storing while the other is reading out at approximately half the VGA pixel rate should work. With appropriate timing, even lines become the even field and odd lines become the odd field (I may have this backwards). It is still not a trivial undertaking. Keep in mind that the quality you will get on NTSC or PAL will be poorer than the VGA due to fundamental NTSC or PAL bandwidth limitations. Also, flicker for line graphics will be significant due to the interlacing at 30 Hz.

RGB to PAL Converter Chips

(From: Gary L. Sanders (75052.2665@CompuServe.COM).)

Philips has chips, as does Raytheon, these would take digital RGB and convert to oversampled PAL output.

(From: Mike Diack (moby@kcbbs.gen.nz).)

Analog devices does a chip (AD720) which has the delay & filter elements on the chip itself.

Digital Video Conversion Chips

> "I'd appreciate on an Integrated Circuit (IC) made by a Hong Kong company called Display Research Laboratory."

(From: Philip Decker (pdecker@lds.loral.com).)

The IC is a Video Interlace Processor (VIP), part number VIP-01033. It converts 16-bit digital VGA video (5:6:5, R:G:B) to similarly formatted NTSC/PAL compatible video.

The IC can also be bought as part of a circuit board with additional components, producing composite, Y/C, and SCART analog RGB outputs, in three different configurations:

- piggy-back to VGA, via feature connector ($55)
- external VGA to TV converter ($90)
- ISA bus card with VGA included ($180)

Black Level Clamp

> "I'm looking for a simple GOOD black level clamp circuit for clamping a video signal."

(From: Joseph H Allen (jhallen@world.std.com).)

This is actually a very interesting subject. Assuming you have a constant video level (or AGC), a simple diode clamp on the horizontal sync tips (diode clamp the sync so that the black level is where you want it) is actually a high quality black level clamp. The sync level is constant after all. I use this method in accurate video digitizers for DC restoring the video before putting it into an A/D converter. The cool thing about simple diode DC restorers is that the capacitance is usually much less than that of the analog switches needed in other types. For example one of the best analog switches is the readily available 74HC4316, but even this has 40pF (if memory serves) on its pins.

The really hard part is finding a high quality large-signal linear video amplifier. If the video is capacitor coupled to the video amp, then the average brightness level will change the voltage of the black and sync levels seen by the amplifier. This is ok if the video amp is linear, but most aren't so the sync amplitude ends up changing depending on brightness. I.e., the black level will change depending on the brightness of the image (this is completely unacceptable for medical image capturing devices, for example).

The way linearity is measured for video amplifiers is the term "differential gain". It gives the largest difference in percent between a constant small amplitude signal (traditionally the color carrier is used for this) measured at different voltage levels (hopefully which sweep the entire output swing of the video amplifier).

Now you have to be very careful about manufactures differential gain measurements. Many of them play games to get even a mediocre 3% - 1% differential gain. Typically they specify this parameter with a reduced output range (when you really want the parameter to apply to rail-to-rail output swings so you can get a 2V signal needed for most A/D converters) or limit the input range, the gain or flat out lie (I have no idea where comLinear got the specs for their clc520/522 variable gain amplifier, for example. It says .5% in the datasheet, but I measure it to be more like 5%).

All older video amplifier ICs (like the uA722 and NE592) are really lousy. Discrete transistor amplifiers also suck (many monitors use a cascode amplifier which is very bad). Most new ICs suck too- especially those which are labeled as video amplifiers. The only ones which I have been satisfied with are the newest current feedback OP-amps (the + side is high-impedance, but the - side is zero ohms. Usual op-amps are linear, but have a limited bandwidth because the - input is high impedance). These have enough open-loop gain so that they really are linear. One that I really like is the AD9617: .01% differential gain (!), 160MHz bandwidth, immense slew rate (settles to less than 1% of final value within 10ns or so) and only costs about $10.

If you need variable gain (for AGC perhaps), the best chip to use the AD834 500MHz multiplier. This little 8-pin chip is expensive (like $40) but it is the only thing that even approaches being linear (and even it is quite a bit worse than the AD9617).

(From: Brian Campanotti (bcampano@toronto.cbc.ca).)

Look at the Clamping ICs from Gennum Corp (part numbers GB4550 and GB4551). They do input buffering and clamping. They are a good front end to any video project.

(From: Mika Iisakkila (iisakkil@alpha.hut.fi).)

Since your application probably needs some kind of an input/output buffer anyway, you might consider some integrated DC restored video amplifier. Elantec makes excellent such chips; data sheets are available on their web site under "application specific: video".

EL2090 is really good as far as video quality goes, but a bit expensive for applications that don't need 100 MHz bandwidth and near-zero droop. EL4089 is simpler and cheaper, but not quite "broadcast" quality. There's also some new chip, but I haven't looked into it yet.

For both chips, you'll need to get the sample pulse from somewhere, so you can't lose the LM1881. I've used the burst gate output from it to control 2090's sample input, and quality of the result far surpasses my measuring instruments.

Inverting an Analog Video Signal

Inverting a video signal means doing something to both the luminance (intensity) and chrominance (assuming a color signal). This is not totally trivial (at least, it is more than just putting it through an op amp). You would have to convert to baseband, strip off the sync and invert the signal, recombine with sync, remodulate to channel 3 or 4.

If you want to also invert the colors, then you have to decode the chrominance to RGB, invert these, reencode, recombine, etc.

The assumption here is that the input is an NTSC or PAL composite video signal and that the desired output is a valid composite waveform with negative sync tips. In this case, what is required is as follows:

- Sync separation to identify and preserve the sync relationships.
- NTSC or PAL to RGB conversion.
- Inversion of the individual RGB components.
- RGB to NTSC or PAL conversion along with the sync.

Bypassing the conversions would be messy as you would be dealing the chroma phase space - I wouldn't even want to risk a wild guess as to what would be involved.

For monochrome video, the conversion steps would be replaced with a simple inverting amplifier and possibly an analog switch to merge the sync.

There may be some shortcuts one can take but you get the picture (no pun).

(From: Joel Kolstad (kolstadj@CSOS.ORST.EDU).)

Also note that straight video signal inversion will produce some... interesting... color changes, but not the same changes as you get from photographic film. For monochrome video, the end result will look like a photographic negative.

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Miscellaneous Video Conversion Topics

CGA Boards with NTSC Output

Old CGA cards had RCA outputs. Usually those cards had one monochrome monitor output and other output was composite video (usually NTSC).

CGA to VGA

This requires both converting the signal levels from TTL to analog as well as doubling the scan rate since modern VGA monitors will not go down below 31 kHz H. CGA is around 15.7 kHz. If you aren't fussy about how the colors map, the signal level conversion may be just some resistors. However, the scan rate conversion requires capturing the data on each line and spitting it out twice in one line time, and providing the proper H sync to match. This would consist of a double buffer digital line memory (for the CGA TTL bits) and timing logic to store line n while reading out line n-1 twice at double the rate. It's all doable but not a project for a digital novice.

NTSC/PAL to RF (Channel 3/4) Output

This is called an RF modulator. Every VCR in the universe has one of these and the vast majority are in self contained modules that can be reused. It will be the silver colored metal box that has the two RF (antenna and TV) connectors.

These are also available from surplus electronics outlets for under $5 or as generic replacements for VCR servicing for $12 to $20.

The only connections required to make them work are a source of regulated power - 5 to 12 V depending on model and possible s control voltage to select output instead of pass-through mode.

SVGA Monitor on Sun Sparc

This question comes up somewhat less frequently than the opposite (Sun fixed or dual frequency monitor on PC SVGA):

- It needs to accept the single or dual fixed frequencies put out by the Sun frame buffers. This shouldn't be a problem for most modern higher-end SVGA monitors but it should be confirmed. These specs should be in the Sun user manual.
- It needs to accept composite sync. Sometimes, this is listed as a feature in the monitor specifications. Or, it may work but not be advertised where the monitor is to be connected to a PC (i.e., why manufacture more than one version of the monitor circuitry if you don't have to?). Else, you will need an adapter to separate the H and V sync.
- You will need a 13W3 to HD15 cable. Unless the adapter cable provides them, the monitor sense lines will not be present (at least not automatically), so you may have to tell the Sparc the resolution explicitly.

(From: jmz@southwind.net).

Most any multisync "VGA" style monitor will work with the GX, TX or CG3/CG6 frame buffers on a Sun Sparc. Commercial 13W3 cables and adapters are available or you could get the instructions from a couple of places on the net.

I use my ViewSonic 17s on both Macs and Suns.

You should have a copy of Birdsall's Sun FAQ and you may wish to join the Suns-at-Home mail list, for all Sun self-maintainers. Use a search engine for these and they should vector you to the cable pinouts as well.

S-Video to Composite

(From: David Kuhajda (dkuhajda@locl.net).)

Usually the chroma line (C) is passed through a capacitor and tied to the luma line (Y) after it is passed through a resistor. Usually 470 pF and 100 ohms.

Composite to S-Video

Basically, all that is needed is to separate the Y and C signals. It would probably be best if the C were put through a high pass filter to remove the Y and Y were put through a low pass filter to remove the C but the following appears to work with just a cable and a small capacitor.

- Tomi Engdahl's S-Video to Composite Video Page.

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Items of Interest

Various Video Standards

- Various Standards for Analog Component Video

General VGA Information

(From: Tomi Holger Engdahl (then@tinasolttu.cs.hut.fi).)

VGA monitor pinout can be found at:

- http://www.hut.fi/Misc/Electronics/docs/old/vga_bd15.html

and more related links at

- http://www.hut.fi/Misc/Electronics/pc/video.html#connections

VGA signal timing details are documented at:

- http://www.hut.fi/Misc/Electronics/docs/pc/vga_timing.html

Information on how one commercial VGA to TV converter grabs a VGA signal can be found at:

- http://www.hut.fi/Misc/Electronics/circuits/vga2tv/box800.html

Information about video signals in general can be found at:

- http://www.hut.fi/Misc/Electronics/video.html

Comparison of Composite, S-Video, Component Video, and RGB

(From: Dave Martindale (davem@cs.ubc.ca).)

Composite is better than using an RF modulator and feeding the signal into the TV tuner but is otherwise the worst of them all.

S-video uses two signal paths, luma and chroma. It's better than composite video, which mix both together into a single signal.

But component video is better than S-video. With component, you have three separate signals - usually Y, R-Y, and B-

Y. This bypasses the subcarrier encode/decode process entirely, and gives better quality.

There's also RGB, which is potentially just a bit better than Y/R-Y/B-Y, but can also be considered a different type of "component".

TV Capture Cards for PCs

Here are some Web sites of companies who market various video products for PCs.

- http://www.hauppauge.com/hcw/index.htm
- http://www.aimslab.com/f_products.htm
- http://www.fast-multimedia.com/fast/html/products/products.html
- http://www.tekram.com/tvcaptur.html
- http://www.miro.com/e/e2-products/products.html
- http://www.diamondmm.com/products/visualization/dtv-1100/
- http://www.matrox.com/mgaweb/mediaser.htm#mediatv

But be careful, what they say is not always the reality...

Here is an example of a homebuilt video digitizer:

- http://www.ucl.ac.uk/~ucapwas/video.html

Mixing of Independent Video Sources

If they are truly independent, then this is a non-trivial problem. You will need to either:

1. Genlock the two video signals so that they are in sync before mixing. Depending on the sources, the difficulty may range from easy to impossible. Production video equipment will probably have the necessary inputs and outputs. Consumer stuff probably will not. For mixing N signals sources, N-1 will need to have genlock inputs.

   If this is not possible then (assuming two sources):

2. You need a real time programmable video delay. This would typically consist of a video A/D, dual ported frame store, readout delay timing logic, and video D/A. Since there is no way to assure the precise phase stability needed for PAL encoding, you would probably need to separate the luminance and chrominance and deal with them separately.

   The delay would need to be anywhere up to 1/2 frame (or 1 frame if only one of the sources can be delayed). Not an afternoon project. For N sources, you would need N-1 0 to full frame delay units. Also note that commercial broadcasts will sometimes shift frame reference when cutting between remote locations which are not genlocked. If these sources are to be supported, you will need an automatic adjustment scheme to maintain synchronization.

For info on the availability of commercial devices, you may want to post to one of the video newsgroups - rec.video.production, for example.

Studio Video Recording or Filming Directly from Monitors

> "I'm designing graphics for a computer that is used on a the set of a TV show. When the camera operators shoot the screen, horizontal lines roll up and down. I assume it has something to do with the scan rates. I know there is a small program for the Macintosh that corrects this, but I know of nothing for the PC. Does anyone know?"

(From: Dic (dic@werple.mira.net.au).)

This depends on whether they are shooting on video or film. There are display cards for PC which allow you to dial up the vertical output rate, which you want to match to either 30Hz(NTSC frame rate) or 24Hz (typical film frame rate). Multiples are fine, i.e. 60 or 48Hz respectively.

But that isn't the end of it. You may have (approximately) matched the frame rate of the camera, but you have to also lock them together as there will be a certain amount of drift due to slight differences in the two scan (frame) rates. For film there are devices called a Computach or a Synclock, which attach to the movie camera and take a video input (you can just feed it sync from your PC card but you may need to fiddle the level or polarity).

On set, they roll the camera and adjust the shutter phase so the vertical blanking bars on the PC fall in between movie frames. The synclock then keeps the camera perfectly synchronized to the PC sync.

If you're shooting on video it's a bit harder. You need to genlock the video camera to the PC, which can be awkward as the PC sync may not be quite steady enough (directors HATE having to lock to ANYTHING).

The hardest thing to do is run several PC's in the same shot, because they won't be scanning in sync; you can lock your camera to only one at a time. If anyone knows of PC videocards that can be genlocked together I'd be very interested.

We do a lot of this kind of work and at the end of the day, particularly if there is more than one PC in shot, we record the computer graphics to video and use Amiga monitors, because they look like PC monitors but take video input. We use Umatic or Betacam tapes because the playback machines can be drum locked together. Obviously though, if you need a high degree of interactivity with the actor, this won't work too well.

The vertical blanking bar on a PC is quite fine so if they aren't in the foreground you can usually get away with just matching the vertical rate of the PC as close as possible to that of the video/film camera. You won't see flicker, just a fine dark line moving up or down the picture slowly.

That is about the sum total of my experience but if anyone else has better suggestions I'd be very interested. I have seen some TV/movies with multiple computers in shot with no sign of flicker or blanking bars; maybe the bars are just too fine to show up?

(From: falcon@tao.agoron.com (Tom Strano)

In my personal experience, I've found that simply setting the video mode on a PC to 640*480, any color depth, and a 60 Hz refresh rate, results in a very stable picture, even when taped with a cheap consumer camcorder and no attempt at synchronization. I've done this with at least 3 different computers, all with different monitors and video cards, and it always works fine. Perhaps I'm just luckier than some technicians...

Video Controller Timing

> "I wonder if anyone could tell me a good reference on how CRT controllers operate. Specifically, how do the HSYNC, VSYNC, BLANK, and dot clocks interact. Or, would some kind soul like to explain it?

Thanks."

I am not exactly sure what you really want but here are some simple descriptions:

- DOT Clock: the pixel clock. 1/(Pixel period).
- Hactive: the time during which video on a line is actually displayed.
    - Hactive*DOTclk=#Pixels.
- Hblank: the time during which no video is displayed and the beam is being retraced.
- Hsync: positive or negative pulse during Hblank which synchronizes the horizontal deflection circuits of the monitor.
- Htotal: Hactive+Hblank.
- Vactive: the number of lines during which video in a frame is visible.
- Vblank: active for the number of lines during which video is not visible and the beam is retracing to the top of the screen.
- Vsync: positive or negative pulse during Vblank which synchronizes the vertical deflection circuits of the monitor.
- Vtotal=Totaltime=(Vactive+Vblank)*Htotal.
- Csync: Hsync combined with Vsync usually be ORing or XORing.
- Cblank: Hblank Ored with Vblank.
- Composite video: Video combined with Csync usually the video is .7 V p-p positive-bright riding on top of .3 V negative Csync.

For RGB, some monitors will want 'sync on green' which is this type of signal only for the green video. R and B and just the straight video. Mono composite is this signal. NTSC/PAL: RGB color encoded and modulated. Composite video is used for the luminance (intensity) with the color information modulated on a subcarrier (which is ignored by a B/W TV).

One source for info on timing specs is the data sheet for a video DAC or RAMDAC. They will usually define all of these parameters.

Sync Generator Chips

(From: Rob-L (rob-l@mars.superlink.net).)

DigiKey lists 74ACT715PC-ND as "Video Synchronous Generator NEW!" It is a 20 pin DIP and costs $17.50 each for small quantities. The surface-mount version is SC instead of the PC in the above number. You have to pay an extra $1 for the datasheet if you want one. 1-800-DIGI-KEY is their order line. http://www.digikey.com/ is their web address.

(From: (opal@opal.co.il).)

Try philips SAA1101.

Sync Separators

(From: Myron Brookshire (harris.mbrooksh@ic1d.harrris.com).)

Try using the National Semiconductor LM1881 It's a 8 pin DIP that does exactly what you need.

I think it costs @ $8.00 and you only need a couple of caps externally.

(From: Jan Arvidsson (janarv@algonet.se).)

The EL4583C from Elantec has a dedicated HSYNC output in addition to CSYNC and VSYNC outputs, available on the less expensive LM1881 (National). It is of course very easy to derive a pure HSYNC signal from the CSYNC output!

Dead VCRs and Composite Monitors

Most VCRs go to their graves not because of electronics problems but because of the death of the tape transport. Or, perhaps, because the owner was not willing to spend the money or take the time to resuscitate (or has killed it due to improper servicing). Of course, it might just need a 50 cent rubber tire (but that is for another FAQ). What this means is that the tuner and video circuitry is generally as good as the day the VCR rolled off the assembly line.

If you have a composite monitor (probably gathering dust at this point), then this in conjunction with the otherwise useless VCR will result in quite a nice TV. Many CGA monitors as well as early auto-scan or multi-scan monitors have NTSC (or possibly PAL) compatible composite inputs. Some even have built in speakers. A set of RCA patch cables and you are all set. Since they were designed for high resolution (at the time) computer applications, the quality is generally excellent. (Note: I do not make the same quality claims for modern SVGA monitors as their display is optimized for high scan rate computer video and not CGA or NTSC). In addition, controls are usually accessible to permit any desired degree of underscan or overscan.

It may even be possible to use the VCR's timer to turn your rig on and off automatically! (It just requires faking out the record/cassette interlock and locating a signal that can be used to control a power relay.

Conserve your landfills - save a VCR!

Video Cables

> "Does anyone know about the specifications of the video and sync signals for VGA monitors?"

Video: .7 V p-p, (more positive is brighter).

Sync: separate horizontal and vertical TTL signals. May be either polarity.

> "I am trying to send VGA signals over some 180 feet of cable, I'd especially be interested in the required line impedance of the cable."

Line impedance: 75 ohms terminated at both ends.

> "Is it possible to produce a Composite Sync signal (or maybe even a composite video signal) that could be fed into an off-the-shelf VGA monitor, so I could use only 3 instead of 5 coaxial wires in parallel?"

RG59U 75 ohm coax is what is normally used, but you will need a good quality cable to go 180 feet without too much signal degradation. Of course, it also depends on what resolution and thus what video bandwidth you need and how much dispersion (signal delay as a function of frequency) you can tolerate.

It is relatively easy to combine the H and V syncs together and then combine these with the video (usually the green signal for 'sync-on-green') but most low cost VGA monitors do not support this mode and you would then need to separate the signals at the far end. You could come up with alternative ways of combining the signals to save on cables but these will all complicate your circuitry at the monitor end. There are multiple coax cables inside a single sheath for just this purpose.

Building a 5 BNC Cable

This is straightforward, if time consuming and tedious.

The five coaxial cables (75 ohm, RG59 typical) are wired as shown in the table. The corresponding VGA connector pin numbers are in ().

```
   Coax Center         Coax Shield
---------------------------------------
  Red Video  (1)      Red Return (6)
  Green Video  (2)    Green Return (7)
  Blue Video  (3)     Blue Return (8)
  H Sync (13)         Ground (5,10)
  V Sync (14)         Ground (5,10)
```

Tie pin 11 (ID0) to Ground to indicate a color monitor. Leave pin 12 (ID1) open.

Make sure that the lengths of the cables are fairly well matched - to within a couple of inches - to assure that the 3 color channels line up precisely. (One foot of cable is about 1.5 to 2 ns of delay which is significant for a 10 ns dot clock!).

Also note that you will lose your 'Plug-and-Play' capabilities without the direct control connections to the monitor (or for monitors without these features).

That's it!

You will wish that your fingers were about 10 times smaller than they are, however. :-)

Tweaking the Deflection Rates of a Fixed Frequency Monitor

Pulling a fixed frequency monitor by more than a few percent will likely be a problem. I know this is not the answer you were looking for but getting a new inexpensive video card, video card designed for fixed frequency monitors, or new monitor, may be a better solution.

If you insist, the adjustment would be called something like horizontal oscillator, horizontal frequency, or horizontal hold. If you do tweak, mark everything beforehand just in case you need to get back to the original settings.

WARNING: Make sure you understand the issues involved in working inside a monitor! See the document: Safety Guidelines for High Voltage and/or Line Powered Equipment. Something that looks innocent can really ruin your whole day!

There is also some risk to the monitor - changing it too far may result in damage either immediately (the horizontal output transistor or power supply may blow) or increase component stress reducing reliability and shortening its life. There is no way to know without looking at the design.

Modifying a CGA (or EGA) Monitor for NTSC or PAL Input

These are often high quality monitors and would make nice TV displays - especially as there are many no doubt gathering dust on their way to the dumpster!

However, these are digital (TTL) monitors with respect to the video inputs and proper linear video amplifiers may not even be present. Therefore, you may need to implement both the NTSC or PAL decoding as well as boosting the signal levels to the hundred volts or so needed to drive the CRT.

The scan rate of CGA is the same as NTSC so deflection is not a problem.

For PAL (625/50) instead of NTSC, the vertical rate will need to be reduced to 50 Hz but this should not be a problem. The horizontal scan rate is close enough (15.625 kHz).

Similar comments apply to EGA monitors that have a compatible scan rate. EGA represents a range of scan rates between 15.75 kHz and 21.85 kHz so this should not be a problem.

How Can I Determine Monitor Specifications or Whether It Supports SVGA?

There is no easy way to tell by just examining the monitor visually. Even those with only a 9 pin rather than a 15 pin connector are sometimes SVGA (e.g., Mitsubishi AUM1381 and NEC Multisync II which will do 800x600 at 56 Hz V non-interlaced and 1024x768 interlaced at 43 Hz V).

You cannot even safety test scan rates on all monitors - some will blow up or be damaged by being driven with incorrect video.

For a monitor that you already have, posting the model number or looking it up is really the only way to be sure of its capabilities.

Quicky tests:

1. Check the video connector. If it has a high density (VGA) 15 pin connector then there is a greater likelihood of SVGA but not always.

2. Check the manufacturing date on the back. If it has a manufacturing date of 1991 or later, the likelihood of it supporting SVGA is higher as demand for VGA-only monitors was rapidly declining by this point.

3. Check the dot pitch on the CRT by examining the screen with a magnifier. If it is really coarse, the monitor

probably cannot do anything beyond VGA.

4. Become familiar with the major manufacturers and models so that you will recognize the common SVGA models.

While not conclusive, positive results on the first 3 of these tests definitely increases the likelihood that it supports at least some SVGA modes. Of course, if you recognize a model number, you have dramatically increased your odds of success - assuming it works!

The following URLs provide quick access to the general specifications of many common PC and MAC compatible video monitors:

- Griffin Technology
- Hercules
- Monitor World
- Rasterstone
- Table of monitor specs

Low Cost VGA Hacking

Typical question:

> "I have an old mitsubishi monitor, model number C3919N, Scan rate is 15.5-23.5kHz horizontal, analog. I want to run video from my pc svga card into this monitor. I found the correct video mode, resolution, etc. in which it works, but have one problem. I get two perfect images displayed on this screen."

(From: Martin Moeller (mmoeller@delphi.com).)

I have a copy of a very detailed book on using old 19" monitors for VGA:

- The Cheap VGA book
  Self Published by a Michael Johnson, Esoteric Electronics
  35-R Derryfield Road
  Derry, NH 03038
  Night only Phone: 1-603-434-8494

This book contains a lot of good information and advice. He also sells kits for less than $50 (see comment below --- sam) to make the sometimes needed sync inversion from VGA. (VGA cards invert H and V sync depending on mode to tell the monitor what rate to go to. As far as I know only IBM ever used this.)

I have not tried his kits but the book is very good. BTW if you pay much more than $300 for a 19' surplus monter you have been moderately had. I do not have any other connection with this person, I just think his book is very good if you are even thinking of using a "non-VGA" monitor with a VGA card.

(From the Editor).

A circuit to perform the automatic sync polarity correction is shown at:

- http://www.hut.fi/~then/circuits/vga2tv.html

The cost of the parts for this circuit is probably under $5 even if bought from Radio Shack.

Note: I believe there may be a problem with the use of normal or LS TTL for the sync buffers of this circuit due to their sourcing of current when the input is LOW. A gate with a Low Level Input Current of less than .2 mA should be used. (--- sam)

Real Time Multi-Screen Displays

These are the type of displays used to view multiple video inputs simultaneously on a single screen - security monitoring, for example.

You have two problems: compressing the signals to 1/4 screen and synchronizing them. The straightforward (though not simple) approach is to digitize each at 1/4 resolution into a frame buffer which is read out at NTSC rates. This overcomes the issues of genlocking and timing of the 4 quadrants.

On-Screen Display Implementation

> "I am looking for chips that do on-screen display of text and simple graphics. I've got some information about a Philips chip PCA8516 which seems to be a pretty nice complete chip for doing everything I want. Are there other chips out there that do this as well?"

(From: Jack Climent (rocket5@haven.ios.com).)

When you are looking for something for the consumer marketplace, Look toward Mt. Fuji :-).

The MB88303 from fujitsu is an "NMOS Television Display Controller" And the NJM 22075 is a "Sync & Video SuperImposer". These two chips and very little else form a complete on screen text & Min graphics system. Add a uC and you are in business. Also low cost and easy to implement. Have hardware & software someplace if needed.

(From: Winfield Hill (hill@rowland.org))

This isn't an easy thing to do, as quite a bit of electronics is required. Fortunately, this function is needed for TV sets, VCRs etc and several manufacturers have created custom VLSI chips to do the task, which is called On Screen Display or OSD. For example, Phillips, SGS-Thompson, Rohm, and NEC, etc. all make OSD chips. Some, like Motorola, include the OSD function within a microprocessor.

I like the NEC uPD6464A chip.

Using an OSD chip, you can roll your own design (e.g. see Sept and Oct 1996 Electronics World, which uses a discontinued chip!), but it's still a non-trivial task! One easy solution is to purchase an OSD already on a pcb, with all the extra circuitry and C source code software. E.g. BOB-1 from Decade Engineering in Turner, Oregon (503-743-3194). It uses the Rohm BU5963AS chip and cost $169 each ($200 with the software).

SCART Site

- http://www.mindspring.com/~kjack1/scart.html

Video Resizing

> "I'm looking for a device to do resize (in horizontal direction only) of a video signal. Basically I need a fractional decimator (in this case 2:3). Harris has some stuff that might be useful, and Phillips has some devices but I think they're more geared towards NTSC/PAL (data rate here is around 20 MHz, but, then again, isn't the luminance typically sampled at a pretty high rate?). Anyway, I also know I could do it in an FPGA with bit-serial arithmetic, but I'd rather buy something."

(From: David L. Tosh (dlt@earthlink.net).)

Check out:

- http://www.gennum.com/vbprofam.htm

Gennum makes several multirate filters vor video resizing.

Video Resolution of Various VCR Formats

Luminance Specifications:

- VHS (240 lines) - FM Dev: 1 Mhz; Freq Range: 3.4-4.4 Mhz. (Sync tip - White)
- SVHS (400 lines) - FM Dev: 1.6 Mhz; Freq Range: 5.4-7 Mhz.
- BETA1 (250 lines) - FM Dev: 1.3 Mhz; Freq Range: 3.5-4.8 Mhz.
- BETA2/3 (240 lines) - FM Dev: 1.2 Mhz; Freq Range: 3.6-4.8 Mhz.
- SuperBETA (285 lines) - FM Dev: 1.2 Mhz; Freq Range: 4,4-5.6 Mhz.
- ED BETA (500 lines) - FM Dev: 2.5 Mhz; Freq Range: 6.8-9.3 Mhz.

The above refers to resolvable horizontal resolution - the maximum number of vertical lines that can be seen using an arbitrary high quality monitor to view the VCR's output. Also, this applies only to luminance - intensity, not color. The color resolution is much lower and in the particular case of SVHS vs. VHS at least, not improved over VHS since it is recorded in exactly the same way. Also, I don't know whether this is a just noticeable difference (JND) or percent response type of spec where the lines are really just resolvable.

Vertical luminance resolution in the monitor or TV is determined by the video standard (NTSC, PAL) and the quality of the monitor or TV. Specifically, for NTSC (525 total lines for NTSC) there can be a maximum of 482 or so active video lines and something like 580 for PAL (625 line). The remaining lines are for blanking and sync during retrace. These are physical scanning lines.

Vertical luminance resolution for the VCR is determined only by the number of active video scan lines for each standard.

Factors which reduce the effective vertical resolution are CRT focus (spot size) and stability of the interlace, and Kell factor. (See the section: What is Kell Factor with Respect to Interlaced Displays?.

Depending on the video standard, vertical color resolution may be less.

Depending on the video source, there will be a variety of other factors which reduce the effective resolution horizontally and vertically.

What is Kell Factor with Respect to Interlaced Displays?

(From Bob Myers (myers@fc.hp.com).)

The Kell factor - which has to do with the fact that we're often undersampling an image from the standpoint of the Gospel According to St. Nyquist - IS a factor in the reduction of vertical resolution, but interlacing plays a part as well. This comes from at least two factors:

1. The monitor or receiver usually cannot precisely interleave the two fields.

2. More importantly, there are steps taken to reduce the interline flicker which reduce the effective vertical resolution. This includes running the line width of the display somewhat larger than would otherwise be the case, and in interlaced cameras, discharging the entire screen (including the lines from the "other" field) after every field scanned.

Interlace is particularly troublesome on moving images, where you will often perceive momentarily "missing" details. There was a LOT of discussion regarding the gory details of interlacing in the recent HDTV debates within SMPTE and other groups.

- Back to Video Conversion FAQ Table of Contents.

Common PC Video Connector Pinouts and Assorted Monitor Info

Many of these are also available at the Sci.Electronics.Repair FAQ site (and its mirror sites) in the document: Pinouts for Various Connectors in Real Life(tm).

Also see the connector info at:

- http://oacosf.na.astro.it/rossi/hwb/hwb.html
- Gamesx.com - A/V and Miscellaneous Pinouts

Video Graphics Adapter (VGA)

Note that IBM called VGA 'Video Graphics Array' probably in reference to the video memory. However, we will use the more popular terminology since it agrees with the naming conventions of the other PC standards.

Original VGA (31.5 kHz - 640x480)/SVGA (35-37 kHz - 800x600) 15 pin sub D:

```
                                                                6
 1 Red (Analog)   6 Red   Return    11 (ID0) GND (Color)    11. . . 1
 2 Green (Analog) 7 Green Return    12 (ID1) NC (Color)       . . .
 3 Blue (Analog)  8 Blue  Return    13 Horizontal Sync        . . .
 4 Reserved       9 No Connect      14 Vertical  Sync         . . .
 5 Ground        10 Ground          15 No Connect             . . .
                                                            15  10  5
```

Note: Monitor ID Lines ID1,ID0=NC,G for color; G,NC for Mono. ID0 only may be used.

Mono VGA is similar using only the Green Video and Return.

VGA (VESA Standard)

(From: Bob Myers (myers@fc.hp.com).)

Note that many of the pins shown above as "no connects" (actually, these were sometimes used as monitor ID bits by many manufacturers) are now defined under the VESA Display Data Channel standard. This standard provides two protocols for display ID and control, including support for the full ACCESS.bus interface. The current definition of the "VGA" pinout per the DDC standard is:

```
                                                                      6
 1 Red (Analog)   6 Red   Return       11 Monitor ID0 (opt.)    11. . . 1
 2 Green (Analog) 7 Green Return       12 Data (SDA)              . . .
 3 Blue (Analog)  8 Blue  Return       13 Horizontal Sync         . . .
 4 Reserved       9 +5 VDC (frm host)* 14 Vertical  Sync          . . .
 5 Return        10 Sync return        15 Data clock (SCL)*       . . .
                                                                15  10  5
```

Those signals marked with an asterisk would be supplied by the host only if the host supports the DDC2 protocol (I2C or ACCESS.bus).

VESA Display Data Channel Standard

(From: Bob Myers (myers@fc.hp.com).)

This defined several protocols for digital communications between a host system and its display. DDC provides 3 different modes:

- DDC1 - A unidirectional (display to host only) serial communications system which provides basic display ID and feature support information (including supported timings, display size, colorimetry and gamma, etc.) to the host. This uses pin 12 on the 15-pin "VGA" connector as a data line.
- DDC2B - Adds clock (pin 15) and return (pin 11, I think - I'm at home, and don't have the standard with me) to enable at least ID information to be obtained via an I2C interface. I2C is a bidirectional interface, but display control via DDC2B is not defined at this time.
- DDC2AB - Full ID and control of the monitor via ACCESS.bus. As ACCESS.bus is basically a command and protocol definition on top of the I2C hardware interface, this uses the same lines as DDC2B.

DDC was the first and only definition of the 15-pin D-subminiature video output connector which VESA has provided. No further definitions on this connector will be made, as VESA is instead concentrating on the new Enhanced Video Connector standard which is due out later this year. This will define a completely new connector which will include support for DDC and separate syncs as in the 15-pin D-sub, and will also include support for audio I/O, video input, and the USB and P1394 serial interfaces.

VGA - 9 Pin

This is pretty standard as the NEC Multisync II, Tatung CM1495, and others use the same pinout. However, there is at least one other pinout that has been used which is similar to the CGA pinout. Also see the document: Pinouts for Various Connectors in Real Life(tm).

I used a multimeter to determine this on the VGA to 9 pin adapter for a NEC Multisync II.

> Pin 1: Red Video Pin 2: Green Video Pin 3: Blue Video Pin 4: H Sync Pin 5: V Sync Pin 6: Red Return Pin 7: Green Return Pin 8: Blue Return Pin 9: Ground

Note: IBM PGC assigns pin 4 to Composite Sync and pin 5 is a no-connect.

BTW, don't use an EGA 9 pin extension cable to connect it to VGA. While this will work, the wires are not shielded or the wrong wires and you will get ghosting and ringing at vertical edges. I constructed mine using proper 75 ohm coax for the RGB and H and V sync as well (though it is not needed for the sync).

(From: Carl Mueller).

If you're sure it's a VGA monitor (not CGA or EGA, which are not compatible with VGA), then there are two possible likely pinouts for the plug. I believe they are both detailed in the ibm PC hardware FAQ. One possibility is the CGA pinout, and the other is the 9-pin VGA pinout. Check the grounds to find out.

Enhanced Graphics Adapter (EGA)

p> EGA - TTL (15.74-21.85 kHz) 9 pin:

```
 1 GND                       6 Secondary Green Video/Intensity
 2 Secondary RED Video       7 Secondary Blue Video
 3 Primary RED Video         8 H Sync TTL Positive
 4 Primary GREEN Video       9 V Sync TTL Negative
 5 Primary BLUE Video
```

Color Graphics Adapter (CGA)

CGA - TTL (15.75 kHz - 320x200 or 640x200) 9 pin:

```
 1 GND                       6 Intensity
 2 Unused                    7 Unused
 3 RED Video                 8 H Sync TTL Positive
 4 GREEN Video               9 V Sync TTL Positive
 5 BLUE Video
```

Dell UltraScan 17ES

This pinout may be used by a number of Dell monitors. The connector looks like a standard VGA/SVGA HD15 but is wired differently (for some unfathomable reason).

(From: Chris Lawson (lawsonc@micron.net).)

> Pin 1: Gnd Pin 2: Red video Pin 3: Gnd Pin 4: Green video Pin 5: Gnd Pin 6: Gnd Pin 7: NC Pin 8: VSync Pin 9: HSync Pin 10: Blue video Pin 11: NC Pin 12: NC Pin 13: NC Pin 14: NC Pin 15: NC

Monochrome Graphics Adapter (MGA)

MGA - TTL (18.43 kHz - 720x350) 9 pin:

```
 1 GND                         6 Intensity
 2 Unused                      7 Video
 3 Unused                      8 H Sync TTL Positive
 4 Unused                      9 V Sync TTL Negative
 5 Unused
```

MacIntosh Video

Mac II - analog (35 kHz H, 66.67 Hz V - 640x480) 15 pin. Mac II and Quadra - analog (49.7 kHz H, 74.55 Hz V - 832x624) 15 pin.

```
 1  Red Ground              9 Blue Video
 2  Red Video              10 Sense 2
 3  Composite Sync         11 Ground
 4  Sense 0                12 Vertical Sync
 5  Green Video            13 Blue Ground
 6  Green Ground           14 Ground
 7  Sense 1                15 Horizontal Sync
 8  Reserved (+12)
```

Mac (16") Monitor Info

(From: Dale Adams (adams9@apple.com).)

Note that the Apple 16" monitor is a fixed frequency display - i.e., it only works at one resolution and scan frequency. Here are the partculars:

- Resolution: 832x624
- Pixel clock rate: 57.2832 MHz
- Vertical scan rate: 75 Hz
- Horizontal scan rate: 49.7 kHz

Here's the pinout for the Apple DB15 video connector:

```
Pin    Signal          Description
-----  -----------     ----------------------------------------
1      RED.GND         Red Video Ground
2      RED.VID         Red Video
3      CYSNC~          Composite Sync
4      MON.ID1         Monitor ID, Bit 1
```

```
5      GRN.VID         Green Video
6      GRN.GND         Green Video Ground
7      MON.ID2         Monitor ID, Bit 2
8      nc              (no connection)
9      BLU.VID         Blue Video
10     MON.ID3         Monitor ID, Bit 3
11     C&VSYNC.GND     CSYNC & VSYNC Ground
12     VSYNC~          Vertical Sync
13     BLU.GND         Blue Video Ground
14     HSYNC.GND       HSYNC Ground
15     HSYNC~          Horizontal Sync
Shell  CHASSIS.GND     Chassis Ground
```

You can pretty much ignore the ID bits. You can try the following cable pinouts to match to a VGA connector.

```
 Mac Video DB15                        VGA Connector HD15
----------------                      --------------------

 2  ------------------- Red Video ------------ 1
 1  ------------------- Red Ground ----------- 6
 9  ------------------- Blue Video ----------- 3
 13 ------------------- Blue Ground ---------- 8
 5  ------------------- Green Video ---------- 2
 6  ------------------- Green Ground --------- 7
 15 ------------------- Hsync ---------------- 13
 12 ------------------- Vsync ---------------- 14
 14 ------------------- Sync Ground ---------- 10
```

Mitsubishi Diamond Scan Monitors

These monitors accept PC video (at least standard VGA - 640x480 at 60 Hz - but have non-standard connectors. Here are two types - there may be others.

(From: Tony Matt (tonym@world.std.com).)

Cable for Mitsubishi Diamond Scan 20M (Model HC3925ETK)

```
 Pin Function        PC Connector    Monitor Connector

 Red (Analog)              1                  2
 Green (Analog)            2                  4
 Blue (Analog)             3                 10
 Reserved                  4                  6
 Return                    5                  6
 Red Return                6                  1
 Green Return              7                  3
 Blue Return               8                  5
 Sync Return              10                  6
 Monitor ID0              11                  6
 Horzontal Sync           13                  9
 Vertical Sync            14                  8
```

1. Both connectors are high-density DSUB-15 male (VGA).
2. Cable is marked "CABLE-FA5"; unsure if this is Mitsubishi marking.
3. Cable material is Fujikura E49075 (AWM Style 2560).
4. Color signals are carried on coax with their respective returns.
5. Two wires of the cable are connected to Pin 6 at the monitor end; one of these wires is connected to Pins 4 and 5 at the PC end, the other wire to Pins 10 and 11.
6. Ferrite cylinders are shrink-wrapped around cable near each end.

Cable for 13" Mitsubishi Diamond Scan (Model AUM1391A)

```
Pin Function        PC Connector    Monitor Connector
                    HD DB-15 male   DB-25 male

Red (Analog)              1                  2
Green (Analog)            2                  4
Blue (Analog)             3                 14
Red Return                6                  3
Green Return              7                  5
Blue Return               8                 15
Sync Return              10                  1
Monitor ID0              11                  1
Horzontal Sync           13                 16
Vertical Sync            14                 17
```

1. Cable is marked "Mitusbishi CAT. NO. 246C057-8".
2. Cable material is E41447 (AWM Style 2560).
3. Color signals are carried on coax with their respective returns.
4. Pins 10 and 11 use separate wires in the cable, which are connected together at Pin 1 of the DB-25.

Sun 13W3

This was introduced by Sun Microsystems and is a nice compact robust connector. Other manufacturers have copied it but there are several variations. See: MonitorWorld Video Standards Page. Towards the bottom they have several different 13W3 pinouts. Some only accept composite sync, some have the sync pins reversed, etc.

Pin 1: NC
Pin 2: NC
Pin 3: Sense 2
Pin 4: SRTN
Pin 5: CSYNC
Pin 6: NC
Pin 7: NC
Pin 8: Sense 1
Pin 9: Sense 0
Pin 10: CRTN

Pin A1: Red

Pin A2: Green
Pin A3: Blue

The following I picked off the net so I do not know the accuracy of the resolution table.

Analog: 13W3 connector:

```
         +------------------ * gnd
         |   +-------------- * vertical sync
         |   |   +----------   sense 2
         |   |   |   +------   sense common (gnd)
         |   |   |   |   +-    composite sync
         |   |   |   |   |
         |   |   |   |   |   grey
    red  |   |   |   |   |   green blue
     |   1o  2o  3o  4o  5o    |     |
    (O)                       (O)   (O)
       6o  7o  8o  9o 10o
       |   |   |   |   |
       |   |   |   |   +---    composite common (gnd)
       |   |   |   +-------    sense 0
       |   |   +-----------    sense 1
       |   +---------------- * gnd
       +-------------------- * horizontal sync


    * May be NC. My spies tell me Sun considers these obsolete.
```

The green video input is used by grayscale monitors.

Sense table - 1=nc, 0=strap to gnd

```
  Sense      Type/scan rate
 -------------------------------------------
    0      TBD (?))
    1      Reserved
    2      1280x1024, 76Hz
    3      1152x900, 66Hz
    4      1152x900, 76Hz, 19"
    5      Reserved
    6      1152x900, 76Hz, 16 or 17"
    7      Nothing (no monitor connected)
```

Sun/Sony GDM17E10

(From: Andy Cuffe (baltimora@psu.edu).)

This is a good SVGA monitor (same as Sony Multiscan GDM-17SE). The Sun version doesn't connect the H and V sync lines to the video connector. If you open it, on the the video board there will be a 3 pin connector labeled H sync, V sync, and ground. All you have to do is connect these to some unused wires in the video cable. There will be several wires going to a small board which I think is used for monitor detection, or other functions only used by a sun station. You can just cut any two of these and use them for sync. Cut off the 13W3 and attach a HD15 connector, remembering which pins are used for sync.

If you're not into soldering, I'm fairly sure there is an adapter fit this that just converts the separate sync to sync on green. If I remember correctly, the web site that was selling it incorrectly identified it as a fixed frequency monitor and said you needed one of their special video cards. It is NOT fixed frequency.

Sony PVM-2030 and PVM-2530 Profeel Pro Monitors

(From: Rob Myers (myer3812@nova.gmi.edu).)

I have the pinouts for the RGB connectors on newer Sony monitors (specifically, the PVM-2030 and PVM-2530 Profeel Pro monitors). These pinouts are directly from the owner's manual. The connector used is a DB25 female.

- High state = 5V (open)
- Low state = 0V (short to ground)

Note On Pins 3,4,5,6,11:

- If pin 9 is high/open (Analog RGB mode) then .7Vpp, 75 ohm signals must be input to these pins. Pins 1 and 25 are not used.

- If pin 9 is low (Digital RGB mode) then TTL signals must be input to these pins. Pins 1 and 25 are only used in this mode.

```
Pin   Signal         Descr
---------------------------------------------------------------
1     IBM Select     High: IBM mode (RGBI)
                     Low:  3 Bit TTL (RGB)

2     Audio Select   High: Audio input from pin 13
                     Low:  Audio input from LINE A/B/VTR jacks

3     HSync/CSync    Horizontal or Composite Sync, Negative Pol.

4     Blue Input     Video Inputs: Positive Pol.

5     Green Input    (Sync on green optional in analog mode)

6     Red Input

7     NC

8     NC

9     Analog/Digital High: Analog mode
                     Low:  Digital mode

10    RGB/Normal     High: RGB input selected
                     Low:  LINE A/B/VTR input selected

11    VSync          Vertical Sync, Negative Pol.
```

```
12    Blanking        High: Video input from RGB input only
                      Low:  LINE A/B/VTR signal is superimposed over
                            signal from RGB input

13    Audio Input     -5 dB / 100% mod.

14    NC

15-24 Ground

25    intensity       Positive Pol.
```

These monitors are regular NTSC monitors, but I'm sure they can be connected to computers the same way I connected the KX-2501... using a simple buffer circuit and special video drivers. Another possibility is to build a component-to-RGB converter for really high quality DVD playback (better than S-Video)... the blanking feature seems interesting but the RGB source would have to be synchronized with the composite source. I think the KX's/XBR's have the blanking input, too.

The Sony RGB Multi Input pinout is also valid for the kV-25XBR; it should also work with the kV-20XBR and KX-1901, and I know it works with a KX-2501. (The KX series monitors are the original Sony Profeel monitors from about 1983, and they are very common.)

A female 34-pin floppy connector will mate with the Sony connector just fine. I was able to use the analog RGB input on a KX-2501 to display VGA PC video using a sync level converter circuit and drivers from:

- http://www.hut.fi/Misc/Electronics/circuits/vga2rgbs.html

SGI Octane to Sony GDM-17E21 Cable

(From: Yves DELAY (yves.delay@imag.fr).)

I am trying to connect a Silicon Graphics (SGI) 17" screen display to an SGI Octane CPU. I would like to build my own HD15 to 13W3 cable.

The monitor is standard SVGA with the VESA Display Data Channel (DDC) and works fine on a PC.

SGI OCTANE CPU video pinout (13W3):

> A1 Red (analog)
> A2 Green (analog)
> A3 Blue (analog)
>
> 1 Monitor ID bit 3 (TTL)
> 2 Monitor ID bit 0 (TTL)
> 3 Composite sync (active low), TTL
> 4 Horizontal drive (active high), TTL
> 5 Vertical drive (active high), TTL
> 6 Monitor ID bit 1 (TTL)
> 7 Monitor ID bit 2 (TTL)
> 8 Gnd
> 9 Gnd

10 Gnd

Below is the pinout of the SGI 13W3 to HD15 cable, part number: 018-0500-001, Rev. E VIST 9717, obtained after a phone call to the SGI hotline.

```
 Signal     SGI OCTANE (13W3)                Monitor: GDM-17E21 (HD15 male)
----------------------------------------------------------------------------

 Red              A1                        1      Red
 Red Gnd          A1 Gnd                    6      Red Gnd
 Green            A2                        2      Green (+ composite sync)
 Green Gnd        A2 Gnd                    7      Green Gnd
 Blue             A3                        3      Blue
 Blue Gnd         A3 Gnd                    8      Blue Gnd

                                     Pins 6, 7, and 8 tied together, along
                                       with both connectors metallic shell
                                       and cable shield.
```

Notes:

1. ID3 (1): not used
2. ID0 (2), ID2 (7), and Gnd (8): all tied together.

3. Other pins: not used.

S-Video Note that this is often called S-VHS. I don't know whether this is correct. I assume that S-Video refers to the use of separate luminance (intensity) and chrominance (color) signals and that S-VHS refers to a modified recording standard for the VHS tape format to achieve higher resolution on special S-VHS tape. S-VHS may or may not use S-Video signals and vice-versa.

In any case, S-Video uses a 4 pin mini-DIN connector. Viewing from the female-end with the key at the bottom:

Pin 1 (lower right): Y Ground
Pin 2 (lower left): C Ground
Pin 3 (upper right): Y (Intensity/Luminance)
Pin 4 (upper left): C (Color/Chrominance)

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-- end V1.94 --

RCA/GE TV (CTC175-187+) Solder Connection and EEPROM Problems

Version 2.02

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

The procedures described in this document require access to potentially dangerous voltages, proximity to the CRT and its implosion risk, and other possible dangers lurking inside a television set. Furthermore, while your symptoms may fit those described below, there is no guarantee that resoldering the tuner module WILL fix your problem. The actual cause could be elsewhere.

We will not be responsible for personal injury resulting from attempting these repairs nor damage to the equipment that may result from lack of soldering experience or inadequate desoldering or soldering equipment.

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Introduction

IMPORTANT NOTICE: If you find that your TV has symptoms matching those caused by bad solder connections as described in this document, or have had an RCA/GE/Proscan TV repaired for similar symptoms, or are just curious, there is a class action suit pending against Thomson Consumer Electronics which if approved, may entitle you to a cash rebate. Go to the TOB Settlement Information Website for more info and a claim form. The deadline is May 20, 2001.

Scope of This Document

Problems with bad solder connections, mostly in and around the tuner are very common with several series of late model (e.g., CTC175-187 and higher chassis) RCA/GE/Proscan TVs. Ignoring these erratic and intermittent problems can lead to serious damage including failure of the EEPROM and possibly other expensive ICs. Therefore, it is essential to deal with the solder connections as soon as these symptoms appear. The repairs are straightforward though perhaps tedious. Thomson may reimburse for reasonable cost of repairs.

Also, some LXI TVs may actually be of RCA/GE manufacture: LXI is sold by Sears. If the model number starts with 274.something it is an RCA CTC176/7 or 187 chassis. (pwhite4@aol.com (PWhite4).)

Sometimes, similar symptoms are the result of bad solder connections elsewhere on these chassis. Check around the pins of large components like power transistors, power resistors, transformers, etc. However, since problems with the tuner soldering are so common, this is usually the place to start.

Note that many other RCA chassis as well as other manufacturer's TVs are also susceptible to similar symptoms with similar causes.

Some of the common symptoms include:

- Random power cycling. It may come on in the middle of the night!
- Picture shifts or changes size vertically or horizontally.
- Picture turns to snow or shows other reception problems.
- Picture turns to random display of time or other data.
- Noisy or muted sound, volume buttons have no effect.
- Remote has no or unexpected effect.

The articles in this document have been compiled over the last few months from postings on the USENET newsgroup sci.electronics.repair.

Contributions are welcome to increase the coverage of this set of notes as well as those for the very similar set of problems and solutions for late model Sony TVs: "Sony TV Tuner and IF Solder Connection Problems". (Symptoms are very similar and repair requires removing and resoldering connections inside the tuner and IF boxes. Unfortunately, at least on some models, removing these modules is a real treat!)

Proper attributions will be made for all providers of solutions. I apologize if I have incorrectly referenced you or left your name off. I will be happy to make any necessary corrections in the next revision. Please email me with any additional sections. I would very much like to improve the details of the repair procedure if possible.

Corrections and additions to any specific symptom or solution are also welcome.

I have no connection with Thomson Electronics or any other manufacturer of consumer electronics. These articles have been included unedited except for some spelling, grammar, and format cleanup.

Problems with CTC195 and More Recent Chassis

(From: David Kuhajda (dkuhajda@locl.net).)

The CTC195/197/203 series with the onboard tuner has a batch of other problems, not the same type of failures that the CTC177 line was notorious. Most of which are addressed with service bulletins given the units serial number. However they are suffering from a conductive glue syndrome the Thomson engineers are still in denial about. It seems the glue they are using to attach the surface mount components is sometimes becoming conductive from the manufacturing process and will cause all kinds of really odd intermittent problems, most of which cannot be fixed unless you get lucky enough to see it several times while working on the set. Specifically c17503 and c17504 inside the tuner, and some down by the microcontroller are the most common culprits.

The latest Thomson sets we have been seeing have a stand up tuner that runs off the I2C bus, but those are failing at an alarming rate. Seems they are using the same I2C prescaler IC by Philips that Zenith and Sony are using and also having high failure problems. If you generate too much static by sneezing near the cable line you can blow one of these ICs. For a cheap TV set if you can live with the poor focus, contrast, and poor convergence on most of the Thomson sets, they are comparable with everything else that is selling that cheaply.

Safety

Before removing the case on any TV or monitor, make sure you understand AND follow the safety guidelines provided in the document: Safety Guidelines for High Voltage and/or Line Powered Equipment.

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Solder Connection Problems and Solutions

Symptoms of Cracked Solder Connections

Here are some typical sets of symptoms resulting from bad solder connections in and around the tuner of these late model TVs:

> "I have a 26" RCA television with a "squeezed" vertical and "snowy" picture, at its worst times it also shuts off and on again. This problem is occurring 50% of the time, I noticed that tapping the panel where the 75ohm and rca connectors are attached will realign it temporarily. Is this a symptom of the "solder cracking I read about in RCA's or a bad EEPROM and if it is a bad EEPROM why does a smack offer a quick fix and why is it shutting off and on?"
>
> "This picture is short vertical about 1/2 inch at top and two inches at the bottom. Anyone seen this problem on this chassis. Is it possibly related to all the bad solder joints in the tuner area?"
>
> "I have an RCA TV with the following symptoms:
>
> - The audio will suddenly switch to maximum volume.
> - The volume buttons on the TV and the remote control have no effect on the volume during this time.
> - If the blaring condition occurs and I attempt to adjust the volume very low, then when the condition returns to normal, the volume comes back at this very low volume. So the signal to adjust the volume must be received by the controller while the speaker is blaring.
> - If I use the remote to mute the volume a slight diminishing in the volume can be noticed, but the mute is not accomplished.

- If I cycle power, the problem persists, unless I leave the unit off for a while (sometimes 30 seconds, sometimes a few minutes) before turning it back on.

- If I adjust the volume to minimum and turn on the muting, just using my stereo for sound from the VCR, the TV will still begin to blare in short burst and then eventually come on and remain at full volume."

"My parents' RCA TV has lost some volume, and is now barely audible when on full volume. The controls are all electronic and on screen. Is this a known problem with RCAs, and could there perhaps be a pot I could adjust inside to 'boost' the volume?"

"I have a GE 31" (about 3 years old) where the picture moves down the tube, like a DC offset is present. The top of the picture is down about 1/3 from the top of the screen and the bottom of the picture compresses. Occasionally, the picture turns to snow. If I turn off the power and back on, it temporarily cures the problem. Could these symptoms also be caused by poor tuner connections?"

"I have the SAME TV, and mine is about 1/5 off. Some channels also have lots of Snow etc."

"I tried using a VCR as a tuner & running the signal in through the RCA plugs in the back. Same difference. I still experience the same problems. Does this rule out the turner?"

"I am having the following problem with the TV:

- The screen will go black and display: 1:5P A-- (the "P" is sometimes an "8" or possibly a "B")

- The screen will suddenly go from showing a picture to show nothing but "snow". There is no sound, the remote control won't shut it off, the power button on the set won't shut it off, it has to be shut down by unplugging it.

- When it is plugged back in it will sometimes come back on without pushing the power button or using the remote, screen shows nothing but snow, no sound.

- Sometimes when it is plugged back in it works normally (won't come on until you push the power button or use the remote), it then acts normally except there is no sound until you use the remote or the buttons on the set to adjust the sound."

"My RCA XL-100 TV has begun to develop a life of its own -- it intermittently goes crazy."

"My two and a half year old GE 25" set started having troubles with the picture shrinking from top to bottom, losing signal strength (snow) and now shifting of the picture off the bottom of the screen. This would occur usually right after turning it on, and sometimes could be cured by turning off the set and turning it back on again. Lately it has been getting worse so I took it in for repair. Lo and behold, there were several GE and RCA sets there that had similar complaints. All ended up needing an "S-kit" from GE, an item apparently supplied to the repair center for free from GE. I needed a crystal as well. This sounds like some kind of widespread problem that maybe should be looked at as if it is an unwritten warranty? Anyone care to comment?"

"I have a 27" GE Model 27GT610. About a year ago a problem started to develop. It would take turning it on 2-3 times before the picture came up. Initially all I would get was a black screen and static on the speakers as if it wasn't on a broadcast channel. Over the last year it has progressed to taking me 20-30 minutes to get the picture to come on. I suspect it might be a corroding startup relay but am unsure. Does anyone have a part# and component# that could point me in the right direction? Any other suggestions would also be appreciated. Thanks, btw I already have the FAQ.

"I have a 2 year old RCA XL100 television. It has worked just fine up until the last 2 or 3 weeks. I now have severe problems with it and am hoping that someone who reads this posting will recognize the symptoms and help steer me in the right direction to fix the damned thing! I know of another person who had the exact same model and 2 years after he bought it, it started acting up in the same way, so I assume this is a well documented problem that I'm seeing...

When the set is turned on, the "reception" on some cable channels is terrible, but others are fine. Turning off and on again fixes those channels, but within a few seconds, the reception goes bad again. There is a time display function and a mute function on the TV. When I press a button, the channel displays in the upper right corner. Likewise in the lower left corner with mute. When the TV is misbehaving, these words "walk" down on the set. The MUTE word goes so far that it's unreadable since only the tops of the letters show. Turning off and then back on temporarily solves the problem. Whenever this phenomenon occurs, the top of the picture gets "squashed" down and a black band appears at the top of the screen. When I look at CNN, the sportsticker at the bottom is almost unreadable and it appears that the lower part of the picture is forced into the non-viewable area of the screen. If I struggle through these problems for an hour or so, then everything is almost back to normal, but the problems do appear intermittently. When I switch over to the VCR tuner, my reception problems are solved, but I still get the screen "walking" behavior, so it looks to be more that the tuner chip (unless that also controls these extra functions). Does anybody know about this problem??? Is it just a bad chip or component that I can replace? What should I do about it? (I'm a EE and am quite capable of fixing simple soldering problems and such myself). Before I take it to a repair shop or buy a new one, I'd like to see if I can fix this one... in a word... HELP!"

"I have an RCA FMR70ER TV that only works when the room temperature is warm. If the temperature is cool the TV will never turn on .

"The problem tends to show up after the TV has been on for a few minutes. The picture will appear to have signal problems (i.e. a snowy picture), and then the top line of the picture will begin to dip down, until it is approximately 25% of the way down the tube. There is just black above it. When its really bad, the picture will be just snow, the top will drop down almost half, and there will be a very bright band at the bottom of the screen. Now, one way to remedy this problem is to shut the TV off, and then back on again. Sometimes this will 'reboot' the TV and the picture is fine. Sometimes it doesn't work.

The problem is beginning to become more persistent and annoying!"

"I have a General Electric 21" (or 23"...can't remember) colour remote control television. It's about two and a half years old.

The problem we're having is that the picture is 'dropping' off the bottom of the screen. This sometimes happens shortly after turning the TV on, or sometimes not for some time after turning the TV on. What happens is that the whole picture seems to move down a bit on the screen, then it moves a little further, then before you know it, there's about a couple of inches of black at the top of the screen, above the picture. You can't see the bottom of the picture because it is now below the bottom of the screen (i.e. the picture doesn't just shrink). Sometimes a bright white line will appear at the very bottom of the screen, and after a snapping sound the picture will jump back up (sometimes back to the top, sometimes just part of the way up). Then it happens all over again, kind of random. If you turn the TV off, wait a few seconds, then turn it back on, most of the time (not always) the picture will start out back at the top of the screen as it should."

"2 year old GE has tuner problem. Some channels part snowy others very snowy. Sometimes don't work at all. But, only on some channels.(Vertical is not shrinking). Any case histories?"

"I have a CTC177 that instead of the two relay clicks of the degaussing circuit will click 6-8 times when it is first turned on. Signal was coming from U3101 - changed IC, no change in problem. Works fine once it's warmed up, anyone else have this problem?"

"I have a weird problem, or at least I have never seen it before. I have a GE colour television that when it is initially turned on the lower channels are not existent (snowy) and the upper channels are crystal clear. When the TV has been on for about half an hour, all the channels are crystal clear."

"I had/have the same problem w/ an RCA CTC175. Picture shrunk down to letterbox size. When i was going to check the joints, I turned it on (hasn't been used in a couple weeks), to see if the picture came in full size, but to my surprise i had no picture. When i say no picture i> mean it's like my cable has been disconnected. After a little fiddling here and there i came up with the following:

- Cable box hooked - no picture on any channel.
- Straight cable to TV - only cable channels 54, 55, 64, & 76 (nice and clear).

Should i go ahead and resolder the tuner connections and see what happens or does it sound like the microprocessor may be out?"

"I have a GE TV 25GT543, CTC187AA chassis with a vertical intermittent where a whack on the side fixes it. Is this 'the resolder under and around the tuner' fix? Is there anyway to tell exactly which connection is really the bad one rather than randomly resoldering everything within sight? I like the feeling I get when I know that I have really found the source of the problem rather hope I got it....."

"Volume and channel OSD shifted off to the right so that channels are not visible. Closed captioning and customer menus shifted to the left. Tuner shield was done about a year ago and is ok. Problem occurred after a power surge that caused C7 the main filter capacitor to fail. Otherwise the set seems to work fine. Horizontal and vertical sync pulses are present on pins 26 and 27 of the micro."

General Repair Considerations

Caution: See the document: Troubleshooting and Repair of Consumer Electronic Equipment before attempting to repair or replace the tuner module. You *must* have proper soldering equipment and desoldering tools. Attempting to remove, solder, or replace the modules(s) without these *will* result in a mess and a very expensive bill when you finally take your TV to a professional.

Someone brought me a TV to look at. After a little prodding, it was learned that he had lent it to a friend and it died after six months or so. The 'friend' then attempted to replace the tuner module based on the description on a refused estimate from a TV service shop. He did not have proper soldering equipment - perhaps only a Weller 100 W soldering gun. Needless to say, the TV did not work - nearly every pad on the PC board under the tuner had been destroyed. I had to run wires from the pins on the tuner to the their destinations on the mainboard. It was not fun. Luckly, no permanent damage was done but it could have easily been a lot worse.

I've also heard of at least one case where rather than resolding all the ground connections as described below, a much simpler repair was made by just adding a thick short jumper wire from the metal shield to a ground on the PCB or existing ground wire soldered to the PCB. This probably isn't quite as effective as the proper repair may be a reasonable alternative to try if your soldering skills aren't very well polished. However, I don't know whether this will work on all chassis versions. The specific example was for a CTC187.

About that Special RCA Solder and Soldering of the Tuner in General

Also see the section: That Special RCA Solder - Various Opinions There seems to be some disagreement on whether to use the 'special RCA soler' or not:

(From: Charles Godard (cgodard@iamerica.net).)

The solder RCA recommends doesn't flow properly. The only returns I've had after doing this repair have been because of using their solder. The best way to do the job is to use regular 60-40 lead tin and apply the right amount of heat with a controlled heat solder gun. Too much heat and you peal the board, not enough and it won't stick or will crack again.

I first flux the joint's with rosin solder paste. I clean my tip before starting, and a couple of times during the job. Again, I use a controlled heat solder gun.

This seems like a simple job because it is 'simply' soldering. Don't be fooled. I've been at this business for twenty years and am an expert at soldering. Of the first dozen or so of these sets that I worked on, I had a couple of solder spills that cost me a couple of extra hours to locate because I didn't realize I had made a spill and assumed another problem. Another hazard is that if you are not skilled and attentive, you may loose one of the small resistors or capacitors from the board. If you find it, then you've got to figure out where to put it back. :> If you flex this board you may cause a crack on a resistor or capacitor lead that could be very difficult to find.

In addition to all that, there are some hidden joint's that won't be apparent to even a skilled technician the first time he does the job. (The stuff in the middle :)

If you are a trained technician and do soldering regularly and have a controlled heat gun, and are used to working with these flimsy consumer type circuit boards, then you can probably do it with no problem. There are some jobs that are suited for do-it-yourselfers and I don't hesitate to tell a guy if I think he can do it and save a few bucks. This is not a job I would recommend for the average guy to tackle. I can think of very few solder job's I've ever done that require more skill and attention than this one.

Sorry, I'm sure that's not what you wanted to hear. However, next time you have a problem, just ask. I may have an easy fix for you, and will be glad to give it if I do.

Descriptions of the Solutions

Here are some of the responses - many from experienced techs who fix (too) many of these sets:

(From: J. Caldwell).

Following the instructions packed with the service bulletin will allow a proper job to be performed. Overheating the board substrate and surrounding components will cause future and horrible failures.

The connection will NOT look shiny but shouldn't look bubbly or crinked, the solder will only flow if you use the special solder paste, rosin core solder will cause it to corrode oddly so clean all rosin core off the board.

A standard Weller station does the job quite well and experience has shown me that the full repair with jumpers and the special solder (as the bulletin states) is the best thing to do for reliability and customer satisfaction. I was mistaken in earlier ramblings.

(From: (JohnSon) johntrum@netonecom.net).)

This sounds like the typical shield/pcb solder joint problems that RCA has had made famous with their CTC175/177 chassis. It's a common problem. We have fixed literally "tons" of them. I'm guessing it would be this series of chassis because you also mentioned the EEPROM.

The symptoms you mentioned are all associated with these bad solder connections and there are even more symptoms that can appear from this same problem. No video, color drop, etc. are other common symptoms. Just get your solder iron hot and do a good job soldering ALL bad connections related to the shield areas and you'll be in business again. You'll still just have a "new model" RCA, but, the symptoms you describe should go away. If you catch it while it is in the "smack" condition, you shouldn't need any parts. If you wait until it dies completely, you could be looking at an IC or EEPROM replacement. You DON'T want to replace the EEPROM, trust me!

(From: Jaclyn (lambert@sos.net).)

Possibly.. :) Once you think you've got all the solder connections done - you've only just begun. Also check for cracks on the pads surrounding the tuner grounds. Oh, you might want to order an extra pound of solder before you begin....

(From: Louis A. Iannotta (bouncer@nauticom.net))

The problem is bad solder connections under the tuner shield. The bad connections cause false signals to the EEPROM which cause the reduced vertical height. RCA just recently has issued a bulletin and a kit to repair the connections with a special "elastic" solder which isn't supposed to crack under temperature fluctuations.

(From: Chuck (Nordic@osuunx.ucc.okstate.edu).)

I would open the tuner control module and solder all the posts that are around the periphery of the board. Also on rare occasions, the solder connections break on the main board jack that the plug from the tuner control module attaches to. Resolder them also. Good luck.

(From: JohnSon (johntrum@netonecom.net).)

I am sure you are probably talking about the "infamous" Thomson (the RCA/GE owners) bad solder joint chassis'. They started with the CTC175/176/177 and from what I see they have continued on up through the CTC187 at least and maybe further. You can confirm your chassis number by checking inside the back of the set or on the back of the set sometimes. These sets have a variety of symptoms accompanying the bad solder joints. The two you listed are only a couple. When repairing these sets, all of the trouble areas should be repaired at that time. You will be just asking for more problems if you don't. If you are very technically minded, you may be able to repair this yourself. If not, you could try a local repair shop. I have heard repair prices for this range from $50.00 to $140.00. I don't have any idea what the shops are doing to repair them for $50.00, but, I suspect they may be just going in and soldering the obvious bad joint, at the time. As I mentioned, this would only be a temporary repair at best. The majority of the problems are under the shield of the "built into the board tuner", but, there are others also. I know our charge to repair them, complete, runs about $100.00. (lots of soldering to do the job right.) If you decide you need further info, post what model and chassis number you are working on. If it is the problem that I think it is, I can tell you, from our complete repairs, we have never had a recall on these chassis for this same trouble and we have literally repaired tons of these things.

(From: Kevin (giddy@ac.dal.ca).)

In RCA/GE chassis CTC-175,176,177, There is a common problem with bad solder on the tuner shields and around the microprocessor shield.

The symptom is usually intermittant snowy picture and reduced vertical height. Please do not be misled into trying to troubleshoot the vertical section as you may be wasting your time. Often you can confirm if this is your problem by grabbing the RF input connector firmly and wiggling it while observing the picture.

Thomson seemed to have solved the problem around the end of 1993.

I have done lots of these.

(From: BELJAN E (lvpy67c@ix.netcom.com).)

It is the CTC series chassis and the tuner solder joints break. You should take the set in as soon as the problem develops to avoid permanantly damaging the set. The S-kit is most likely the repair kit for the GE series (S stands for solder) it has special flexible solder that will keep the tuner from going again.

(From: Marlin (mister-m@ix.netcom.com).)

Yea! These RCA/GE all are having the problem of loose grounds. They are mostly around the Micro and Tuner grounds. If your having problems with the picture becoming snowy you may have to remove the tuner shield and do those also.

The intermitten power on and off may also be around T4401 Flyback Transformer. Check or resolder this area also.

(From: Mark Paladino (paladino@frontiernet.net).)

I'm not familiar with this model in particular but the symptoms you describe my be similar to another well documented RCA tuner problem. That problem involves tv's of about the same vintage and after a year or so develop symptoms similar to what you describe. The solution to those maladies is resoldering all of the tuner shield connections where the shield connects to the pc board. I have accomplished the "fix" on several RCA TVs of that vintage with similar tuner symptoms and in each instance was able to completely correct the problems and restore the tv to workable condition.

(From: Mr. Caldwell (jcaldwel@iquest.net).)

It is not a picture tube. Why is it that some people think that the picture tube is bad when the set has a snowy picture?

It's solder connection in the tuner, the tuner is not replaceable it is part of the mother board. Call RCA and ask them if they will foot the bill. If not call an authorized repair center and get an estimate.

(From: Lawrence E. Manion (MANION.L.E@worldnet.att.net).)

Get the problem fixed now or the connections will cause enough noise on the microprocessor that it will eventually 'deprogram' the EEPROM and you'll need that replaced and it's quite expensive as this part holds *all* adjustments.

There are only 2 or 3 controls that are manually aligned.

I have fixed many, many TV's with this problem. It is common to all RCA, GE, LXI model. The problem is easy to fix, but its hard to get the area ready for repair. To those that are brave remove the back, pull out the chassis, (some plugs must be removed so mark as needed) turn the mother board over. Now find the metal can near the cable connection. Their will be 4 solder connections, remove (its harder than it look) then remove shield to expose inner tuner area. You will need to solder all ground inside and around the shield mound you removed, and the connection that was unsoldered from the shield. Now solder any connections that looks bad including surface mounded components i.e.: transistors, IC, and the cable input connections. reassemble in reverse order then your problem will be gone. Be careful not to bridge any connections that is NOT connected a good mag light is a must! I normally charge $70 labor for this job takes about an hour of work and 8 hours of playing time to confirm the problem is fixed. Only one out of 20-30 TV's required parts.

(From: John F. Reeves (jreeves@uwf.edu).)

On the CTC175 family of chassis, the tuner shield soldering job must be performed before any other troubleshooting can be done as this procedure will correct many such symptoms. the tuner shield on the bottom of the board must be removed and resoldering around the shield structure should be done. There are four posts that need to be resoldered, and check for any other suspicious looking connections. There are other circuits to check also. Give the entire board a good look. When that is done, see if there is any change in your symptom. These chassis also have a service menu that can accessed by pressing and holding the menu button then momentarily pressing the power and volume up buttons. CAUTION!!! If you are not familiar with these procedure DO NOT MESS WITH IT!!! You can really foul up your set. This procedure is included in the service manual.

(From: Paul White (pwhite4@aol.com).)

I advise resoldering the chassis, all ground and shield lugs that feed through the board, especially around and under the tuner shield. If you can't do this take it to a shop and tell them the symptom and that it needs resoldering, if they don't know what you are talking about take it somewhere else. If you wait to long the problem will get worse and will damage IC U3201, the EEPROM IC, which means a complete alignment of this IC. Most techs will fudge these settings and may be ok but don't wait till that occurs for your own benefit.

(From: Bill A. (Lucy27@ix.netcom.com).)

Yup!! Actually, the whole tuner shield/microprocessor shield grounds all are poorly soldered. You can sometimes with the naked eye or magnifier see some of the loose connections, but if you solder just a few now you will be back in there in a month or less guaranteed. So just do the whole solder job. It is actually a much better repair and you can rest easier at night knowing that you resolved the problem rather than patching it.

The 'classic' problem is prone to the CTC175 through CTC187 chassis. I'm also seeing the same problem on the newer generation CTC178 through CTC189 chassis. Instead of RCA redesigning their 'On-Board' tuners, they would rather re-design the solder thats been around for hundred years give or take. Good Luck!!!

(From: Edwin Calmes (uscalmes@yahoo.com).)

After thousands of on-board tuner repairs. I have started to get recalls (couple of years old) and finding that sets suffered from grounding problems around the tuner, Again!! After re-doing the grounds once more, recalls within weeks, sometimes DAYS. Apparently, the foil is breaking loose from the board around the tuner. Solution: Scrape all the points mentioned in the RCA tuner modification (except the goofy solder), and then re-solder once more. But do not overladen the the joint with too much solder. Then it lasts a couple years at least.

Detailed Solder/Shield Repair Procedure

(From: Gilbert (osmyn@together.net).)

RCA CTC175A Tuner Solder Locations shows the problem areas for this chassis. I have highlighted in red the ground points that were actually broken on that set, and in yellow the ones that were either suspicious or appeared OK. The section of the panel which is connected to the power supply's ground, (labeled "main ground") seems to be the most likely to break of them all, and wreaks the greatest havoc. I keep a print of this on my bench (stapled to a few pages from the Sci.Electronics.Repair FAQ Web site!) and refer to it whenever I do a complete resolder of one of these shields.

Photos of another CTC175 showing parts location can be seen at CTC175 Mainboard - Top View and CTC175 Mainboard - Bottom View.

(From: Sam.)

I don't know how similar other chassis are but the photos may be helpful in any case. I have oriented RCA CTC175A Tuner Solder Locations photo to be the same as the diagram below. I assume the inconsistency in aspect ratio is just due to the ASCII art!

(From: Mr. Paul (jcaldwel@iquest.net).)

RCA now offers a 'kit' to repair these, the only thing in the kit that is of any use is the paper template that shows exactly where to solder. But I'll give it a shot:

First under a bright light, after removing the bottom shield look for solder splashes or components that may have been desoldered by heat.

Kind of short....view from bottom with RF connector toward top:

```
  __|RF|_________________________________
 |                                       |
 |                                       |
 |                                       |
 |                                       |
 |                                       |
 |                       X               |
 |                                       |<
 |                       X               |< Bad connections in lower right
 |_______________________________________|< corner causes vertical bounce.
```

Two X's will cause a snowy pix, they are posts from the shield that are supposed to poke through the bottom but don't quite make it. A small round pad that may look like a test pad or that has a component lead poking through the board are good points to solder.

Also when you remove the board in some sets the leads on a filter to the left of the deflection/color/etc. IC can be bent and short, usually resulting in a snowy pix or just snow. (View from bottom, IC is below tuner, filter is to left, has three in-line pins.

(From: Glen Sapilewski (glen@step.Stanford.edu).)

I made up this CTC175 Tuner Solder Locations diagram to help understand what was under the tuner cover and where to solder.

(From: Ken Bouchard (bouchard@ime.net).)

On all of these RCA chassis, with the 'sandwich' type tuners, the shield must be removed, and then carefully solder everything you can see on the top and bottom of the tuner. Then re-install shields and solder them in as many places as you can as well.

A special solder (very very expensive) is sold to the repair centers, that has an elasticity to it to allow a correct fix for this problem. However, you can get away with just normal soldering in most cases, to cure the problems.

I cured our set of all of this, by soldering and soldering.... Most of it has to do with grounds that pass through the tuner, as well as 0 ohm jumpers and such that have bad soldering....

The connections that are bad, are feed-through holes as well as all connections around the perimeter of the tuner can. Each feed-through can be spotted and rca supplies you with a mask. There are about 15-20 connections in all. RCA has a fix for this, which uses a very special ($700 a pound) solder which has elasticity to it. That and the solder mask helps to make a fast repair. Also look about for ends of any chip components that were poorly soldered. Got to have a fine point tip, or your likely to short something out in your effort to repair.

Be advised that there are many surface mount transistors, chip caps, and resistors that are in the tuner, so you will need a fine point low wattage or temperature controlled soldering iron for these.

(From: Tech 7 (gscivi@aol.com).)

You don't really need a template! Just solder the shield all the way around, and at each point where it comes through the chassis. (this is easily observed by removing the top shield cover as well). and instead of adding jumpers, I simply solder each corner of the bottom shield to the pc board. Jumpers work just as well, so if you want to follow the instructions of the people who didn't make it right in the first place, be my guest. A close inspection will also reveal the locations to solder. And resolder the upc shield too!

Tuner Repair Instructions for Typical 3 Year Old CTC Chassis

(From: Henry Poland (hep@gte.net).)

Disconnect the power, remove the back of the set. You'll see the circuit board in held in a smaller plastic sub chassis/tray. flip the set so that the picture tube is face down on the table. Remove the 2 screws that hold the tray. You can now flip it back up but be careful after removing the tray that the set doesn't fall backwards and break the picture tube neck. the circuit board slid into the tray from the front. Take off the hex nut on the antenna input, look at the video and audio input RCA connectors next to the antenna you'll see a bracket held in place with a removed plastic rivet. push it out from the rear and remove it. Look at the power cord where it connects to the tray, you'll see a plastic tie strap cut that. There may or may not be one screw towards the front of the tray that holds the circuit board in the tray, if so remove it also. The circuit board should now be free to slide out of the tray.

Now that the board is free turn it over and you'll see the bottom of the tuner. It's a metal cover about 2.5" by 3" You'll have to unsolder 4 solder points on the tunner cover. Do this with care, you may need an 80Watt or better iron to do this. Once done you can Very, Very Carefully pry the tunner cover off. Take Care not to damage any Components/ Circuit Traces on the board. Now you can solder all the grounds to the tuner shield and the four pin that the cover is soldered to. Use care, don't overheat the small SMT capacitor, resistor and diodes.

It's not a hard repair if your careful.

Still Doesn't Help?

> "I need some help with this GE tv. Its a 1993 vintage model 27GT613 with a chassis number of CTC177BH."
>
> I resoldered the tuner shield and connections. However, when I powered it to check to see if I had resolved the intermittent tuner situation I found that I receive stations 2-13 with much snow in the picture."

(From: Nice address (jbc@blkbox.com).)

If you are sure that you did not make a mistake in soldering, check the RF coils. The coils are small wires through the PC board in the tuner section. I have seen a few cases where the wire was probably not clean when soldered. You may have to scrape each wire and solder it again. A bad MIXER coil may cause snow on some channels and be ok on others. EEPROM alignment will not solve the problem.

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EEPROM Information, Problems, and Solutions

Bad EEPROM

Almost any problem can be due to a bad EEPROM since it contains the 'boot' information needed to set up all the TV's subsystems. These include reception, raster, picture, menu, closed captioning, color, sound, and other symptoms The most common cause are the bad tuner solder connections discussed elsewhere in this document. However, EEPROMs can and do fail on their own.

Where the TV has died totally - particularly after having had prior problems caused by bad solder connections - the EEPROM may be corrupted so totally that the set cannot even 'boot':

I, however, the TV comes on well enough to access the user adjustments:

(From: John Del (ohger1@aol.com).)

> "Try running the color adjustment *down* all the way and keep holding the button down until pointer stops moving. If the EEPROM has damaged data, running ALL the adjustments up and down at their extremes may restore them. If this solves it, have the tuner serviced by a Thomson service center to keep the data from being scrambled again (or perform the soldering as described elsewhere in this document --- Sam). A carry in job for just the tuner service w\update kit should be approx $100 depending on

market."

If you have an oscilloscope, monitor the DATA line from the EEPROM when you turn the set on. Normally data should appear for a short time and then disappear. If there is a continuous stream of data on the DATA line, the EEPROM is probably corrupted. (For the CTC177, it is U3201, pin 6 if you don't have a schematic.)

> "I have a GE model 25GT505 that suddenly developed a problem. Here's what happened:
>
> For 2 years the set has worked fine. Went on vacation for two weeks - house at 63 degrees. Used TV for 3 hours one night with no problems. Next morning, picture is bad as follows:
>
> Picture is as wide as the screen but the vertical height is compressed. Picture starts about 1/3 of the way down the tube and extends to about 1/3 of the way up from the bottom. Furthermore, the bottom traces seem to be overlayed resulting in brighter than normal lines."

(From: DCAVS (dcavs@aol.com).)

This is a common problem for all GE, RCA, ProScan televisions of a variety of chassis. It is due to a design and manufacturing flaw. You should call RCA Customer Relations at 317-587-4151 and take it to a Thomson Authorized Service Center. (Thomson Electronics of France owns the names, RCA, GE, and ProScan for Televisions.) Thomson has been sending their customers $75.00 for carry in service and $95.00 for in-home service. This amount should cover the bill as any technician who knows what they are doing should be able to complete the repairs quickly. There is a small chance that the data in the EEPROM IC that stores all the setup data has become corrupted. In this case the set needs to be reprogrammed to operate correctly. This is a time consuming process and can have a great affect on the quality of reception.

Verifying that the EEPROM is Bad

> "I have a dead RCA CTC175 chassis in my shop that I have traced down to a bad EEPROM. The tuner shield solder connections were repaired, but how do I read the EEPROM contents when the set can't be fired up? We have done a number of these EEPROM change outs, but never with a dead set."

The following applies specifically to the GE model 31GT657 but the general approach (with appropriate changes in chip IDs and pins) applies to many other models:

(From: seabulls@unlimited.net).

If you do have troubleshooting experience, scope pins 5 and 6 of U3201 when the set is first plugged in to see if data is being exchanged momentarily. if the data continues on and on, then the eeprom is bad. If data occurs for just a moment then settles into a steady 4.8V, then troubleshoot the horizontal drive circuitry, and if there is no data and no 5V on pin 8, then troubleshoot U4101 and the 1.5meg resistor off pin 4 (I think) for open. As Hank pointed out, you could have a blown fuse and shorted flyback although they are unlikely on this chassis. If you do have a blown fuse, U4101 is most likely shorted and the 140V rectifier is probably shorted too (CR4106 I think is the location). The flyback, while possible, is the last thing I would try.

(From: Videotek (dmcdonal@Direct.CA).)

You are right, it is probably the EEPROM. When you install the new one, the set should fire up, but the horizontal sync will likely be out. Just enter the service menu, and reprogram the eeprom. There are about 80 parameters that need to be set. To verify that it IS the EEPROM, scope the data line on the EEPROM, and plug the set in. If you see a burst of data, and then nothing then the EEPROM is OK. If you see continual data, then the EEPROM is bad, as the CPU is trying to find it, and the eeprom is not responding. If no burst of data, then check your power supply.

Everything from soup to nuts can be blamed on that blasted EEPROM. No audio, no vertical, no color. All bad eeprom. I have changed hundreds, and have 3 sets in my shop now waiting for their turn to my bench.

(From: Charles Godard (cgodard@iamerica.net).)

I keep one known good EEPROM to use as a test. It just takes a few minutes to sub it. It doesn't matter what chassis the EEPROM is from when you are using it for test purposes. You can remove it and order the correct one if the set starts with the sub or if your symptom disappears with the sub.

About the only thing you might have to do with it is to set the horizontal frequency for various models but you can get a pretty good idea whether or not the original is the problem.

More on Diagnosing EEPROM Problems

(From: Darren (fatal@net.bluemoon.net).)

For the RCA series CTC chassis that have been produced in say the past 6 or 7 years, there is a 4 pin IC near the front of the chassis..... that is the EEPROM. Every chassis has letters such as CTC175 A or K or E2 etc. When you call for this part you need to know the exact letters of the chassis, because the programming in the eeprom differs for every chassis. I have a complete list ng of all eeproms to chassis part numbers. The info on the ic is useless. The majority of the EEPROMs run about $4 to 6 which is not all that much. We stock all RCA EEPROMs.

How do you know when your RCA needs a new EEPROM? The two most common reasons are: no power (TV will not turn on) or no audio.

Yes, sometimes the TA audio chip goes bad, or the fat flameproof resistor that feeds the main voltage to that IC burns up, or solder loosens from the board.

When you determine you need a new EEPROM, and you put it in, audio should come back. But if it does not and you know the audio IC is good, chances are you may have zapped the IC or the new one is defective. These EEPROMs are extremely sensitive. To determine if it is the EEPROM, you need to desolder a pin on the main IC and apply a 4.6 volt source to it to see if it will bring audio back. I don't have the schematic handy so I cannot tell you which pin that it is but that is a definite way to determine a bad ic due to an EEPROM.

Once you replace the EEPROM, you need to reprogram the set. off of the main menu you have to put the TV into service mode. If you were smart (and the TV was not in shutdown) you copied all the codes from the old EEPROM, so you know the settings for the new one. Knowing these codes is extremely important! There are something like 50 main options 100 more just for the tuner set-up. Get the service manual!

Replacement EEPROMS

Replacement EEPROMs are now available from:

- Dalbani (1-800-325-2264) for over 150 different RCA/GE chassis between CTC175 and CTC187. About $3 in singles.

- MAT Electronics. Go to "Catalog", then "EEPROMs". Listed by chassis number.

- TV Man has all Thomson, RCA, and GE EEPROMs in stock.

EEPROM Organization

The Technician's Desk provides a listing of RCA CTC175-177 family EPROM Reference Data. This tech-tips site is currently free but I don't know how long that will last!

(From: Mr. Caldwell (jcaldwel@iquest.net).)

There are three sections to the EEPROM:

- The factory identification section is where the generic microprocessor gets the data on what chassis it is in. If this get's scrambled the set might think it's a PTV or other size set or has a different type of audio system, etc. This is only alterable by a device that can directly write to the EEPROM and cannot be modified by the TV (except when something goes wrong) or the technician without knowing the data and having and I2C EEPROM programmer.

- The factory adjustment section is that part that stores technician alterable settings such as horizontal hold, stereo alignments, etc. and can be adjusted by entering a code and then using the remote or chipper checker from Thomson.

- The Customer adjustment section holds all customer controls and is adjustable in normal use of the set.

Since this chip is an I2C bus memory chip it should be quit easy to buy one of each chip from RCA and pull out the chassis coding for each chip then buy the IC in bulk at 1.00 a pop. It's an interesting chip anyway and worth experimenting on.

I think Phillips has such a programmer available since I2C is there baby.

BTW, you should get the FULL 'service' model number and FULL chassis number when ordering parts. Having the service model number makes it easy to look up the full chassis number, you only need the full chassis number to actually get the EEPROM but some parts require the 'service' model number.

The service model number is the model number in smaller print on the back that has 3 or more extra digits on the end.

CTC175 CTC176 CTC177 EEPROM Addresses and Comments

(From: J. Dow).

The contents of address 0x00 of a CTC175/176/177 chassis V-line EEPROM is:

```
bit 0: 1=speakers enabled 0=disabled
bit 1: 1=tone high 0=normal
bit 2: 1=air 0=cable
bit 3: 1=autocolor enabled 0=disabled
bit 4: 1=closed captioning enabled 0=disabled
bit 5: unused
```

```
bit 6: unused
bit 7: unused
```

The contents of address 0x00 of a CTC175/176/177 chassis W-line (with ST-9 micro) EEPROM is:

```
bit 0: 1=speakers enabled 0=disabled
bit 1: 1=tone high 0=normal
bit 2: 1=air 0=cable
bit 3: 1=autocolor enabled 0=disabled
bit 4: 1=closed captioning enabled 0=disabled
bit 5: 1=alarm enabled (4K EEPROM only)
bit 6: unused
bit 7: 1=adjust/setup menus disabled (commercial sets only)
```

Now it's pretty clear, if the very first bit of your EEPROM gets cleared, the sound is gone. So, before you touch anything else, try writing 0x0F to address 0x00.

If you're familiar with I2C, you know, address zero (and subsequent addresses if you're really unlucky) can be cleared easily by accident if one keeps the data (SDA) low and bangs the clock (SCL) long enough.

On early sets, crazy things like that happen when the micro loses ground due to an intermittent tuner shield contact. Newer sets have the micro grounded thru other paths; nevertheless, EEPROM corruption is not completely eliminated.

The EEPROM has a bunch of chassis dependent setup as well. Losing the channel list and labels is only an inconvenience, but losing the tuner setup can make the TV worthless if you can't realign the tuner. Losing some other values, such as hor. freq., B+ voltage, etc. can make the set blow the fuse....

The EEPROM map varies, even for the same chassis due to revisions. EEPROMs are *not* interchangeable! A factory new EEPROM does *not* have any correct alignment values: it's only good enough to start up!

No TV made by Thomson(GE/RCA/ProScan) has ever had a non-volatile memory built into the microcontroller. Some sets have more than one EEPROM. Some ancient AccuScan boat anchors have the channel list in the *remote* and not the *TV* set.

Once I had the pleasure of aligning a couple of hundred chassis in a couple of days; The defaults were grossly incorrect for tuner settings; failing minimum gain, tilt and out-of-band rejection specs. Some channels wouldn't come in at all, and a few sets wouldn't sync up.

If you don't understand how the micro works and what's in the EEPROM, it's all black magic and you'll be cussing and replacing chips at random. If you know the game, you can fix a number of things without ever having to solder or buy a component!

Difference in EEPROM Contents Depending on Model

Videotech has settings for several sets with the CTC175 and CTC177 chassis. However, these at best get you started.

(From: Matthew L. Kruckeberg (MKRUCKEBERG@pol.org).)

Various configurations require various EEPROMs. Stereo/Mono, AV jacks/no AV jacks, PIP/no PIP, linear power supply/switch mode power supply, pincushion circuitry/no pincushion circuitry, hotel set/consumer set, and the screen size are all variables stored in the section of the EEPROM not accessible from the on screen menu. There also at least 2 different microprocessors. The early sets were produced without closed captioning and require a different micro. I agree that there is a lot of confusion caused by the variety of EEPROMS and the lack of properly trained techs to service these sets. I have seen quite a few butcher jobs to the tuner shields, wrong EEPROMs installed, and incorrect or no realignment of the EEPROM values. Unfortunately there are many people who think they are qualified to service these units just because they claim to know how to solder. When in doubt about the correct EEPROM check with the local RCA parts distributor with a chassis number or better yet buy a manual.

Comments on EEPROMs

(From: Raymond Carlsen (rrcc@u.washington.edu).)

There are dozens of different models, each with different functions supported by "instructions" in that EEPROM. You could buy one of each (chip) and clone them with a burner, but unless you have hundreds of sets to repair, it wouldn't make sense to go to all that trouble. There are now quite a few after-market sources for those EEPROMS. The specific one for the chassis you're working on must be installed or the set will not work properly.

Some of the 'programming' of the chip must done *after* it is installed, by the tech, such as the tuner setup adjustments. Each tuner is of course different and so requires tuning. Other factory-programmed EEPROM data cannot be changed by the tech during setup... that's the basic reason the EEPROM must be replaced when the tuner grounds corrupt the data.

Rather than start from scratch each time the chip must be changed, the tuner settings can be 'copied' from the old chip (Note: not always possible), i.e. readings written down on paper and then entered into the new chip during the setup adjustments. After you've done the tuner resoldering, install a socket for the EEPROM. Unplug the TV, install the replacement chip and power up the set. With the set still plugged in (but turned off, of course), remove the chip and install the "bad" one and copy the "parameters". Put the replacement back in and enter the values you copied down. The set should now work properly. I've been able to do that on all but one set I've worked on. You will not find that information in the RCA service literature. It's essentially a workaround, dreamed up by a tech to save time. Bless that one!

Lastly, don't get me started on why Thomson treats it's servicers like [censored]. Chipper Check... Nipper Net... all paid for by techs who can barely afford the coffee they're drinking. Who needs it? You *must* buy RCA's test fixtures and software to service and do even simple adjustments on the new sets! I pass. If that's leading edge.....

EEPROM Part Numbers

> "I have a GE 27 inch stereo TV (model 27GT613, chassis CTC177BH) on which I just repaired the tuner shield cracked solder connections."

(From: Michael D. Long (longm@tusmp004.allied.com).)

A friend of mine who repairs machines said it was the EEPROM before he even scrolled done to see that you had had a repair tech look at it. He also has told me that to replace the eeprom you need to get the correct eeprom from RCA and prior to removal all of the factory settings need to be recorded from service menu(he doesn't remember exactly how to get to it without a tv in front of him--check a sam's photofact for details--you can also get the correct part number from that too.

(From: "Nice address" (jbc@blkbox.com).)

Do not trust Sam's photofact for the correct part number. There are about 14 different part numbers for CTC177. They may all use the 24C02 but the default values are different.

Hey, NAP uses a 24C01 and they charge about $25 for it. Has anyone built the I2C programmer yet?

(From: YonyMar (yonymar@aol.com).)

Your problem could be caused by a bad EEPROM. First you need to get the correct replacement EEPROM. The letters at the chassis will get you the correct part number, i.e. CTC177XX. Before you remove the old EEPROM enter the software service mode and copy down all the settings so you can write them into the new EEPROM. I would suggest using a socket also.

Article on EEPROM Problems and Servicing

The July 1997 issue of "Electronic Servicing & Technology" magazine has an article "Servicing EEPROM problems in RCA televisions", by Bob Rose. (Editor: Nils Conrad Persson (CPersedit@aol.com), Sales: Electronic Servicing & Technology, 76 N. Broadway, Hicksville, NY 11801, 1-516-681-2922. Editorial office: PO BOX 12487, Overland Park, KS 66212 1-913-492-4857.

ES&T has also had articles on CTC17x servicing and of course all sorts of other repair of consumer electronics in general. While not something you will find on the newsstand, you might be able to get a peak at one if you snuggle up to your local electronics repair shop :-).

(From: Ted Gondert (vcrepair@bbs.industrynet.net).)

The article is good with some useful information. There is a chart with average values to use for setup/alignment of the new EEPROM. Compared the printed numbers to what I wrote down from RCA CTC175A that was repaired by replacing the EEPROM using a socket and switching the old for new EEPROM after turning on the set to read the old parameters. Then setting the new ic to match. His numbers are close, so maybe TV would work about the same, just set new EEPROM to the average values in the chart.

The article also explained cure for the no sound problem caused by the speakers being muted by pin 29 on microprocessor high. That can be fixed by removing resistor R1915 in the muting transistor circuit, etc., as mentioned on the sci.electronics.repair newsgroup many times. But, he said RCA doesn't approve of it and recommends this technique:

1. Disconnect AC from chassis by unplugging the set.
2. Unsolder pin 8 of EEPROM (and isolate from pad).
3. Use a pick to short pin 8 to the pad, temporarily restoring B+.
4. Plug in set and turn it on.
5. Remove the pick and therefore the short circuit (to the pad).
6. Use the menu function to select speaker on-off.
7. Reinsert pick to restore B+.
8. Turn speaker back on.
9. Unplug set and resolder pin 8.

I haven't tried it but sounds interesting. Wonder if some other EEPROM problems can be cured that way? ;-).

Restoring EEPROM Defaults on CTC177

Restore defaults I assume.

From: jcaldwel@iquest.net (Mr. Caldwell)

Trick # 722

1. Press and hold menu then press power and then press volume +
2. Release menu
3. Press menu (vertical will collapse don't panic)
4. Press menu
5. Press power

You may have restored the EEPROM, it's worked for me with some very weird problems with the eeprom where I'd normally have replaced the eeprom.

Note: You need the FULL chassis number and failing that the FULL model number to get the correct eeprom.

The full chassis number may be on the back if the set but it is always inside and, it begins with CTC get all the digits after it. I.e CTC177AE CTC177BA CTC177BA2 etc etc

The generic number on the eeprom will only get you an un-factory programmed eeprom that will not work or work *very* strange.

The full model is the 'Service Model' in small print near the large print model number. There are several digits after it that point to the correct chassis number and thus the correct eeprom number.

In-Circuit EEPROM Reprogramming

In many cases, while the contents of the EEPROM have been corrupted by write errors caused by bad solder connections, the actual chip is undamaged and really does not need to be replaced.

The following isn't something you could likely justify for one repair but if you have a motel full of RCAs, it could easily pay for itself and then some in saved time and money! Note: I have not tested this software/device so I do not have any first hand knowledge of its performance.

The hardware interface schematic is free from the Web site or you can buy it preassembled.

(From: Jim Lawnichak (tvdr@mail.emeraldnet.net).)

If you get the chance, stop by http://www.emeraldnet.net/~tvdr and take a look at Quick Clip. The program eliminates most tuner alignments and repairs the EEPROM while its still in the set.

(From: David (dakuhajda@aol.com).)

Thomson's proper repair per their tech-tips is to reinitialize the EEPROM using the chipper check interface and software via computer.

It only takes 5 minutes to reinitialize the EEPROM. It also gives the option of storing both the main EEPROM and the pip tuner EEPROM data values to disk for future writing to a new eeprom on the set being worked on.

EEPROM and Audio Problems

First, make sure the audio hasn't been shut off in the menu (either due to EEPROM corruption or by a human). (From: Paul R Gendreau Jr. (tvman@biddeford.com).)

The 175/6/7 (and more) chassis has a SPEAKER MUTE feature for those chassis that sport speaker output jacks, and the speaker mute is also used during the POWER ON or POWER OFF functions. Even if your model doesn't have the jacks - the software and hardware to mute the speakers exists! When the EEPROM data is being corrupted by the poor solder connections - one piece of data that can become corrupted is the bit that is set to turn the SPEAKER MUTE circuit on. Since the on screen display for that model has no menu feature to allow the customer (or technician) to turn the speakers back on - you cannot correct the data in the EEPROM without an EEPROM programmer. There are some servicers that are using EEPROM programmers to access the data.

A easy and cost effective work around is to disable the speaker mute circuit in hardware. This involves the removal of a diode or a surface mounted device (SMD) transistor - what part to remove depends of the chassis involved. If Q903 is present on the foil side of the board - remove it. If Q903 is not there, then CR1953, a diode, will be present on the component side of the board and it should be removed. Only one component, not both, will be in a given TV. Removal of whichever of these 2 is present will disable the speaker mute circuit. If the rest of the EEPROM data is OK or can be corrected by the on screen menu then this procedure will save the replacement cost of the EEPROM (less than $5.00 wholesale) and the tedious job of performing about 100 alignments to the tuning system which is *REQUIRED* after EEPROM replacement.

On the negative side: The customer will find a difference in the way the TV operates! The software in the TV mutes the speakers during POWER ON or POWER OFF functions. This make both of those functions very quite. With the speaker mute circuit disabled there will be a small burst of noise during both of those functions. The level of the noise is not objectionable - but it will be a cause of concern for customers that are not forwarned. I would guess that over 80% of our customers choose the modification and subsequent cost savings rather than have the EEPROM replaced.

(From: Woodie Morris (bwmorris@bellatlantic.net).)

Here's what I do:

- If it's a stereo model, short Q903 emitter to base. (surface mounted)

- If mono, cut or remove CR1953. (From: Sam). However, see below. There could be potential problems down the road with these half baked solutions: (From: David (dakuhajda@aol.com).) We have replaced many blown speakers in these sets that someone else had removed or shorted that same transistor. The mute at turn on and turn off is critical to the long life of the speaker.

EEPROM Replacement Tricks

(From: Raymond Carlsen (rrcc@u.washington.edu).)

Hopefully you saved the old chip. If so, you can use it to put the original values back for the tuner (assuming a snowy picture was not one of the original problems). There are no "ball park" values. Install a socket for the EEPROM. Fire up the set with the new chip, then power it down. Without unplugging it from the AC outlet, remove the new chip and put the old one back in. Turn on the set and run the menu and copy down *all* the parameters for the tuner. Turn the set off again and install the new chip. Put in the values you copied down and exit. Power down and unplug the set for a few minutes. Now, fire it up again and see if it works. You may have to reset some of the operational parameters like height and RGB values, but the tuner should be OK. I've used this technique several times with very good results. It saves having to start from scratch. The trick is that some of the values in the EEPROM are sent to the micro when the set is plugged in, and others when the set is turned on. That's the reason you don't unplug it to swap chips. It's a bit of a gamble with the new chip, but worth it for the time it saves. Good luck.

(From: n3evg@aol.com)

Next time you're faced with a RCA/GE dead set due to shot EEPROM from bad tuner grounds and connections...and worried that you can't dump the contents of the bad EEPROM to reset the tuning alignment and other parameters, do this:

Remove the "bad" chip and solder an 8 pin dip socket in its place. Now take the new chip, plug it in the socket, plug in the set and turn it on. If all goes well and the set comes on (make sure you have already had all the solder connections repaired in the tuner before this of course) turn the set off and Without unplugging the set! Remove the new EEPROM and replace the original in its place. Turn the set on and enter the programming menu and proceed to copy down the contents of each of the memory registers. Do all of the tuning channels regardless of how many stations you are receiving. After you have completed, you can now replace the bad eeprom with the new one and program each of the registers. When finished, I then turn the TV off, unplug it wait a few seconds, plug it back in and make sure everything held. Sometimes I have to redo the horizontal hold and RGB registers.

(From: jcaldwel@iquest.net (Mr. Caldwell).)

- Pull plug!
- Get an 8 pin socket and remove the new IC and reinstall the old IC in the socket (I'm hoping it's not zapped).
- Plug set in and turn on.
- Enter the access code to get the numbers out of the old EEPROM and copy them down (all entries - even channels you aren't using --- sam).
- Pull Plug.
- Put new IC in socket and copy in the numbers you wrote down.

Now enter all the numbers from the old IC into the new IC and see if problem is solved. If not, I've forgotten which numbers are for the sound but since you copied the new IC's numbers you should have no problem when you read the service literature or someone here tells you what they are .

Also pull the shield from the bottom of the tuner and resolder the grounds or expect to keep doing this.

If you zapped the old IC then use the TV for target practice with a high powered rifle, I suggest .308 with a soft-point :-). Just kidding, you should probably get it professionally aligned.

Unless you are willing to purchase the equipment needed to perform the tuner alignment and preserve your sanity or some kind repair shop owner who lurks here will accept the chassis you send them for repair.

Steps to Troubleshoot Dead Set on CTC177

This may also apply with minor changes (e.g., part numbers) to other CTC chassis.

(From: David Kuhajda (dkuhajda@locl.net).)

1. With the back off, plug the TV in. Do you hear a chirp as the power supply comes up?

   - If yes, check for +5 V at pin 8 of EEPROM U3201, if it is there, the power supply is working at least in standby.

   - If not, remove the small 1.5 Mohm 1/4 watt resistor (I think it is R4104) and measure it. It is very common to be open, and you won't hear the power supply chirp.

2. If power supply passes #1, remove the top shield off the tuner and run a jumper clip from the tuner ground shield and the vertical output heatsink, at the front of the circuit board. Plug the TV in and press power button. If the TV turns on, you will have to rebuild all the ground connections inside the tuner and run a couple of extra jumpers. Be very careful when removing the bottom tuner shield as there are many small surface mount components that are easily damaged. DO NOT place a screwdriver under the shield and pry up on it. Use a good soldering iron with a small high temp tip and resolder the inner ground posts preferably with the solder Thomson supplies, or use a good quality Silver Solder. Resolder all the outside grounds and add an extra jumper from the top tuner ground to E116 jumper at the bottom tuner ground.

3. TV fails #2 test. Place a scope on pin 5 or pin 6 of the EEPROM U3201 and plug the TV in. You should see data for an instant then it will go away. If data is there all the time, the EEPROM is corrupted and the TV will need to go in for service as you will need several signal generators to realign the TV's chassis values and a calibrated cable signal generator to realign the tuner stored values. Should be around $90 for the repair.

   (However, see the section: Getting into Programming Mode on dead set and others dealing with tuner alignment. --- sam).

4. Where the TV seems to turn on, you hear the degauss relay click when you push power and you feel the high voltage come up on the face of the picture tube but no picture appears, the possibilities are:

   - TV is going into shutdown due to corrupted EEPROM data. See above.

   - HV stays up but no video. Turn the screen drive on the back of the flyback up (bottom control). What do you see?

     - Retrace lines and a blank raster? Bad eeprom from #1 cause, above. - White line across the screen? Shorted CR4704 and 2 open resistors.

   Proper resetting of screen control on flyback Once the TV is fixed: Turn TV on to a video input with no signal. Turn the control up until you see the retrace lines, turn it back until the lines go away and you just see the raster scan lines.

   ## Getting Into Programming Mode on Dead Set

   Where the set does not come on at all or shuts down immediately, the following MAY get you going.

WARNING: If the shutdown is actually being caused by excessive HV, this could result in a dangerous and/or destructive situation!

(From: Wes Black (wesmike@aol.com).)

On the "T" Chip solder a temporary jumper from terminal 26 to ground this will bypass the HV shutdown circuitry. You should be able to fire the set up and enter into the program mode. When finished be sure to remove the jumper. This procedure has worked many times for me. Oh Ya!! don't forget to resolder the tuner section first.

(From: J. Caldwell (jcaldwel@iquest.net).)

Setting the horizontal frequency to low (by accident or from corrupted EEPROM) may cause the TV to shutdown or give the with the appearance of being dead.

To fix this is you need to check the value of the main 'critical safety capacitor' a.k.a 'redundant capacitor' a.k.a 'tuning capacitor' This is a larger blue capacitor that is connected from the collector of the horizontal output, it can be connected to ground in smaller sets or is run through the pincushion circuit to ground.

Once you have the RCA part number order one, solder this in parallel to the existing capacitor and the set will fire up and not activate the high voltage shutdown circuit. You can enter the factory setup, reset the horizontal frequency for a stable picture, turn the set off and remove this added capacitor.

I've used this sporadically only to be able to copy down all the other values in an EEPROM since if this happens on it's own it's a good idea to replace the EEPROM. This is not needed if you have the RCA signal generator for these newer chassis.

(From: Tech 7 (gscivi@aol.com).)

Don't let the set run too long with the shunt capacitor either! This does work however, and is even the suggested method by RCA itself! After a number of these badly machined chassis, I have learned to count the service menu items in the event this very symptom crosses my bench. (once the resoldering has been accomplished, there is no need to replace the eeprom!) ; Clip shunt cap to horizontal output, turn set on (full AC), enter service mode, press Volume Up 76 times, Channel Up once, you are now in the horiz oscillator adjustment parameter. Volume up/down will adjust the oscillator to near sync. As soon as you see two or three slanted sync bars shut the set down, remove the shunt capacitor and try the set again. Isn't this fun?!

(From: Vern (vgdeuel@ticnet.com).)

Before you change the EEPROM, try using a Variac starting at about 40V AC. You may be able to get the set to come on enough to reset the register. If you change the EEPROM, your tuner setup may not be right anymore.

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Tuner Alignment and Related Problems

Tuner Alignment Problems

> "This RCA CTC175 came in with dead set diagnosis, as usual the problems was the EEPROM. I installed a new one and the set came on, but the new EEPROM came with the parameters set at default, and in some channels I had poor reception. When I get into the service mode I can adjust this parameters (100 and further) of the electronic tuner and I achieved a good reception changing this parameters. The problem is that, as far as I know, the way to save these parameters is pressing power, but when I restarted the set, got poor reception again. When I checked the parameters, the new data was there, at least in the display, but it has no effect in the reception. I think the procedure to save this parameters is not the correct."

(From: Dogcatcher (Dogcatch@ix.netcom.com).)

The correct procedure for aligning the tuner parameters is with a special piece of gear that you can purchase from RCA called a 'TAG001' generator. According to the manual once you adjust any of the tuning parameters you must align all. It is true, I've tried to "tweak" them in myself and you think it looks clear but when you turn the unit off or change the channel it is snowy again. I really suggest you check with RCA or a distributor and do it right.

(From: PWhite4 (pwhite4@aol.com).)

Pressing the power button is how you write your settings to memory. You are saving the parameters correctly. I have noticed on the CTC175 chassis that the settings for several of the parameters above 100 can affect the reception of the different bands in the tuner. 2 through 6 or 7 through 13 etc. can become snowy and clear as you adjust. If you don't have the RCA Tuner Alignment Generator (TAG) you just have to fudge until you get all the tuning bands acceptable. This is very time consuming and frustrating.

GE/RCA CTC177AF Tuner Alignment

(From: J. Dow).

Tuning voltages for channels: 2,6,14,17,18,13,34,37,48,50,51,57,63,76,83,93, 110,117, and 125 are stored in the EEPROM. Primary, secondary and single tuned. Three values per channel. Every chassis is different because of individual variations in manufacture, coil knifing, etc. So the factory default middle values are no good for any particular set.

You may try to copy the data from the old EEPROM from 0x54 through 0x8C into the new one. If that doesn't help, you really have to realign the set.

If you have the factory ATE rig it's less than 4 minutes.

If you have the service rig (TAG001 or similar), it can be half an hour or more.

The procedure is described in the service manual.

You need a VHF/UHF signal generator at least; a spectrum analyzer is also very handy but not essential. You also need a lot of patience if you're doing it by hand and not software.

Comments on Alignment after EEPROM Replacement

(From: Author Unknown) The EEPROM data is different for the CTC175, CTC176, CTC177 and up chassis. For correct EEPROM alignments, access to the service data is required! You can install an EEPROM IC and only adjust the fist dozen settings, which deal with picture color and size, and this might result in a pretty good picture. But the TV will be far from correct in operation! Keep in mind that the tuner alignments are all set to mid-range when you install the new EEPROM. The tuner is therefore far out of alignment and requires full alignment! Proper alignment requires 3 things:

1. The correct service information for the chassis involved.

2. A signal generator capable of generating a signal on all cable channels.

3. A digital volt meter.

While items 1 and 3 are either inexpensive or common, the signal generator is neither!

For any problems you might have, I recommend that you find a factory authorized service center for the brand you want repaired. There are several reasons for this suggestion. The primary reason is that only a factory authorized service center has the service manual, technical support and access to original specification parts that should make the service of your product effective. In addition, only a factory authorized service center will have knowledge of common problems which may occur in your model and may have suggestions from the manufacturer as to the best solution for those problems.

Call the manufacturer to locate your nearest FACTORY AUTHORIZED SERVICE CENTER, or check your local Yellow Pages. Then call ahead to confirm that the service center is authorized not only for the brand of product you need serviced but for the specific type of product (for example, a Sharp FACTORY AUTHORIZED SERVICE CENTER may not repair Sharp CD players).

If your product is less than 2 years old and you have concerns regarding early product failure, product quality, or repair problems, then you should direct those concerns to the manufacturer. Many manufacturers are eager to assist you if you take the time to call or write. If you do contact the manufacturer, it is important to have ready the model number, serial number and purchase date of your product. Many times they cannot assist you without that information.

If you need to have a product repaired within the terms of the manufacturers warranty and you do not have your bill of sale (proof of purchase) then all is not lost! Most companies are prepared to send you a PROOF OF PURCHASE DOCUMENT if you call them with the model number, serial number and what you feel is the purchase date. This can take some time to obtain. If the FACTORY AUTHORIZED SERVICE CENTER you'll use has a fax number - ask the manufacturer to fax the letter to the service center. This will speed the repair along.

(From: Matthew L. Kruckeberg(MKRUCKEBERG@pol.org).)

Alignment is a must for proper operation. You will need a service manual for the instructions which should be available from your RCA distributor. You will also need a RF signal generator capable of generating the entire tuning range on the set (up through cable channels 120+). RCA sells one under the part number TAG-001 for about $200. There are about 150 parameter that will need to be aligned. With a lot of practice I have gotten the time down to about 45 minutes but the first ones became afternoon projects. Unless you plan on doing a lot of them you may be better off cutting your losses and referring the job to a shop with the needed equipment and experience.

The problem with just copying data from the old EEPROM is that you run the risk of copying corrupted data. By the time a set fails to turn on due to EEPROM corruption the problem has existed for quite some time and corruption is usually widespread and a complete realignment should be done for peak performance.

(From: David Kuhajda (dkuhajda@locl.net).)

You are definitely not completing the repair properly unless you perform the eeprom chassis alignment per Thomson's specifications. Thomson sells a relatively inexpensive TAG generator that can generate all cable channels up to 125 and IF output. They calibrate it before they send them out. It also is crystal controlled, so it does not drift much over time, at least ours hasn't in five years of use. You cannot use cable as : 1. most cable systems don't send out 125 channels and 2. Cable systems are never 100% on correct frequency. Since we do over 2000 Thomson sets a year, it takes generally less than 45 minutes to troubleshoot, repair, and realign the CTC177 series of sets, all done to Thomson's specifications. It is extremely important to use the special solder and add the jumpers where appropriate per Thomson's solder kit.

Back in 1995 a local hotel was having continual failures of the CTC176 chassis sets in over 200 rooms. Thomson paid us to go in and resolder all of the tuner grounds, spring of 1995, the sets were approximately 1.5 years old. We are now in 1998 and these same sets are starting to fail again. Thomson says it is due to the difference in expansion and contraction due to temperature of the metal shield and the solder. The special solder takes quite a high level of good soldering technique and a precisely controlled soldering iron. Once it sets up it stays slightly flexible, and the jumpers bypass the external grounds that cause the most problems should they fail again.

One special note: the short internal jumper changes the tuners parameters and causes the set to need an eeprom tuner alignment for proper operation.

Except for the fact the we only have UHF over the air broadcasts here, we would have not had anyone complain but channel 15 looks really bad unless the tuner is properly aligned.

The newest Thomson sets do require the use of a computer interface to perform many adjustment operations. As well as turning the speakers back on after the set detects mare than 3 dc shorts at the rear speaker terminals.

Some Channels Still Fuzzy After Soldering Tuner

(From: Steve Helling).

I don't suppose you have a Thomson manual for the set, but they have a tuner troubleshooting flowchart and voltage chart in the manual. If the tuner checks out OK, it may simply need a tuner alignment. That requires a Tuner Alignment Generator (TAG) and DMM. It's done through the service menu. Don't move the coils or anything like that.

If the EEPROM was corrupted due to the tuner ground problem, it could have messed up the parameter 100-156 tuner alignments. More likely you have a component failure or solder bridge in the tuner section.

If you're serious about fixing the set or expect to see more Thomson sets, you'd be smart to buy their service manual, as well as the CTC175/176/177 Training Manual and CTC177/187 troubleshooting Guide.

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Setup Information

Setup Menus for the Uninitiated

> "There are some secret codes on this GE TV. I had a Circuit City guy here before, and he held down the power-key or something & fiddled with the other keys during startup. Its almost like a computer's BIOS... Wild! Is this list available to mere mortals?"

Setup for CTC175/176/177

(From: yonymar@aol.com).

The following is the setup procedure for the Thomson CTC 175/176/177 chassis.

Software setup procedure:

1. Press and hold Menu button, press Power, then Vol+.
2. Two displays appear at the right and left of center. Use the Vol+ button to step the right display to # V76 (Group 1 setup V76).
3. Press Ch+ or CH- button to access parameter.
4. Press Vol+ or Vol- buttons to change software value.

Group 1: V76 Service Adjustment Parameters

```
Parameter   Parameter Value          Range
(Ch+/-)     (Vol+/- to change)

00         Security pass # for Service Adjustment.  Must set to 76.  May not
           advance until value set.

01         Horz freerun freq          00-31
02         Horz phase                 00-15
03         Width (27/31 )             00-15
04         Pin amp (27/31 )           00-07
05         Vert center                00-15
06         Vert height                00-31
07         Red bias                   00-127
08         Green bias                 00-127
09         Blue bias                  00-127
10         Red drive                  00-63
11         Green drive                00-63
12         Blue drive                 00-63


13         Security pass # for Chassis Adjustment.  Must set to 77.  May not
           advance to higher param. until value set
```

Group 2: V77 Chassis Alignment Parameters

```
Parameter (Ch+/-), Value (Vol+/-).

  14 to 24.
  25        Security pass # for Tuner Adjustment (Must set to 78)
```

Group 3, V78 Electronic Tuner Alignment Parameters

```
Parameter (Ch+/-), Value (Vol+/-)

100 to 156.
```

Or more specifically:

(From: Glenn Watkins (blueribb@comcat.com).)

To access the second level of the service menu, first press and hold MENU. Then tap the POWER and then the VOLUME UP buttons. You should see 4 zeros. Press VOLUME UP until the right zeros read '76'. You are now in the first level. Now press CHANNEL UP until you get to 13. Now press VOLUME UP again to '77' on the right zeros.

You are now in the second level.

Thomson has a CTC 175/176/177 Technical Training Manual which has all this information. Get a copy!

(From: P. White4 (pwhite4@aol.com).)

If this set has the RCA CTC195/197 chassis you will need a lap top computer and the RCA chipper check software to adjust the digital convergence beyond the 25 steps in the set up menu. RCA is forcing the software on us in this chassis and any beyond it.

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Miscellaneous Problems

Bad Buttons?

(From: Zapper (zap@mhv.net).)

I have run into at least 6 sets of the CTC177 family with bad channel up/down switches. One switch would get 'leaky'...stick on I guess. Everybody that I talk to has not seen this except fer me.

Lost Sound After Repairs?

(From: mandacat@ix.netcom.com).

I've had two RCA (Thomson) Chassis with intermittent vertical problems. The fix was to install jumpers to carry the ground through all points on the PCB.

The interesting thing in troubleshooting this intermittent (prior to learning the cause) was that you would typically resolder what you thought was suspicious solder connections (grounds and components to the PCB). Now to the point. One of the sets I worked on lost sound AFTER the repair. I found out that if the set didn't have an 'Internal speaker off' option, one connection on the sound module was not soldered at the factory. I soldered it when I was re-soldering connections and I lost sound! If you have the schematic, I think its Pin 3 on the TDA7263 Sound Module which is not connected at the factory on sets that do not have the internal speaker off feature. Very Interesting! Another way to re-enable the sound would be to lift R1915 (you can cut it on the top of the chassis) from the collector of Q1903 (Transistor is always turned on for the case mentioned above).

The Ultimate in Trapezoid Distortion on CTC177?

> "The raster is full height and is centered, but narrow at the top (less than half the width of the screen) and nearly full width at the bottom. The image is extremely distorted with gross convergence error at the sides.
>
> With the vertical drive connector removed from the yoke, the display consists of the red line sloped down from left to right, the green line roughly horizontal and the blue line sloped upward from left to right. The three lines cross approximately in the middle of the screen. The ends of the lines fit the shape that the raster has when the vertical yoke connector is in place. That is, the upper ends of the lines are closer together than the bottom ends. A rough diagram of this display may be viewed at
>
> All waveforms associated with the horizontal output, vertical output and high voltage transformer (T4401) appear as depicted on the service notes."

My first thought was mechanical - the yoke is grossly tilted on the neck of the tube - the TV was dropped or something. This would result in both trapezoidal distortion and convergence problems (probably purity as well).

Another possibility is that a portion of the horizontal yoke windings (the upper half, in this case) have opened due to bad connections or a break in the wire. This would mean that the R, G, B electron beams would see less deflection at the top than the bottom and could conceivably result in the severe convergence problems as well.

A short between H and V windings of the yoke is not a likely cause as this would result in much more severe (if that is possible) problems (including much smoke).

I do not know whether EEPROM problems could result in this but considering that so much is controlled digitally these days, I would not discount it as a possibility. Width and Height are digitally controlled so that some peculiar failure in an LSI chip or the EEPROM might be possible.

First, eliminate the more likely possibilities unless you have an EEPROM to swap and quickly confirm.

The November issue of Electronic Servicing reviews the 175 and the 177. It appears that the EEPROM in these sets can cause a great deal of weird problems. It goes into great detail and gives some circuit diagrams of these sets.

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Service Information, Costs, Reliability, Reimbursement

Source for Thomson (RCA/GE/Proscan) TV Service Manuals

(From: Michael Caplan (cy173@freenet.carleton.ca).)

The following has always worked for me:

> TCE Publications
> 10003 Bunsen Way
> Louisville, KY 40299
> Phone: 502-491-8110

Solder and EEPROM Repair Costs

> "I live in New Haven, CT and my local RCA/GE repair center tells me that a repair for this problem will cost about 145$??? Everyone who has responded to this post says under $100. Am I being taken to the cleaners?????????? That would really piss me off."

(From: Paul R Gendreau Jr. (tvman@biddeford.com).)

We are an RCA/GE factory authorized service center. (You should have this work done by an authorized service center because we are the ONLY people who understand where all the problems are with this TV!) Our rate for this job is $77.00. Furthermore, if the TV is less than 2 years old it would be a good idea for you to call RCA/GE (same company). Call consumer affairs at 1-317-587-4151. Explain how you feel about the cost of repair and the set not being very old. The numbers of posts in this group referring to this problem confirms that there is a PROBLEM. Ask them to reimburse you for part of the cost.

RCA/GE/Thomson is a good company and has always been willing to address complaints from consumers.

That Special RCA Solder - Various Opinions

(From: Raymond Carlsen (rrcc@u.washington.edu).)

I understand it is a different Tin/Lead formulation with Gallium added to both lower the melting point and make it more flexible after it hardens. With regards the melting point, as people have pointed out here, you have to get it up to at least 800 degrees to make it flow properly. Well, yes and no. I get the best results With a Weller PTC station and a PTE8 (800 degree screwdriver tip), which I think is the biggest physical size tip made for that iron. That's the clue... use a big tip and solder quickly. Use the edge of the tip for the areas close to SMDs. The large mass heats the metal quickly so you don't have to cook the board.

(From: Charles Godard (cgodard@iamerica.net).)

I've done hundreds of these sets and since the first few when we didn't know about all the 43-46 (depending on how you count) joints, have NEVER had one come back and NEVER expect to see one back. If one ever does come back, I'll fix it for free! Guaranteed!

I've had a few from other shops and from refurbish shops that were not properly soldered. But, if done right with 60-40, they will not come back!

We have been soldering grounds containing various mixes of metals ever since the PC boards first came out. Soldering grounds is nothing new. The same requirements hold now as always did. Flux + Clean joint + proper heat will make a good joint! Every time!

Of the ones that I've seen lately that have come from the refurb shops, the same problem exist. They didn't heat the NEW solder to the flow temp and it still didn't make a good joint. Even with the NEW solder, they still can't get it right.

Is there anything wrong with using the new solder? NO

Is it a waste of resources? YES!

Why would it work? It is a gimmick to make the tech heat the ground connection to the proper temp to make the solder bond to the ground. It requires a higher temp to flow the NEW solder. In the process, the temp of the ground metal is heated enough to accept the bond.

Why would TCE recommend the new solder? It's called CYA (Cover Your A**). There's got to be an excuse for their continuing to sell so many of the units with a manufacturing defect. This is an excuse because they can't figure out how to fix the problem on the assembly line without spending mega bucks.

Do I care? No it makes me mega bucks.

What causes the problem in the manufacturing plant? The solder bath does not heat the grounds to the proper temp.

If the manufacturing process heated the grounds to the proper temp, would there be any problem with the finished product? NO

Is the original solder in the solder bath sufficient to make a good ground if proper heat is applied? YES

Then why would there be any need to change the specifications for the solder applied to the board on a refurb job instead of instructing the tech to heat the joint to the proper temp to flow the solder? CYA

If the original solder in the solder bath is not sufficiently flexible to make a good ground, then is there a defect in engineering or the manufacturing process? YES

Why don't they just put the new solder in the solder bath? Because the temp required to flow the new solder would peal the board.

Why don't they just heat the solder bath hot enough to make the grounds bond with the solder? Because a temp that high would peal the board.

Why do they do it this way? Because it is a cheap process.

Is there any need to use the new solder? NO, just heat the grounds until the solder flows.

Will the joint hold if 60-40 is used? YES, just as they have always held ever since we first started working with PC boards if solder is properly flowed, various metals notwithstanding.

(From: Brian Broderick (beab951@yahoo.com).)

You are incorrect about the lack of heating of the tuner caused the poor solder to the tuner grounds. The problem was that the board and tuner had a different expansion rate, this caused the solder to tear apart over time. Since TCE used wave flow and pre-heated the entire unit before the solder was applied, the stress started as soon as it cooled down. If you re-solder, it will last longer but the same problem will come back in time. TCE changed the tuner shield material several time before finding the right match. The solder was a by-product of the tuner shield material, the new shield had a melting point that was close to the solder melting point.

TCE was sued over this and is very tight lipped about this information. I was there, as a EE and a QA person. I watched the hole bloody mess develop.

(From: Dave Moore (penguin@datastar.net).)

Call TCE at: 1-317-415-4370 and request that they fax you an order form for S-kits.

The kits are free and if you do the rework the way that it is described, your customers will have a permanent fix.

The advice being given to you by those who would just use regular solder is a temporary fix that will probably last about 5 years if your customers are lucky. Of course some tech's will delight in this thinking of repeat business... Others may have actually convinced themselves of this to justify the "easy money". Some will pretend that they know better because they are old timers. I've been working in the electronics industry for over 25 years. I consider this long enough to know whereof I speak.

In any event I'm sure that if you use regular solder you won't have any comebacks for probably about three to five years. And if you do it the way TCE says you might have problems there too because they have not covered all the grounds that should be jumpered with their rework instructions.

Here are links to my computer enhanced rework instructions:

- Rework Diagram Using Normal Solder
- Rework Diagram Using TCE Special Solder
- Soldering Template
- Detailed Soldering Instructions - Page 1
- Detailed Soldering Instructions - Page 2

I have used the computer to show only the the ground traces so that it is easy to see the ground scheme around the tuner. I have a modified jumper scheme that grounds a couple of points that aren't covered in the TCE instructions.

I have not had any comebacks using my improved rework instructions, and have the satisfaction of knowing that my customers are getting the best service possible.

I'm tired of watching the mindless babblings of debate concerning this subject.

(From: Steve Helling).

Right On, Dave. Regular solder doesn't get it. I've been doing warranty work for Thomson since before the CTC17x & CTC18x chassis with the tuner problems came out. Have done several hundred tuner repairs on these sets.

The original technical bulletin issued by Thomson for this problem, TV 94-006 (5 August 94), instructed the tech to inspect and resolder tuner ground connections as necessary. Nothing more. Less than a month later, they issued an enhanced procedure for doing the same old resolder job. The resoldering wasn't holding up, so in February 96, they issued TV 96-005, giving the current procedure with special solder and jumpers.

I have seen about a dozen sets come in that had obviously been resoldered somewhere else, and the connections had cracked again. I had one of my own customer's sets come back in less than two years after I had resoldered the tuner grounds with plain solder per the first bulletins.

I know all of you who have been slapping tin/lead on the tuners don't want to hear that it doesn't hold up, but that's the facts, jack! If you haven't seen any of those sets you've soldered come back, it's probably because those particular customers don't trust you anymore and took their sets somewhere else. Maybe out to the dumpster.

(From: David (dakuhajda@aol.com).)

Use the special solder PERIOD.

We have properly resoldered thousands of these ground connections, over one thousand before Thomson came out with the solder kit. Many of those are now coming back with cracked solder connections 3 years later. Actually, looking at only the 3 motels that were resoldered in early 1995, approximately 15% of them have failed since the start of this year. Once we got use to having the soldering iron at the exact proper temperature, the repairs only take a few extra minutes.

The engineers when they first designed the sets overlooked the fact that they were working with 3 different kinds of metals with different heat-cold expansion rates, this is why even when soldered properly they can and do break again. The "special" solder is of a material that stays somewhat pliable after it sets up, allowing for sufficient expansion so the solder connections will then outlast the expected 5 years of the picture tube.

The new sets do not have nearly the failure of the old ones in the tuner grounds. Why? they have changed the solder formulation, the metals used in the shield and added traces to bypass the failure of the connections. They also greatly reduced the size of the holes the can gets inserted into.

Prior to Thomson bringing out the s-kit, we were adding 3 extra jumpers in the most critical failure points and using a silver based solder. This was our best attempt to provide the customer with the best possible repair.

Terry's Comments on Why Factory Solder Fails

Factories try to minimize:

1. Power consumed per manufactured item,
2. Fabrication time per manufactured item,
3. Materials used per manufactured item.

Frosting a beer mug and vapor soldering a circuit board are similar. Higher temperatures (more power consumed), longer deposition times (more time to fabricate) and more solder (more materials) produce solder more like hard ice on a mug rather than frost. "Frosty" solder is softer and will fail from thermal cycling or mechanical stress much more easily.

Factory quality control departments try to minimize in-warranty failures (mean time between failure) just to the point where it balances the (1), (2), and (3), minimums, above.

Thomson Consumer Electronics Saga

(From: Gregg Lansley (gregglns@ix.netcom.com).)

The good news is that Thomson Consumer Electronics has recently released a repair kit for the 175/177 chassis. The bad news is, as far as I've been able to determine, that this kit appears to be limited, as yet, to Thomson authorized service dealers, which I ain't. My supplier, Andrews Electronics in California, doesn't stock it and doesn't know when/if they will. The stock number is S-Kit-1. I've only seen a copy of the instruction sheet that comes with it, but it consists of solder and paste flux (enough for 10 repairs) and a template. The key seems to be the solder. To quote from the instruction sheet:

The special solder supplied in the kit is *not* a rosin-core solder. Paste flux must be used to get the solder to flow. The solder included in the kit remains elastic when cool to prevent joints from breaking due to thermal expansion.

There. Now, you know everything I know!

> "I guess that's good news for the RCA/GE group (Thomson), but, unfortunately it took them over 2 years to correct the problem. They should have had a factory recall on these tv's and made their customers happy or at least "happier" than they are now! Instead, I have found, they won't even honor their extended warranty in several cases. I just fixed one of these tvs for a lady that had exactly that problem. Her extended warranty is good to January 1988. She called Thomson when she started having problems with the tv. They gave her a list of about 3 or 4 "authorized service centers" for the RCA/GE tvs. She spent the better part of 2 hours on long distance calls and to her surprise, they would not honor the warranty as stated. The warranty states that they will provide IN HOME service for any tv that is 19" or larger. She has a 20" tv and when she called the closest warranty center, they told her they did not travel that far for repairs. The distance was approximately 75 miles for the closest "service center" that they referred her to. She got the same answer from the other places they offered . They said they would fix it if she brought it in, but, this lady is elderly and obviously her mother is older. She got this tv for her mother, with the extended warranty, so she could eliminate the problem of having to haul it somewhere if she had a problem."

Typically, these days, the customer is expected to bring in sets of that size. However, if in home service was a condition of the warranty, then it seems to me a service call should have been made. Look closely at the warranty, however, and see if there's some fine print that allowed them to get out of making such a distant service call. Remember, these documents are written by lawyers!

> "Her reasoning was that it was a GE and they are a "GOOD TV""

> "We bring good things to life"!

Fooled *her*! In my opinion, those sets are crap. For that matter, what about "RCA"? For years, they were a better color TV than GE. How many consumers really know that today, RCA = GE? Don't own one, don't want one. But how does the average would-be purchaser know this?

I noticed these things beginning to come in, with the same type of problems, about a year ago. Not till I began reading this group did I realize how common the RCA/GE failure is. I don't think a week goes by without somebody posting about the CTC175/177. In fact, I've saved several of the posts on the subject. Now, if a customer stops by with one, and expresses disgust at the set's needing repair at such an early date, I just bring them over to the computer and let them read a few of these posts. The one that sticks in my mind was made last spring. Somebody posted of an odd problem they'd been having with a late model RCA or GE, and whoever replied said something like, "Oh, you must have a CTC 175/177. Hehehehehe!"

> "And the company would back up any claim they gave in writing! Right?? WRONG!! She was so disgusted after she attempted to get them to repair it that she called me back and said to come and pick it up, fix it, and she would just pay for it. She was not messing around any more with them. So, on top of buying the tv and paying for the extended warranty, she now has an additional charge for my repair bill. I'm sure she won't be purchasing another Thomson product.. ever!! This tv was purchased brand new in January 1995."

Barely more than a year old. Unfortunately, that's fairly typical for the RCA/GE with that problem. In fact, I have to go look at one today, same problem description, about the same age; a 27" floor model.

> "I'm also sure she is not the only customer who has experienced these similar problems. Don't get me wrong, I don't think this mishap will put a company the size of Thomson out of business or anything close to that, but, I'm sure it hasn't helped their public image at all."

Oh, I don't think it's even registered with the public. You'd think that you'd read of this dismal repair record in a publication like Consumer Reports, but they are silent on the matter. Makes you wonder how much the magazine is worth....

> "I know they sold a ton of these sets that will still need repairs in the future too!"

Yeah, we'll have work for some time to come.

> "I just think their announcement is just too little, too late. I'm sorry for rambling on, but, some of these companies and their greed just get me a little pissed off."

Don't blame you. I think you're absolutely right. Although maybe there is just a bit of corporate honesty showing here; the RCA symbol is, after all, a *dog*! ;-)

In Defense of Thomson Consumer Electronics

At least here are a couple of people's experiences:

(From: Daryl Smith (darsmith@spk.hp.com).)

Thomson Consumer Electronics has been good about taking care of this problem, despite the TV's being out of the warranty period, in my case, anyway.

There is a 1-800 number to call Thomson Consumer Electronics about this problem. My 2 year old 31" GE TV had the same problem. I called, they sent an acknowledgement letter, I had the set repaired (~$90), I sent a copy of the repair bill along with the letter back to Thomson, and they reimbursed me the full cost of the repair. I don't have the number with me right now, but if you can't locate it elsewhere, I will dig it up at home. I had it repaired in late May and the reimbursement check came last week. You will also need to send them a copy of the original sales receipt for the TV. Good luck.

(BTW, they originally said they would pay up to $75 toward the repair labor + the full cost of any required parts, but the check came back for the full $90 it cost to have the set fixed, so I'm not complaining. Maybe it was for the extra effort to get a 31" set hauled down to and back from the shop [it must be a factory authorized shop].)

(From smaher@freyja.solano.cc.ca.us).

I like many others have faced the solder problem. I bought my 27" RCA, Model F273S1WN, television on January 9, 1995, and paid for a two year extended warranty. With the extended warranty, my labor was covered until April 9, 1997.

I first experienced video and sound problems in August 1996 while the television was still on warranty. I had almost the identical symptoms as stated in section 1.2 of you article.

I brought the set in for repair and was immediately informed that I needed a part to repair the problem. After three weeks, I got my television back, and it worked fine until April 17, 1997 (eight days after the warranty expired).

I again brought the set to the same repair company. This time I was told that all the solder connections had to be resoldered at a cost of $115.00. Since my television had the same symptoms as it had the first time it went bad, I asked if they just fixed the same problem again.

The repair company could not find any paperwork of the previous repair so I called the warranty company and they stated to me the the repair done in August 1996, and the problem was soldering not a part replacement.

I called RCA at (317) 415-4151 and stated that I felt I should not have to pay for repairs even though my warranty had expired. They agreed to reimburse me for $85.00 of the cost of the repair.

(From: Dave Fredricks (fred@rea-alp.com).)

If you have to, there is a 900 number supplied by Thomson. Yes it is $2.50 a minute, but if you can clear customer for the bill at least the set is fixed and you get the money. They have been pretty helpful when I have had to use them on a dog unit.

Reliability of Repaired Sets and New Models

Since these are manufacturing problems and not electronic design faults, the long term reliability of these RCA/GE chassis with properly repaired solder connections should be excellent.

However, not everyone shares this opinion:

> "How far to the landfill? I expect these TVs to be problems for years to come. Cut your losses now!"

(From: Bert Christensen (bert.christensen@rose.com).)

My experience with these sets has been that once the grounds are repaired they are quite trouble free. I would much rather have a set with one or two easily repaired faults than one with different faults everywhere like the Zenith System series.

(From: Mick DeMaria (bmvid@snet.net).)

For what its worth. We are an authorized TCE service center in the central CT area. TCE has been giving customers special authorization. Letters for tuner-skit repairs in the amount of $75.00 for carry in, and an extra $20 for in-home on 31" and larger sets. The customer is expected to pay the difference. So far if the s-kit instructions are followed, we have only had one or two repeat failures out of at least 500 repairs done to specs. in the TCE bulletin. Many authorized servicers in this area seem to think the jumpers and special are just BS. I can't say for sure but TCE's procedure seems to work.

(From: John Del (ohger1s@aol.com).)

If you scrap it, donate it to a repair shop. Despite this chassis' notoriety, once PROPERLY repaired and updated, it will outlast pretty much any other TV under $400. We sell these reconditioned with a two year parts and labor carry in warranty, and see less of these come back percent-wise than the new TVs we sell, regardless of brand. Tossing useful products in the landfill doesn't make a lot of sense.

Would You Buy One of These Sets?

(From: Mr. Caldwell (jcaldwel@iquest.net).)

I would buy an RCA/GE TV. The problems with the solder connections have been solved on the newer chassis. Once the connections have been fixed on the problem sets there is no other common problem. If you yell at RCA they have have been paying for the repair.

(From: Mr. Caldwell (jcaldwel@iquest.net).)

I would, the problem with the solder connections has been fixed in the newer chassis. Once the connections have been fixed on the problem sets there is no other common problem. If you yell at RCA they've have been paying for the repair.

(From: Bert Shristensen (bert.christensen@rose.com).)

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(From: Leon Thomas (lthomas@bcn.net).)

I live in Mass. and have sold and repaired hundreds of the ctc175/6/7 chassis. If a technician is called when these problems are first noticed I would call it a minor repair. If the repair is done properly, it WON'T happen again. The most you should be charged for this repair (no parts changed) is around $70.00. I have never had to do a second repair on the same set. I do not recommend anyone without experience touch these chassis. You can mess up the tuner very badly if you touch the soldering iron to one of the many surface mounted components. Pay the $70 and have it done right. I even let people watch me fix this problem to show them what it was. What you have to realize is RCA has made a terrific set with a minor bug. These chassis, in my mind, are the best on the market once they have been repaired. The new chassis they produce now ctc189 is a great improvement. Basically the same design with no bugs. I have sold many of these sets and have had not one return!

Discontinuation of Out-of-Warranty Reimbursement?

I haven't confirmed this so I don't know if getting reimbursement will be possible after the close of 1998. I also understand there may be a class action lawsuit brought against TCE so we may not have heard the last of it in any case!

(From: Cedar On 1/1/99 TCE will discontinue issuing concessions to help cover the costs of the tuner jobs (S/B 96-005). Up to this point TCE would cover $65 of the labor and all of the parts for any of the chassis: CTC175, 176, 177, 185, 186, 187 - units that met the serial number group mentioned in the service bulletin.

Their feelings are that all of the units in that S/N range that are going to fail, have done so already. They will also discontinue the special commercial program design to assist motel and other institutional users with this modification as well.

Getting Service/Reimbursement 1

> "Just got off the phone with Thomson. I was "authorized" to receive $75 for the repair, plus $20 for travel to my house. My local repair shop quoted $110, if I brought it to them. So if I can't talk them down much, I may tackle the repair myself. I'm a EE, which isn't saying much, but I work with many talented techs who can help get the job done."

(From: Siva Subramaniam (SubraS@cat.com).)

The same thing happened to my GE 25" TV. I was told it is a problem with bad solder near the tuner. This problem is very prevalent and GE (Thomson Electronics rather) is aware of it. My TV was out of warranty too, but when I called GE at 317-415-4151 and complained about it, they offered to assist me in taking care of the problem. They paid $75 in labor and all parts charges. They even set me up with an authorized service center locally and paid them directly. I did not even have to get anything reimbursed. I had to pay $90.00 for labor ($15.00 out of my pocket), and the unit now works fine. Even though the quality of GE TV was bad (this solder problem), I laud their customer service. I hope you could get taken care of in a similar way.

(From: algba@ix.netcom.com).)

If you call that # and find that you get nowhere, call it back another day and talk to a different person and you will probably get satisfactory results. I've told this to many customers that didn't get results on the first call and they had success on the next call.

(From: Colin Fisher (gomark06@aol.com).)

Call them at the:

1. Beginning of a month and quarter (best)
2. Beginning of the month (least)
3. Beginning of the quarter (next best)

Why?....that's when many corps dole out budgets.....

(From: Dave (moonwolf@fundy.net).)

We just had our 3 year old GE TV serviced for a problem with the tuner shielding. The tech had to resolder the shield. Even though our warranty just ran out, it was honored. The tech said this was a common problem with GE & RCA - the board heating up and cracking the solder joints. He also touched up a couple of other areas in the vicinity as 'preventive maintenance', he said.

It's back to working fine now.

(From: Gary Ferris (grferris@voyager.net).)

Thomson Consumer Electronics' US headquarters is in Indianapolis, IN. I have found them relatively accommodating if a product is 1 or 2 years old. Any older an they tend to take a harder line (which is not unreasonable). Many other manufacturers have "silent recalls" for products that develop problems in a significant percentage of the same model. These will usually last for 6 months to a year and service centers are reimbursed for the repair as if under normal warranty. Two examples are Gold Star with the infamous reel sensor failure and Sharp with Hi-Fi audio crackling. Both of these were covered for one year.

Getting Service/Reimbursement 2

> "I am trying to decide if I should attempt to repair this myself or take it to the shop. While I have am a degreed EE (who actually has his own lab bench), this only serves to remind me of how much I actually don't know about TV repair. From reading the above information, it seems that there are no component leads that need resoldering, only the shield connections. Is my perception accurate? Are all of these spots easy to access? Is the template in the repair kit helpful/accurate? Can a do-it-yourselfer get the template? Is it really necessary to use the "elastic" solder? (Got to admit - I've never seen elastic solder - wonder if that's a marketing ploy to try and convince you that you'll never have to repair cracked joints three years from now.

(Responses from: Matt Kruckeberg (mkruckeberg@pol.org).)

If your are skilled in soldering you may be able to do it yourself. Be advised that the traces and components under the shield are fairly small and subject to damage and detuning. The template provided is accurate. As to the reliability of the repair only time will tell. I have had no reoccurrances on the units serviced with standard solder 3 years ago before the "elastic" solder kit and jumper wire instruction set was made available.

> "Because of the above uncertainties, I would prefer to have a professional do the repair. However, I want Thomson/GE to pay for it. It appears as though there is an obvious design/manufacturing flaw. My company would recall/repair its product if this happened. So I feel Thomson/GE should also. It's the principle of the situation. But, from this web page, it seems as only RCA is reimbursing their customers for the repair, not GE. Does anybody know a phone number where I can call and complain to Thomson/GE? Has anybody heard of any successes in getting GE to pay for it? Does it have to be a GE authorized repair center? Any help is appreciated."

Good luck. Thomson Consumer Electronics the parent company of RCA and GE televisions has been quite difficult to deal with regarding this problem. I have had them tell customers that I did not know what I was talking about and denying that a problem exists. This after sending out 3 service bulletins on the problem. I even received a letter and phone call from the field service manager stating that such information was not to be released to the general public. The phone number I have for TCE customer relations is 1-317-415-4151. Be prepared for busy signals and a wait on hold. Officially the work is to be done by an authorized service center but I have heard of cases of reimbursement for work done by non authorized servicers, generally in rural areas where an authorized servicer is not locally available. I would suggest having the work done by an authorized servicer since they should have the needed solder, training, and experience. The good news is that these sets have been very reliable otherwise.

Getting Service/Reimbursement 3

(From: Steve Backi (backis@rjrt.com).)

I have an RCA 27" TV with a CTC 177 chassis. This set was manufactured in June 93, and I purchased it in September of 93. A couple of months ago, I started experiencing problems with the set, i.e: snowy picture, picture compressed, picking up other channels. Typical problems associated with CTC175/176/177 chassis. I telephoned several repair shops. Each one of them was very familiar with the problem. I took it to one shop in the area. He charged $115 for the repair. $85 for the solder problem and $30 for additional EEPROM configurations. Based on estimates I seen, this seemed like a fair price.

My repair man gave me the telephone number of Thomson Consumer Electronics, and asked that I request partial reimbursement for the repairs. This is where the fun begins. I first spoke with a customer service rep(Patrice) who would not give me her last name. She stated that she was not aware of any problems. I asked for the supervisor's name. After a brief conference with the supervisor, (I suppose), she gave me the name Ryan Brown. She also said because the set was older than 3 years, I was not entitled to any refund. She hung up before I could get further explanation. I telephoned back, and asked for Ryan Brown. Mr. Kevin Johnson answered my call. He very rudely said he was unaware of any problems despite what every repair person I spoke with and the hundreds of responses on the internet.

While he did say he would not offer any type reimbursement, he was willing to offer a certificate towards the next RCA/GE/ProScan TV purchase. I told him, I will no longer be purchasing any brands manufactured by Thomson Consumer Electronics, because in my opinion, they do not stand behind their products. I will no longer purchase those brands, and I urge consumers not to purchase those products. I suspect that the reason towards my bitterness, is that I own two other Sony TV's, and a Mitsubishi, which are at least 12 years old, and they perform flawlessly.

Getting Service/Reimbursement 4

(From: Karen Justice (Karen.Justice@PSS.Boeing.Com).)

We had the misfortune of buying a 35" RCA TV in September 1995. We chose the RCA based on a Consumer Guide rating that indicated it to be a "best buy". We paid over $1200 for the television. Within 8 months, we were experiencing the "shrinking picture" problem. I believe the manufacturer's warranty was 90 days on labor and 1 year on parts. I called the authorized service dealers in our area as well as several others and learned that the estimate for the repair was typically more than $200. No repair shop was able to tell me that it was a known problem and that I should contact the manufacturer to see if they could offer any type of assistance. I went with a non-authorized dealer close to home who charged me $138 to fix the "vertical output system". Of that amount, $30 was for pick-up/delivery and the rest for labor. The TV worked fine after spending the $138.

Well, less than two years later, the same problem is occurring again. It just so happened that last month's Consumer Report magazine (my subscription hasn't expired) indicated that Thomson Electronics recognized a defect with the TV's and suggested that the Customer Service number be called. So, after numerous long distance phone calls (the first time I was told I needed the exact date of purchase, since I couldn't recall if I bought it on 9/5/95 or 9/6/95, and to call back). I can't imagine that the one day made any difference, but I verified the date, called back and eventually got through. They said they do NOT admit to the televisions having a problem. However, since the TV is relatively new and I have already had one out of pocket expense, they would give me a "special warranty". They said that I am "lucky" to get this, since I had a non- authorized repairman look at it originally. They agreed to pay for all parts and up to $80 for labor, if I went to an authorized service center. They recommended Martha Lake Electronics. I called Martha Lake and learned they have a "flat rate minimum" charge for large TVs and won't even begin to look at the TV for less than $225 and it could go up from there! Pickup/delivery is another $110 at Martha Lake (which is about two miles from my house). So, I contacted the other authorized repair service and he said he could probably do it for $150 plus $40 for pickup/delivery. I called Thomson back to let them know that the amount they are authorizing doesn't even come close to covering the cost of the repair. They were unwilling to negotiate a different amount. They gave me the names of other authorized service centers in other cities within a 30 mile radius that I could call for comparison. They said they had mailed out my authorization on April 29, but I told them I never received it. They checked and for some reason it didn't get sent. After another long distance call of probably 20 minutes they said they would send another authorization today.

Needless to say, I am thoroughly disgusted. I am mad at Consumer Reports for recommending a TV as a "best buy" which was built by a manufacturer that had a running history of a known defect. I am mad at the authorized service dealers who didn't mention the problem to me when I first called in June 1996 when I could have perhaps negotiated with Thomson Electronics to pay for at least part of the repair. I am mad at the repair service dealers who appear to be charging customers much more than they should for this repair (all other information in your article on the internet said that all the repair associated with this problem should easily be accomplished for $99 or less). They tell me it is a "major repair" to do the soldering. I am mad at Thomson Electronics for not authorizing full repair of my television, since it is a recognized problem (in your article, someone indicated they should even authorize a recall).

The one thing I did learn is that I will never buy another RCA (or GE) product again and I will no longer use the Consumer Guide recommendations upon which to base my buying decisions. So maybe I made a one time purchasing mistake, but they have lost my business forever, which in the end, could be even costlier for them.

(a week or so passed)

Since I wrote the note, other problems are occurring with the television (we can't turn it off - other than unplugging it, and the picture is nearly obliterated now with "snow"). By the way, I got a letter from Thomson Electronics on Friday, May 8 (dated April 29), authorizing the repairs/labor (up to $80). I have All Area Servicing coming this morning to fix it (they said they should be able to do the repairs at our house). The "house call" is $54.95 and the repair will be another $100 plus tax. They say that once a complete soldering job is done that the TV's seem to work fine. I certainly hope so. I don't look forward to facing another $150 bill in another two years. Thanks for listening!

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-- end V2.02 --

Notes on the Troubleshooting and Repair of Hand Held Remote Controls

Version 2.95

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

While it is hard to imagine any catastrophic consequences resulting from attempting to repair a remote control, we will not be responsible for such consequences or collateral damage should it occur! :)

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Introduction

Remotes, Remotes, and More Remotes

Twenty years ago, a wireless remote control was a $50 or $100 option (in 1980 dollars) to a TV or VCR. Early remote controls used ultrasound or radio frequency analog transmission and could perform only limited functions - you were lucky to get anything beyond on/off, volume, and channel up/down. Today, a remote control is standard with even the lowest cost basic electronic equipment. Nearly all modern remote controls use Infra Red (IR) light for digital data transmission. Some have more buttons and functions than a personal computer! Unfortunately, many have row upon row of tiny identical size buttons with no logical layout of functions. Others are a masterpiece of ergonomic engineering almost operating by themselves.

There are two kinds of problems with remotes:

1. They seem to have legs of their own and disappear at the most inconvenient times.

2. They get abused by being dropped, dunked in Coke or beer, chewed on by the pet tiger, or left alone to develop dead leaky batteries.

While there are some remotes that will respond to a whistle and beep back to identify their location, most are the ordinary deaf, dumb, and blind variety. I cannot help you locate your missing remotes. If you have disappearing remote syndrome, a well designed universal remote - on a tether - may make a good investment. However, the following was too good to pass up:

(From: Bill Samuel (phantom@isoc.net).)

"In '89, a Customer brings in their VCR for me to fix. (Zenith VRE-200) It won't accept tapes, plus their kids misplaced their remote, so they wanted a price on a new one.

Well, after taking the unit apart, I called them and said, "Sir, I've found the problem with your VCR. BTW, you don't need a new remote.""

Most actual problems with remotes can be solved relatively easily. They are often of a physical nature. Since remotes operate on low voltages under non-stressful conditions, spontaneous electronic failure is relatively uncommon. The following are not good for remotes: Sitting or stepping on them, using them as drink stirrers, door stops, projectiles for target practice, substitutes for dog bones, or depositories for your old leaky batteries.

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IR Remote Diagnosis and Repair

SAFETY

There isn't anything dangerous inside a remote hand unit. Even staring point blank into the IR emitter isn't likely to harm anything. The worst that will happen if you make a mistake is that the circuit will be damaged beyond beyond repair and a new remote control will be in your future! :)

However, if you go inside the TV, VCR, or other controlled device, see the respective repair guide for that equipment for essential SAFETY information.

Testing of Remotes

Unless your remote hand unit has been run over by a bulldozer and is flat as a pancake, don't immediately assume it is actually broken.

- First, confirm that your problem is not simply due to a selector switch in the wrong position or an accidental press of a key selecting 'VCR' instead of 'TV'.

- If your 'problem' unit is a universal type, make sure it has not simply forgotten its programming or codes - reinitialize it. A common cause of memory loss is the batteries falling out or losing contact for an instant due to a fall or bump. To be sure it is properly reset, remove the batteries for a minute or so and also press the power button for a few seconds (to discharge any internal capacitors) before doing the reprogramming. See the section: Forgot Your Universal Remote Setup?.

- Some older TVs in particular may have a 'vacation' or other switch to disable the set (or just the remote functions). For that matter, if you cannot get the equipment to turn on at all, make sure it is plugged into a live wall socket. :-)

- Some TVs may occasionally become confused due to a power surge or for no good reason at all. Unplug the TV for a few minutes to reset it. It is also possible (though I don't have any evidence of this) that a remote can become confused. See the note above on programmable remotes.

- Before doing anything else, check and/or replace the batteries with fresh ones. Who knows how long they have been in there.

- Don't ignore the possibility that your spouse (or the local poltergeist) accidentally dropped the remote spilling the batteries - and put some back in backwards! This could result in either a totally non-functional remote, weak (limited range), or erratic operation. Permanent damage is not that likely but possible with some designs if the resulting voltage to the circuit board actually had reverse polarity.

- Next, try to determine whether the problem is indeed in the remote itself and not the TV, VCR, CD, or other controlled equipment. The easiest way to do this is to temporarily program a universal remote to match your equipment. If this now operates successfully, then you can be pretty certain that the problem lies in the remote unit.

- If you are not able to get a universal remote to operate your equipment, then either you have not found the proper code setting or the remote itself is indeed faulty (or you don't have a universal remote!).

- Should you or a friend have an identical or nearly identical piece of equipment, try the (faulty) remote on that (and its remote on your equipment) as a further test.

- If you have multiple pieces of equipment, make sure you have not accidentally substituted an apparently identical remote for a slightly different model VCR, for example. Not all equipment - even of similar type - from the same manufacturer necessarily use the same signal transmission format.

Diagnosing the Problem

The following assumes that there is no response to the hand-unit even if up close to the TV, VCR, or other controlled equipment. Where the remote works but only over a shorter distance than when new, see the section: Reduced Operating Range.

To narrow down the problem, use an IR detector to determine if the remote is emitting an IR signal when each button is pressed. While this does not guarantee that the signal is correct, it eliminates most common problems from consideration. An IR detector card or an IR detector circuit like one of those described in the section: IR Detector and Related Circuits are very handy for testing remote controls and other IR emitters. Some camcorders (those that do not incorporate an IR blocking filter) are sensitive to IR as well and will show a bright spot of light if aimed at a working source of IR. And, PCs and PDAs with IR links and suitable software (e.g., OmniRemote for the Palm III) may be useful for remote testing. See the section: Some Alternative 'Quick and Dirty' Remote Testers for additional options.

MCM Electronics, Centerville, Ohio/1-800-543-4330, list 2 different shaped cards for $7.29 each (#72-005/3.5 x 2.5" card & 72-003 /4.75 x 0.75" probe. Radio Shack, Edmund Scientific, and others offer similar detectors.

The salvaged IR sensor module from a TV or VCR may also be used as an IR detector. These usually operate from a single supply (12 V typical) and output a clean demodulated signal - you will not see the carrier, only the 1s and 0s. This will be true of an IR detector circuit as well unless you are careful to position the remote and photodiode just so as the circuit acts as somewhat of a low pass filter due to the B-E capacitance of the transistor. Radio Shack and Digikey (among other) also sell inexpensive IR receiver modules (under $5) which would also provide a demodulated signal for your viewing pleasure. However, note that some may be tuned for a particular carrier frequency like 40 kHz and therefore may not respond to all remotes. (Note, I have heard of spurious pickup issues with some of the Radio Shack units - they are not the same as those sold a while ago.)

(From: Brett Walach (bwalach@dpg.devry.edu).)

For anyone needing a great IR receiver at a reasonable price, try Radio Shack's MOD1. It's an IR receiver that demodulates the data for 40Khz x-mitters. The output can then be viewed on a scope or used to drive a small transistor which would in turn drive a speaker! The output from the MOD1 is the inverse of the code sent. That is, the TTL logic level from the MOD1 is high when no IR is present. If by chance you need an IR receiver that operates on a different carrier, try DigiKey (1-800-DIGI-KEY). I know that they have the other two types for sure.

Reduced Operating Range

With proper design, there really shouldn't be anything in a remote control (or the receiver) that degrades with reasonable use (at least in terms of operating distance). However, not all remote controls are properly designed (or manufactured) and there can be other causes for a remote that used to operate reliably from the other end of the house or bounced off the far wall but now won't even respond directly from a few feet away:

- Weak batteries - replace them!
- Dirt, gunk, tobacco smoke or cooking grease residue, and other coatings on the windows of the hand-unit or receiver. Clean thoroughly (but gently) with detergent and water, and alcohol, as required. This may mean INSIDE as well as outside!
- Damaged window in hand-unit or receiver. If someone attempted to clean the window with sandpaper, there could be problems. Remove, replace, or polish the damaged area.
- Weak IR LEDs. Since these are driven hard, it is possible for them to degrade over time. Replace with high intensity IR LEDs from Radio Shack or a real electronics distributor and see if that helps.
- Dried out reservoir capacitor. To drive the IR LEDs requires large peak currents. Sometimes, this depends on the input capacitor fed from the battery and not the battery itself. If this capacitor goes bad, the peak output will be greatly reduced or will be erratic. Test and/or just replace all electrolytic capacitors in the hand-unit.

Remote Repair

Most problems can be remedied without any special skills. However, where bad connections or component replacement is involved, you will have to be able to do just a bit of fine soldering. In this case, a low power (e.g., 25 W) fine tip soldering iron and fine rosin core solder will be needed. Fortunately, the circuit boards in remotes are generally constructed using features sizes (pads and lines) that are state-of-the-art from the 1950s. Therefore, rework isn't nearly as challenging as, say, on your 500 MHz PC!

CAUTION: You can easily turn a simple repair (e.g., bad solder connections) into an expensive mess if you use inappropriate soldering equipment and/or lack the soldering skills to go along with it. If in doubt, find someone else to do the soldering or at least practice, practice, practice, soldering and desoldering on a junk circuit board first! See the document: "Troubleshooting and Repair of Consumer Electronic Equipment" for additional info on soldering and rework techniques.

Test equipment beyond a good eye and maybe a multimeter is rarely needed.

The most challenging part of repairing a remote hand unit may be just getting inside! Manufacturers seem to pride themselves on the extent to which this is becoming more nearly impossible without dynamite:

- Screws - Some well designed (from the point of view of repair) units have a screw or two in obvious places (back cover and/or inside the battery compartment). Once removed (generally with a proper fine tipped Philips blade screwdriver), the two halves of the case come apart, possibly after sliding one with respect to the other a fraction of an inch.

- Hidden snaps - If no screws are visible (and even after removing them in some cases), it will be necessary to carefully examine the seam and possibly inside the batter compartment to determine where the likely locations of plastic snaps. Running a butter knife or similar thin tool along the seam may persuade the unit to pop in half.

- Glue - I don't know if any remote controls use this more-or-less permanent approach but if so, careful use of a hacksaw may be necessary. :-(

Even if the case is slightly damaged after disassembly (e.g., a snap or two break off), the sparing use of a semi-permanent adhesive like windshield sealer will probably be able to fasten it all back together in such a way that little evidence remains of its traumatic experience.

Problems with Remotes

Most problems occur in the hand units due to the abuse inflicted on them by kids, pets, and even otherwise well behaved adults. However, the equipment or even outside interference can also be at fault. Therefore, also see the sections: Problems with the Equipment and Problems Due to Interference.

The following are the most common types of problems and suggested solutions. As noted, most are physical in nature: dead batteries, gunk, bad connections.

For all but the first two, disassembly will be required. Manufacturers seem to be using more and more creative (read: obscure and difficult to open) methods of fastening the two halves of the remote shell together. There may be a screw or two and/or the case may simply 'crack' in half by gently prying with a knife or small screwdriver along the seam or sliding the two halves a fraction of an inch to unlock some catches. Look for screws on the back (possibly under a not-so-easy to peel off label) and inside the battery compartment, as well as hidden snap fasteners.

Dead Batteries or Batteries Inserted Incorrectly

Solution obvious. If batteries tend to go dead quickly - the batteries in a remote typically last years - then you may have a stuck button, some conductive grime under one of the buttons, or a defective IC - or you may be using cheap batteries.

Make sure that all the batteries point in the correct direction as marked inside the battery compartment or under its cover. If it uses more than 2 batteries, getting one in backwards could also result in weak or erratic operation.

Corroded Battery Contacts

Clean off the chemical deposits - first dust out the dried material with a soft brush and then remove the remainder with a damp lint free cloth or paper towel. Polish the contacts with a Fiberglass brush and/or pencil eraser and/or very fine sandpaper or a nail file. If there is evidence that the battery juice made its way inside the case, you will need to open the remote and thoroughly clean the interior. Additional repairs may be needed if damage to wiring, components, or circuit board traces is evident.

Broken or Intermittent Contacts

There are most often between the battery connections and the circuit board. Carefully resolder and reinforce them if necessary. There could also be cracked solder joints on various component pins (particularly those that get abused like switches) as well. Reflow the solder on any suspect joints.

In addition, check selector, power, or enable) switches for proper operation. Remove the batteries and use an ohmmeter to test across the contacts with the switch(es) in all positions. These switches can be easily damaged as a result of dropping or squashing the remote. The contacts may become dirty, gunked up, corrode, or simply wear out as well. Locating a replacement may prove challenging. Disassembling the switch may allow you to clean or restore the contacts in some cases.

Broken Ceramic Resonator

These may fail from shock when remotes are dropped.

The frequency is often 455 kHz (I assume since they are widely used as filters in the IF section of AM radios and are thus inexpensive.)

If you have an oscilloscope, check for signals on the IC when buttons are pressed - if there is no action on any pin, then you may have a bad resonator (or bad IC, etc.). Monitoring on one lead of the ceramic resonator should produce a signal at its resonant frequency when a button is pressed. A typical waveform may have an amplitude of a few tenths of a volt.

If you do not have a scope, one possible indication of a bad resonator (aside from it being smashed) would be a steady output from the IR LED for all button presses - normally the output would be visibly pulsating. Of course, this could indicate a bad IC as well.

A ceramic resonator usually is a small blue or orange object that looks similar to a plastic (sharp edges) or dipped (smooth edges) capacitor.

The circuit board marking will be X1 or CR1 or something like that. Replacements may be available from places like MCM Electronics or other electronics distributors. Or, consider an organ donation from a remote for equipment that has long since gone to that entertainment center in the sky if the frequency of its resonator is the same.

However, the frequency may be fairly critical for proper operation (within 5 percent or better may be required for some) and while not a common failure, I've heard of the resonator frequency changing (probably from a trauma) by enough to cause problems.

(From: Lewin A.R.W. Edwards (sysadm@zws.com).)

If your resonator has 3 pins instead of 2, and you can't find a replacement, you can use a 2-pin resonator, but you'll need to add two small caps (perhaps 33 pF?) between the legs of your resonator and ground.

Dirt, Spills, Gunk, Oily Buildup Inside

This may cause circuit problems preventing keys from operating reliably or physical problems resulting in keys being just plain stuck or sticky. Unreliable or erratic operation from these causes is probably the most common remote control problem after dead batteries.

- If you have recently cleaned the outside with a wet or damp cloth (or in your dishwasher!), then this is quite likely as liquid can seep inside and result in all sorts of strange behavior immediately or delayed by some time.

- Disassemble completely and wash both sides of the rubber membrane keypad, circuit board, and plastic case with water (and mild detergent if necessary) to remove sugar based grime and then isopropyl alcohol. Dry thoroughly.

- For stubborn crud, a pencil eraser and/or Fiberglass brush may be used with care (on the circuit board only). However, the gold plating (if present) and/or copper trace itself is quite thin!

- Where you find a oily film between the rubber and the circuit board, unless you really do a SUPER job of cleaning, it will come back quickly. It may come back no matter what you do.

  Once you think you got it all, do it again - and with soap and water as well - both the rubber and circuit board.

> This goo may originate from a number of sources (no one seems to know for sure) including: body oils, spills, plasticizers from the flexible keypad, protective grease, etc. Unless you had dunked the remote in a vat of motor oil to create this problem there may be no sure way to prevent it from returning in the future. More below.

CAUTION: In some cases, the conductive black material may be soluble in alcohol - carefully test first on the pad of a key you don't care much about. If black material comes off on your cloth or swab, use only the water and detergent. Putting the black stuff back on is much more difficult than removing it. :-)

I have one (1) data point to suggest that cleaning the rubber pad with a soft pencil eraser may be better than washing. However, this may *also* remove the conductive material in some units.

(From: Steve Lenaghan (tamerica@prairie.ca).)

We do a ton of cordless phones and I have never had to repair a conductive pad in my career (35 years). We soak them in scalding water and dish soap for 30 minutes. I clean the PC boards with alcohol and a rough cloth. Works every time.

(From: Michael Shell (mikes1987@yahoo.com).)

People have noticed that the keys (and remotes) that are used more often, tend to have more oil problems. This is in agreement with my observations.

One thing I have to make clear is that I *KNOW* that whatever is going on is NOT due to spillage or other external contamination. If I had not seen it with my own eyes, I would not believe it either! Sometimes the keys that are used most often (and have the most oil) are in the center - this is a LONG way for an external contaminant to have to travel!

The oil behaves a bit differently from most normal household (and hand) oils.

1. It is not sticky in the least
2. It is VERY clear.
3. It is VERY hydrophobic and detergent action is noticeably less than with most petroleum based oils.

I would not have noticed these fine points except for the fact that I have worked with Silicone (DOT 5) brake fluid which, except for an added purple dye, behaves in the same way.

Check this out: Silicone Rubber Components Manual (down at the bottom, section 7.0, Quality).

So, it seems the silicone keypad manufacturers have been keeping a dirty little secret all these years!

I guess we all have to look forward to our 3 year cleaning ritual. I suppose a hardcore hardware hacker could do his own keypad baking and post some before and after weight measurements to tell us how many grams of oil these things hold! (WARNING: you may have to do the baking in an oxygen free atmosphere!)

Worn or Corroded Pads on Circuit Board

These may be interdigitated or semi-circular patterns and suffer from both wear and corrosion. Conductive Epoxy or other similar conductive paint (like that used for rear window defogger repair) or ink may be used for repair. A piece of thin copper foil can be glued to the circuit board and soldered to the appropriate circuit trace. (Gold foil would be better as it will not corrode but might be just a tad pricey for a $10 remote!)

If the plating has worn off and cleaning the contacts doesn't last for more than a few days or weeks, tinning them with a thin coating of solder should help.

Worn Conductive Material on Rubber Buttons

Compare the bottoms of frequently used keys with those that are rarely pushed. If you can see the rubber through the conductive material after cleaning, the pad is likely worn to the point of being non-functional. This may be repaired with conductive Epoxy or other similar conductive paint or ink. A sliver of aluminum foil can sometimes be glued to the rubber surface. 3M makes EMI/RFI foil shielding tape, type 1181, that should work very well for this. Another source for small quantities of metal tape would be a shop that makes stained glass or sells supplies for making it. Pencil lead (graphite) may also work though for how long is unknown (though some have reported good success with this readily available material).

MCM Electronics at 1-800-543-4330 lists a Rubber Keypad Repair Kit for $24.95. It is supposed to contain enough material to repair 400 contacts (2 containers each good for 200 contacts). Their part number is 20-2070. Not cheap but 400 contacts covers quite a few typical remotes. Note: I do not know whether it is easy to mix only enough material for just 1 or 2 contacts - it would be worth confirming that this is possible before ordering. Or else, invite a few dozen friends (and their flakey keypads) over for a remote repair party. :-)

For a similar price, Remote Control Keypad Repair also has a kit for coating the worn out rubber. It consists of a little bottle of some conductive paint which doesn't appear to need mixing.

There is also a material called 'resistive coating' or something like that that goes on like paint. It may be available from an electronics distributor. Or, if you are friendly with your local repair shop, they may be willing to spare a few drops.

Occasionally, the conductive material is not actually worn off entirely only on the surface and there may still be some beneath surface. Light sanding may help.

Unfortunately, there is no single best solution since the material used for the conductive rubber pads in remotes is not all the same.

(From: Paul Weber (webpa@aol.com).)

> "If you're looking for aluminum or copper foil tape with adhesive on it, visit your local hardware store, in the plumbing and/or roof rain gutter sections. Alternatively, try an auto parts store. I've found a variety of adhesive foils (including stainless steel) in these kinds of establishments.

As for as repairing conductive rubber keypads: I've not used the metal tape method, but will probably try it. I've had great success with a thorough cleaning and light buffing of the contact area with very find (1000 grit) wet/dry sandpaper."

(From: Rufus (Pink@Floyd.Edu).)

"If you can find similar pads on another remote's membrane, trim them off square and use them to replace the defective pads. You can use silicone glue to attach them. Be careful to trim off the same amount from each pad so the buttons throw will be the same, and don't trim too deep as to damage the rubber dome."

(From: Wes Hilterbrand (replayelectronics@usa.net).)

"About the best way I have found is to take an old remote (trash or have absolutely no need for) with the same type of conductive pads. Look for a little used pad (such as a record button), add some skillful maneuvering with an exacto knife, and some SuperGlue, and you can sometimes replace the bad pad(s) on your remote with better pads. The way I have done this is to cut the pad about halfway down from the sheet it's connected to (around the pad's circumference, a little ways under the conductive surface). This should probably be done only as a last resort, and WATCH YOUR FINGERS!

BTW, this is just my opinion. I CANNOT be held responsible for any damage incurred due to following this procedure. Try this AT YOUR OWN RISK! Remember, if you mess up your working remote, there is no recourse."

(From: Keith Craig (kcraig@mlode.com).)

"I use a can of 'TV TUBE COAT' (GC Electronics), a conductive paint used for picture-tube aquadag (black paint on outside of picture tube used for ground). Squirt a tiny amount on a piece of paper and use a Q-tip (cotton swab) to drop on the pad."

(From: Mark Saterfield (kc4tzn@webtv.net).)

"Pens are available that come preloaded with conductive ink at local electronics stores though apparently not Radio Shack."

(From: Mike Harrison (wwl@netcomuk.co.uk).)

"It isn't the same as the silver stuff used for car screen heaters, etc., which I'd guess probably dries too hard and cracks off. It's made by Circuit Works, who also do conductive epoxies. Their part number is CW2610 for a repair kit, UK supplier is Farnell, price is UKP 22.33."

(From Rodney A Schmidt (rschmidt@iastate.edu).)

"What I used to remedy it was to use the stainless steel tape that is sold to seal ducting insulation, use a paper hole punch, and super glue the punched stainless onto the pad. I have had

> extremely good luck using this, and since the stainless is adhesive anyway, it stays in place while the super glue is drying."

Cracked Circuit Board

These can be repaired easily as the circuit boards are usually very simple, single sided, and have wide traces. Use Epoxy or an adhesive like Duco Cement(tm) or windshield sealer to repair and reinforce the circuit board. Scrape off any insulating coating and jumper breaks with fine wire and solder. Do not just bridge the gaps with solder as cracks and future problems are a certainty.

Bad IR LED

Test the IR LED(s) with an external power supply (with current limiting resistor) and IR detector and/or monitor voltage across them while operating. Substitute a visible LED and see if it lights up when keys are pressed. Use a scope to monitor the drive to the LED. You should see the pulse code modulated carrier. If faulty, replace with a readily available high intensity IR LED.

Note that strictly speaking, these IR emitters should perhaps be called Infra Red Emitting Diodes or IREDs since they produce no visible light. However, we will use the term IR LED throughout this document since its meaning is understood by the vast majority of readers.

Bad IC

If the remote uses a custom chip, throw it away! However, a failed chip is usually quite unlikely unless struck by lightening (now how would that happen?). Even accidentally inserting the batteries backwards (though definitely not recommended!) - which tends to kill many devices - may not cause any harm to a remote. Check each pin on the IC with a scope to determine if it is at least alive.

(From: Duane P Mantick).

> "An awful lot of IR remotes use IC's from the same or similar series. A common series comes from NEC and is the uPD1986C which, incidentally is called out in the NTE replacements book as an NTE1758. A lot of these chips are cheap and not too difficult to find, and are made in easy-to-work-with 14 or 16 pin DIP packages. Unless you have no soldering or desoldering skills, replacement isn't difficult."

Alternatives to Repair

There are a large variety of preprogrammed universal remotes available starting at $10. These are set up by inputting a code number for each type of equipment you will be using - TV, VCR, Cable box, etc. Don't loose the instruction manual or you will not know what codes to use if the batteries go dead or the remote looses its memory for any reason! Record the codes in pen on a label on the back of the remote and inside the battery compartment. For general TV/VCR/cable use, the $10 variety are fine. However, many will not provide special functions like programming of a TV or VCR or access to other model specific menu functions.

However, some of the One-For-All (and probably others as well) remotes do have capabilities not listed on the package (or web site). Check with the manufacturer (in the case of Universal, this can be via email) to determine whether any of their products have what is needed for your model(s).

Universal 'learning' remotes are available at slightly higher cost (perhaps, $25-100). The better ones are capable of memorizing all of the actual signals sent by your original remotes by viewing the IR transmission directly. Of course, your existing remotes must be working properly for teaching purposes. Make sure you get a money back guarantee with these as some may not be compatible with all equipment. The advantage of a learning remote is that it can be taught to perform setup, adjustment, and programming functions as well as those for normal operation. However the teaching process is likely to be tedious and time consuming and you will have to keep track of which buttons do what - possibly not worth the effort in the end. If the backup batteries should ever go dead, the entire learning process will need to be repeated.

(From: Michael Schuster (schuster@panix.com).)

> "You can get most of the Zenith OEM remotes from MCM Electronics. These include some that were sold under the Gemini name as consumer items; their 4-device learning/preprogrammed remote was particularly nice).
>
> These definitely =behave= as though they have EEPROMS; i.e. learned functions are retained indefinitely without power.
>
> Also the upgradable one-for-all remotes from Universal Electronics (i.e. the ones with the 'magic' key) almost certainly have EEPROM since they can be customized by moving buttons around and assigning straight binary functions to keys not in the original pre programmed arrangement. Such customizations are also retained if power is lost."

(From: Dakuhajda (dakuhajda@aol.com).)

> "Unfortunately RCA remotes cannot be repaired on any made after 1986. The circuit board is molded to the plastic case, only way to get the darn thing apart and you break it beyond being able to put it back together. Rca sells a universal remote control system link 5 that even has the pip feature. Usually $25. If you really want an exact match look inside the battery cover you can get the part number for the remote control, six digits, usually 221000 or similar. You can call any RCA authorized servicer and they can order it for you, or you can contact MCM electronics, Excel electronics, or any other authorized Thomson parts distributor. "
>
> By the way the most expensive RCA universal remote that Wal-Mart sells I use in our shop for almost all but the very newest RCA TV sets. Last 2 years models.

(From: techman@niobiumfive.co.uk.)

Some universal remotes are better than others. I recently bought (here in the UK) one called "Wizard" made by Philex (a big manufacturer of replacement remotes). It has several levels of programming:

1. Manufacturer-based code numbers, which get you a basic level of functionality, similar to simple universal remotes

2. Key reconfiguration. Once (1) has been set, one can select a button and pressing it repeatedly causes it to issue sequentially all (?) codes with the same manufacturer part but varying the second part of the code. Once you hit the right one, you can save the code for that button (in flash). A bit tedious but good coverage.

3. It can learn the code from an existing remote, and save on any button.

All this can be setup for 8 different devices. Settings are saved in FLASH memory so you don't lose any programming when the batteries die. :-) It does has a few undocumented quirks, like setting a new manufacturer code seems to clear all existing "learned" codes. :-(

I bought it from Grandata (UK 0208-900-2329, international +44-208-900-2329) for GBP 16.50 + tax and postage.

I have also wired a phototransistor and an IR LED to the serial port on an old laptop, and experimented with turning that into a learning remote. I must say I was surprised at how many different coding schemes seem to be in use, just running through a) above and observing the waveforms I documented about 20 variations before I got bored. I got it working with my UK satellite "digibox" and with a JVC VCR, but haven't taken it much further. I was particularly interested that the VCR (HR-S4700EK) responds to two quite different coding schemes, presumably it was designed to be backward-compatible with some old code of theirs, but the newer code is required to get all the functions to work. A few codes do functions for which there is no button on the official remote (and are normally only accessible from buttons on the front panel!) One code wipes out all ones timer recording settings! :-(

Original Replacement Remotes

In some cases, the only realistic option is to obtain an original replacement remote control. This might be the case where special functions need to be easily accessible or you have fallen in love with the button layout, style, or decorator colors! If you need to access special functions on your equipment, a learning remote might be an alternative if you have access to a working remote control so you can teach it. However, learning remotes are rarely as convenient as the original. As for color, there is always spray paint!

- Consider the original manufacturer of the equipment only as a last resort as they will likely want to charge you an arm and a leg (or more) for a replacement.

  Panasonic has a web site you can enter your model number and get a parts list with list prices and part descriptions:

  - Panasonic Parts & Service Online

  This site includes support for Panasonic, Technics, and Quasar consumer electronics. However, my quick visit only showed accessory type items (e.g., replacement original remote controls, cables, etc.). Encrypted credit card protection presumably makes it possible to order parts directly.

- Electronics distributors like MCM Electronics do stock a variety of original remotes - prices range from $9 - $143 (Wow $143 for just a stupid fairly basic remote! It doesn't even have high definition sound or anything exotic. You can buy an entire VCR these days for less than $143 including its own remote!), The average price of these replacements is a still rather inflated $40.

- Remote and Manual Service offers factory original remote controls from a large number of companies. I do not know how their prices compare with the manufacturer direct or with places like MCM Electronics:

  - Remotes.com, Phone: 1-800-REMOTES (1-800-736-6837).

- Here is one that also appears to specialize in this area:

  - Replacement Remote Controls

  They also do will research on hard to find remotes.

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Problems Not Due to a Defective Hand Unit

Problems with the Equipment

While circuit problems with the hand unit discussed in the section: Problems with Remotes are most likely, the following causes should not be overlooked if the remote does not work or has limited range:

- Dirty IR window - The plastic sheet which covers the IR detector may be coated with dust, grease, grime, or tobacco smoke, or other wise damaged. If sensitivity has decreased even with a new set of batteries, this is a distinct possibility. It is not always obvious whether a particular type of dirt or damage will affect response. Some condensation may be totally opaque to IR while appearing transparent to visible light. On the other hand, I have a TV where someone must have cleaned the sensor window with sandpaper or a strong solvent - it is totally clouded over but works just fine with my $10 universal remote.

  Test by removing the front panel if possible and direct the remote at the sensor directly. Inspect and clean the sensor window thoroughly with mild detergent and water.

- Defective IR sensor, receiver electronics, or microcontroller can result in the equipment simply ignoring you and/or doing whatever it pleases. The first two of these can generally be tested without service information. However, if they check out, advanced troubleshooting will be required.

  Borrow a replacement or universal remote to determine if the device responds with a known good unit. Check demodulated waveforms with an oscilloscope to confirm proper signal levels and reliable operation. See the section: Diagnosing the Problem as well.

Note that if this is a problem with new equipment (or if it has always been this way), don't neglect the obvious: Has the protective plastic film been removed? This is often present to prevent damage during manufacturing and shipping. It is amazing how many people neglect to remove this - I have gotten 10 year old TVs and VCRs at garage sales with this ugly film still in place!

And, there could be a design or manufacturing problem with your set....

While the IR-receiver module inside that TV may be a mature component and may function well on the test bench, it is entirely possible that the TV manufacturer has made a (design) fault in applying it. An IR-receiver is a very sensitive device, and a television is a very dirty environment. This may be a case of an EMC problem, not an optical problem. Under the right conditions, with this type of IR-transmitters and IR-receivers, distances of 100 feet or better may be crossed...

But, this should not be the customer's problem. The service organization of the TV manufacturer is the proper place to obtain a fix. The complaint is valid and it should be cured.

Problems Due to Interference

Symptoms for the following may range from no, intermittent, or incorrect response or greatly reduced range to the equipment being possessed - a TV changing channels, volume, or powering itself on and off as though being controlled by a poltergeist. (Where the problem is due to more than one piece of equipment interacting, see the next section.)

These are likely possibilities if you have just changed your room layout or added something to it:

- Interference from another remote in the same room which is defective (or is being squashed by a gorilla). Make sure there are no other IR transmitters including those like the a VCR+ or remote repeater that might be activated accidentally due to faulty programming or something pressing on the buttons. Do you know where all your remotes are hiding?

  A neighborhood kid (or adult with the maturity of a kid) may be playing tricks on you from outside your window or even across the street. It doesn't take much (a lens) to extend the effective distance over which a universal remote will operate reliably.

  Cover the sensor of the misbehaving equipment with a piece of black tape to see if the problem goes away. Then round up your other remotes (and/or other animate objects) and discipline them!

- Fluorescent lamps using electronic ballasts - These may be newer ceiling fixtures or the energy efficient compact fluorescents used as replacements for the regular light bulbs in table lamps. The electronic ballasts are switching power supplies and these may result in modulation of the light intensity at high frequencies confusing the remote control receiver.

  Turn off all fluorescent lamps to see if the problem goes away. A cardboard baffle can be taped to the sensor to block the interfering light. Try a different brand of compact fluorescent as not all cause interference.

- Bright lights in general - Enough ambient light, be it from the Sun or a 1000 W flood may overload the sensor. Ceiling fans can sometimes modulate the light with their fan blade rotation or vibration of the filaments of the bulbs which can confuse the remote control receiver and microprocessor.

  Turn off the lamps or move the Sun to see if the problem goes away. A cardboard baffle can be taped to the sensor to block the interfering light. Simply changing the orientation of a lamp shade or slightly moving one of components may be all that is needed.

- Electrical interference from nearby equipment. Inadequate shielding in the sensor electronics could result in susceptibility to RF emissions from other gear.

  Turn off suspect devices. If the problem goes away, they will need to be moved to another location. Shielding is probably not a viable option.

Where Multiple Pieces of Equipment Use the Same Codes

It sometimes happens: A second VCR or TV, even if from a different manufacturer, may use exactly the same remote coding. Where there is no unit select switch on the device and hand unit, only careful aiming (possibly with a set of blinders!) will allow control of one at a time.

There are three ways to solve this problem: changing the wavelength of the light, the modulation frequency, or coding used by the remote. Only the first of these is likely to be realistically possible without major effort and would involve replacing the IR LED(s) in the hand unit with visible ones (red, yellow, or green) and replacing the IR passing filter on the controlled equipment with one selective for the visible wavelength. The silicon sensor in the remote receiver probably will work just fine for visible light. A colored piece of cellophane or plastic may be adequate for the filter. Using a green LED may be best since its wavelength is furthest away from the IR wavelength making the filtering easier.

I have not actually tried this stunt but there is no fundamental reason why it shouldn't work. However, some experimentation may be required to find a suitable high brightness LED and to match it to driver in the hand unit since the LED's voltage drop will be different and may require changing a resistor. And yes, with care, it should be possible to extend this approach to 3, maybe even 4 devices. Multicolored remotes might be kind of cool. :)

Forgot Your Universal Remote Setup?

Hopefully, you saved the instruction manual. No? Some universal remotes like the Zenith Allegro have an 'auto search function' which will sequence through all possible codes. You then push a button to lock in the proper settings when the TV or VCR's channel or power status changes. Of course, since you don't have the instruction manual, you likely don't know how to use this feature either!

The manufacturer of the remote control is the next likely source (after the instruction manual) for the codes and other information. However, there is a good chance that one of the following web sites may be able to help you:

- Memorex has a web site at:

- Memorex.com

  But they suggest using the technical support line (800-636-8352) for remote control programming and other Memorex consumer electronics questions.

- The RCA Web site used to have complete user manuals for their universal remotes. Maybe they still do but navigating that site is so confusing with multiple 404 errors that I gave up. However, I was told that you should go to: "Shop RCA", then "Accesories", then "Universal Remote Controls", then the model in question. The PDF link to the owner's manual is at the bottom of the page listed as "Owner's Manual". Maybe. :)

  - RCA Electronics

- Remotes has extensive info on both Radio Shack and One-For-All brand remotes. This Web site may be more stable than the ones provided by the manufacturers.

- The Sony Web site has detailed programming codes and some troubleshooting info for some of their universal remotes:

  - Sony Consumer Electronics Guide - Remote Control Solutions

- Tandy (Radio Shack) has a nice web resource and fax-back service. This is mostly for their equipment but some of it applies to other brands as well and there are diagrams which may be useful for other manufacturers' VCRs, TVs, CD players, camcorders, remote controls, and other devices.

  - Radio Shack Product Support

  In particular, there is information on many many universal remotes including setup instructions. Since, it is likely that your model is actually one of these rebranded by Radio Shack, it is worth checking.

- Universal Electronics, makers of the One-For-All(tm) line of universal remote controls (and other products) has a web site:

  - Universal Homepage
  - Universal USA

  There is complete info on programming and special functions for many models. Since other universal remotes may be rebranded One-For-Alls, this information may be useful for those as well.

- US Electronics, makers of a variety of universal remotes (1-in-1 CATV, 2-in-1 Universal, 3-in-1 Universal, 4-in-1 Universal, ABC (Promote series), etc.) has a web site:

  - US Electronics Homepage

There are complete specifications and setup instructions for most of their products (with the rest coming soon).

- Zenith has an extensive web site with product specifications for many of their audio/video products. Gemini remotes (e.g., Easy-3) are made by Zenith. There is nothing there at the present time but indications are there may be remote information in the near future.
  - Zenith Homepage
- Metronics International Components has programming instructions for various univeral remotes including Curtis, Magnavox, Quik, RCA, and Sony:
  - Universal Remote Programming Instructions (Metronics)

  And here is another one:

  - xDiv's Universal Remote Control Codes

Next time, make copies of the instruction manual(s) and put them in obvious places like taped to the back of the TV or inside the entertainment cabinet.

Better yet, print the specific instructions and/or codes on a slip of paper and stuff it into the battery compartment of the remote. Or tape the info to the back and then cover with clear tape to protect it from wear.

One of the primary axioms of life is that you will lose those instruction manuals. :-)

Code search Programming of RCA SystemLINK Remote Controls

Perhaps this is your lucky day and this is the type of remote you have that is in search of an instruction manual.

I know this procedure works for models 3 and 4+ and assume it to be similar for the others.

(From: Larry Sabo (sabo@storm.ca).)

1. Make sure the device you are programming is turned off.
2. Press and hold CODE SEARCH.
3. Press and release TV, VCR, or CABLE corresponding to the device to be controlled. The indicator light will flash once to indicate the search is enabled.
4. Release CODESEARCH.
5. Press OFF/ON repeatedly until the device turns on.

6. Press CHANNEL V (channel down) for verification. DO NOT press any other buttons at this time.

    - If the channel changes on the device, the code is valid. Press ENTER to complete the search.

    - If the channel does not change, turn off the device (without attempting to use the remote). Then continue search by repeating steps 5-6. When all codes have been searched, the indicator light will flash twice and the remote will return to the normal mode.

(From: Aldrich TV, Inc. (aldrichtv@centuryinter.net).)

> "I find it works better if you have the unit on and watch for it to go off. It is easy to miss it coming on and then you have already passed the proper code and have to start over."

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IR Items of Interest

Increasing the Range of a Remote Control or IR Data Link

For operation between rooms, a repeater is best - an IR receiver that sends the data over a cable to an IR transmitter in the other location. This would require an IR receiver module similar to the one found in a TV or VCR, buffer to drive the cable, and a IR transmitter modulated at the appropriate carrier frequency (around 40 kHz typically).

If extra distance or sensitivity is needed in the same room, it may not be too hard to replace the IR LEDs in the hand unit with more and/or higher power devices (though the IR LEDs used originally are generally quite powerful) but this would require some circuit hacking and possibly some reverse engineering of the design to determine what is possible. A small convex lens over the IR window on the receiver will help as well but will reduce the angle to the receiver over which response will be reliable. This would be suitable if you always use the equipment from a fixed location like a couch at the opposite end of the room.

Where the transmitter and receiver are both in restricted locations, a short focal length convex collimating lens can be added to the transmitter as well as the receiver. The angular coverage of both receiver and transmitter will be reduced but the range will increase. Reducing the beam divergence by a factor of 2 at the transmitter will increase the range by approximately a factor of 2. Doing this at the receiver as well will add another factor of 2. Several hundred feet should be possible with very inexpensive lenses. I would suggest a lens of around 1 inch diameter with a 1 inch focal length. This is not critical but an IR detector circuit or card should be used to help set up the proper distance to the transmitter IR LED and receiver photodiode.

Remote Remotes (Remote Extenders)

In some situations, it is desirable to be able to operate a remote controlled piece of equipment from another room - where a direct line-of-site path does not exist. One example of this would be to control a stereo receiver in the living room (which has speakers wired all over the house) from a bedroom.

There are a number of ways of implementing this:

1. RF - An IR receiver in the bedroom retransmits the codes over on a radio frequency carrier to an IR transmitter in the living room.

2. Hard-wired - An IR receiver in the bedroom converts the IR to TTL (or other electrical) pulses wired to an IR transmitter in the living room.

   Where at least one video cable exists between the two rooms, a variation on this theme uses a combination of the coax shield and earth ground to send the signal between the rooms.

3. House wiring - An IR receiver in the bedroom modulates a carrier injected into the AC wiring. An IR transmitter picks off the signal from the AC wiring.

In all cases, the IR receiver should be a module that includes automatic level control and generates a logic level output. If possible, it should NOT demodulate the IR signal so that the frequency of the carrier is maintained. The IR transmitter then only needs to convert this logic level to on-off IR pulses. Widgets based on all of these schemes are available commercially.

(From: Robert Scott (Robert.Scott@ncl.ac.uk).)

One of these circuits exists at:

- ftp://ftp.ee.ualberta.ca/pub/cookbook/optic/irrepeater.tar.Z

  (From: Francis VE2FGS (sonytech@videotron.ca).)

  I personally have small pyramids called "Powermid" made by X-10 which work fine.

  Those come by pair, one transmitter and one receptor. You plug them in 120 VAC wall outlet and it transmit signals between the two pyramids with FM signals. It work very fine and I think it's the most practical, cheap, and fast way to transmit IR signals from one room to another.

  I paid about $40 (Canadian) for the pair.

  ## Controlling TVs, VCRs, CDs, etc., From a PC

  (From: Donald Hoffman (dhoffman@epix.net).)

  I know of 2 links to such devices. Try:

  - The B.I.R.D. Computer Controllable Learning IR Remote

- The RedRat Infrared Remote Control for your PC

IR Signal Transmission and Coding

Modern remotes use a pulse code modulated carrier to send the command. Typical carrier frequencies vary between roughly 36 and 56 kHz (although rumor has it that Bang and Olefsun remotes may use 455 kHz for the actual IR carrier - I have not been able to confirm this). Each pulse or bit consists of multiple cycles (e.g., 32) of this carrier. Here are approximate measurements made of the general characteristics of some typical remotes:

Model	Carrier	Cycles/bit	Repeat rate
Emerson VCR	36 kHz	32	10 Hz
Mitsubishi VCR	38 kHz	10	20 Hz
Panasonic VCR	56 kHz	48	10 Hz
RCA TV	56 kHz	28	16 Hz
Sony CD	40 kHz	24/48	20 Hz
Sylvania TV	36 kHz	32	10 Hz
Technics CD	56 kHz	48	10 Hz
Toshiba VCR	38 kHz	20/320*	9 Hz
Yamaha receiver	38 kHz	20/320*	9 Hz

For buttons that repeat, typical rates are 10 to 20 Hz and the entire code may actually be sent only when the button is first pressed with only a 'repeat' code sent while it is held down. (* This extra length 'bit' was evident in the repeat code for the Toshiba VCR and Yamaha receiver - which both seemed to use very similar coding schemes. Repeat for all keys used a 320 cycle bit followed by an 80 cycle gap and a 20 cycle bit.) It would appear that various combinations of NRZ, RZ, PWM, and others are used depending on manufacturer and model. Think of the challenges involved in designing a universal remote!

The carrier frequency and coding schemes (these are even more varied than the table above would indicate) have apparently not been standardized. They may also vary quite a bit even different models of equipment from the same manufacturer. Therefore, it is beyond the scope of this document to enumerate them all. It is possible to see these types of waveforms with an oscilloscope by monitoring internal signals of the remote including certain pins on the controller IC as well as the IR LED or its driver or across the transistor of the IR detector circuit (see the section: IR Detector and Related Circuits).

Capturing Remote Control Codes

(From: Dez Ellis (dezellis@lineone.net).)

Check out ZipLabel.com Computerized Infrared Remote. They have a very cheap and cheerful method of obtaining IR codes. DOS software is provided for textual or binary capture of remote control codes. Windows software for the device is also linked to the site. The Windows software "Monster Clicker" allows you to create any number of virtual remote control functions. This software also has full Macro facilities. It is well worth a visit for the small amount of construction required this is an excellent option.

Links to IR Related Web Sites

The sites below have quite a bit of information on IR remote data transmission, coding schemes, various circuits. There are even tables of formats for the remotes from a number of manufacturers:

- Tomi Engdahl's Optoelectronics Page
- U. of Washington EE Circuit Archives
- U. of Washington EE Circuit Archives - ASCII Schematics

- The SIRCS (Serial IR Remote Control System) Page
- SIRCS and other IR Remote Info and Links

Here is an even more extensive list:

(From: Joe Krantz (joed.krantz@symbios.com).)

- http://www.circumspect.com/seits/Iremote.htm
- http://www.student.nada.kth.se/~d89-bga/hp48/index.html
- http://www.celadon.com/Consumer/consumer.html#TOP OF CONSUMER
- http://ourworld.compuserve.com/homepages/davidhuras/
- http://www.asihome.com/
- http://www.hometeam.com/hci/hcchack.htm
- http://www.homecontrols.com/hccremo.htm#remote
- http://www.derossi.com/hometech/brains/ucix.html
- http://www.student.nada.kth.se/~d89-bga/hp48/remote/index.html
- http://www.ee.washington.edu/eeca/text/ir_decode.txt
- http://www.ee.washington.edu/eeca/text/ircodes.txt
- http://www.irda.org/
- http://xenon.stanford.edu/~warren/remotes/index.html
- http://www.techmall.com/smarthome/4052.html
- http://falcon.arts.cornell.edu/~dnegro/IR/
- http://falcon.arts.cornell.edu/~dnegro/IR/IR.html
- http://www.dbsdish.com/ofa_1.html
- http://206.214.38.196/~universe/ofa.html
- http://www.ee.washington.edu/eeca/circuits/PCIR/pcirhw.html
- http://www.dodgies.demon.co.uk/
- ftp://nada.kth.se/home/d89-bga/hp/remote/remotes/sony/sony.html
- http://www.tiac.net/users/wasser/OFA/SerialCable.html
- http://www.tiac.net/users/wasser/OFA/
- http://www.best.com/~ziggr/ir/

(From: Tomi Holger Engdahl (then@tinasolttu.cs.hut.fi).)

Almost all you can find free from the net you can find linked from

- http://www.hut.fi/Misc/Electronics/opto.html#irremote

Finally, here is a site that appears to have a lot of more or less non-commercial info on medium to high end (they say) remote controls from various manufacturers including detailed coding and other technical details:

- Remote Central

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IR Detector and Related Circuits

IR Detector Circuits

Two approaches are shown below.

1. The first uses a bare photodiode as the sensor. It is simpler, lower power, and shouldn't care what, if any, modulation is used by the IR source.

2. An IR detector module salvaged from a TV or VCR, or purchased from Radio Shack or elsewhere may be used instead of a photodiode. This will have a much greater dynamic range (response to both weak and powerful signals) than a simple photodiode. However, some of these assume a particular modulation frequency and will be blind to anything else. Power requirements may also be more restrictive - it may insist on regulated 12 V).

IR Detector Circuit Using Bare Photodiode

This IR Detector may be used for testing of IR remote controls, CD player laser diodes, and other low level near IR emitters. It will not have the sensitivity or dynamic range of the approach described in the section: IR Detector Circuit Using IR Receiver Module but will respond to all sources of IR falling within the wavelength range of the photodiode used since there is not demodulation or coupling circuitry to get in the way.

IR radiation falling on the photodiode causes current to flow through R1 to the base of Q1 switching it and LED1 on.

Component values are not critical. Purchase photodiode sensitive to near IR - 750-900 um or salvage from optocoupler or photosensor. Dead computer mice, not the furry kind, usually contain IR sensitive photodiodes. For convenience, use a 9V battery for power. Even a weak one will work fine. Construct the circuit so that the LED does not illuminate the photodiode!

The detected signal may be monitored across the transistor with an oscilloscope.

```
Vcc (+9 V) o-------+---------+
                   |         |
                   |         \
                   /         /  R3
                   \ R1      \  500
                   / 3.3K    /
                   \       __|__
                   |       _\_/_  LED1 Visible LED
                 __|__       |
       IR ---->  _/_\_ PD1   +--------o Scope monitor point
         Sensor    |         |            (low active)
       Photodiode  |     B |/ C
                   +-------|    Q1 2N3904
                   |       |\ E
                   \         |
                   / R2      |
                   \ 27K     |
                   /         |
                   |         |
      Gnd o--------+---------+--------o Gnd
                  _|_
                   -
```

IR Detector Circuit Using IR Receiver Module

This one uses an entire IR receiver module as the IR sensor. Its sensitivity and dynamic range will be much better than the circuit described in the section: IR Detector Circuit Using Bare Photodiode since these modules have automatic gain control circuitry built in. However, some modules are tuned to a particular modulation frequency and/or are AC coupled and will not respond to all remotes or other pulsed or continuous IR sources.

The IR receiver module from a TV, VCR, or purchased from Radio Shack or elsewhere, drives the base of Q1 through R1. It may even be possible to eliminate the transistor circuit entirely and connect the LED directly to the module's output (in series with a current limiting resistor to Vcc or Gnd) but that depends on the drive capabilities of the module. You can use whatever Vcc is required for the IR receiver module for the LED circuit as well but may need to change the value of R2 to limit the current to the LED to less than its maximum rating.

The specific case where Vcc is +5 V is shown.

```
                                R2
   Vcc (+5) o------+-----------/\/\--------+
                   |           220       __|__
                   |                     _\_/_  LED1 Visible LED
                   |                       |
                   |+                      +--------o Scope monitor point
```

```
         +----------+                |             (low active)
        -|    IR    |out    R1    B |/ C
 IR ---> : Receiver |------/\/\-----|    Q1 2N3904
        -|  Module  |      10K      |\ E
         +----------+                |
              |-                     |
   Gnd o------+----------------------+--------o Gnd
```

Steve's Instant IR Tester

(From: Steve Rice (punky@efortress.com).)

IR receiver diode (from scrap Penney's unit) attached to 18" single pair wires-passed through heavy-gauge straw (from some unknown latte drink in the early A.M.). RTV the tip to maintain rigidity. Positive end to plus end of 9 V battery. Negative end to 330 ohm 1/4 W resistor, and from there to display LED (I chose a pretty red one from the scrap box), and then back to negative of battery.

Time consumed: 2 hours. (1 hour to make sure the RTV was cured properly.)

Application to numerous remote control sources and to a couple of CD pickups provided nice glow from the indicator LED.

I just received a Fisher 25 disc unit for repair, and the above tester was instrumental in determining that over 12 IR emitters were functional. (Some of these were in locations otherwise very difficult to access.)

Some Alternative 'Quick and Dirty' Remote Testers

In addition to the IR detector circuits, IR detector card, and camcorder or video camera, here are a few other options:

(From: Raydon Berry (rayberry@pt.lu).)

Measure the current consumption from the batteries. Put the multimeter on a range of about 25 mA and when you press each button, the code being sent will show up as a wagging needle on a VOM or an average current for a DMM. If the ceramic filter or the IR diodes have failed, the current remains very low, but if OK, you should see pulses of 5 to 10 mA.

(From Malik (M.dad@mmu.ac.uk).)

> "If you have a IR remote TV in the workshop for testing VCRs and other video equipment, you can modify this so that audio can heard from the speaker which represents the IR signal.
>
> Simply couple the output of the IR receiver (in the TV) to the input of the audio output stage. Use a low value ceramic cap and a high value resistor, this should be possible on all remote TV's and will cost you next to nothing."

(From: ShyGuy4Yu (shyguy4yu@aol.com).)

> "Take a known good IR receiver from an old set. Supply proper DC to it. Feed the output into an audio amplifier. You can hear intermittent operation really well without squinting at test equipment. Put one on the counter for demo to customers.. Great!!"

(From: Sam).

What a nice idea! The only concern I would have is that not all IR transmitters use the same modulation frequency so I don't know how forgiving the demodulator in the IR receiver would be. Thus, you might think a remote control is bad when in fact it is just incompatible.

You could probably learn to recognize the codes by ear after a while as well! :-)

(From: Paul Grohe (grohe@galaxy.nsc.com).)

> "Here is a another "quick" and "very dirty" test of the IR emitter I have used:
>
> Clip a *glass* encased diode (1N34, 1N914, 1N4148, etc.) between your scope probe tip and ground clip. Crank the scope sensitivity up to about 20 tp 50mV/div. Hold the diode by the grounded lead (to reduce noise pickup).
>
> Point the "business" end of the remote directly at the clear part of the diode body. The IR packets will now be visible on the scope.
>
> You may have to move the remote around to find the "hot spot" in the window. The more of the diodes junction that is exposed, the better the response.
>
> A Sony remote generates about 50mVpp with a typical 1N4148/1N914 and more than 200mVpp with a "wide open" 1N34A point-contact Germanium (at 1 cm).
>
> BTW, the time constant of this setup may mask the actual 40kHz carrier pulses. Place a 100k resistor in parallel with the diode to see the individual pulses clearly (sensitivity *is* reduced).
>
> Or just simply hold the remote against an AM radio for a quick test."

(From: Sam)

And, Filip also suggested that last one so I will honor him as well. :-) Almost any sensitive amplifier may pick up some clicks from a working remote. A guitar or microphone amp may work for this. However, none of these indirect methods actually test the IR output but probably are accurate enough in most cases.

(From: Filip M Gieszczykiewicz (filipg@repairfaq.org).)

> "Simply hold a pocket AM radio or Walkman set on AM and push the buttons. This works for

> all the remotes I have.... except the ultrasonic one. :-)"

(From: Bob Quackenbush (quackenb@heidelberg-emh11.army.mil).)

> "Tune an AM radio to a quiet area of the band, hold the remote near the (normally internal) antenna, press and hold any key on the remote. The sound will be a quiet fluttering, so listen carefully. Be careful with your interpretation of the results. "No flutter" may NOT mean that the transmitter isn't working."

(From: David C. Brink (db@mcs.com).)

> "Just dissect the remote far enough to get access to the IR LED(s) leads (if the remote has been through the moving bits of the Lazy-Boy a few times, such disassembly might not even be necessary). Hold a LED in parallel with it and see if it lights when you press the remote buttons."

(From: Sam)

Note: Since the voltage drop across an IR LED is usually less than that across a visible LED, this may not work unless the remote uses two LEDs in series. In that case, substitution may be needed.

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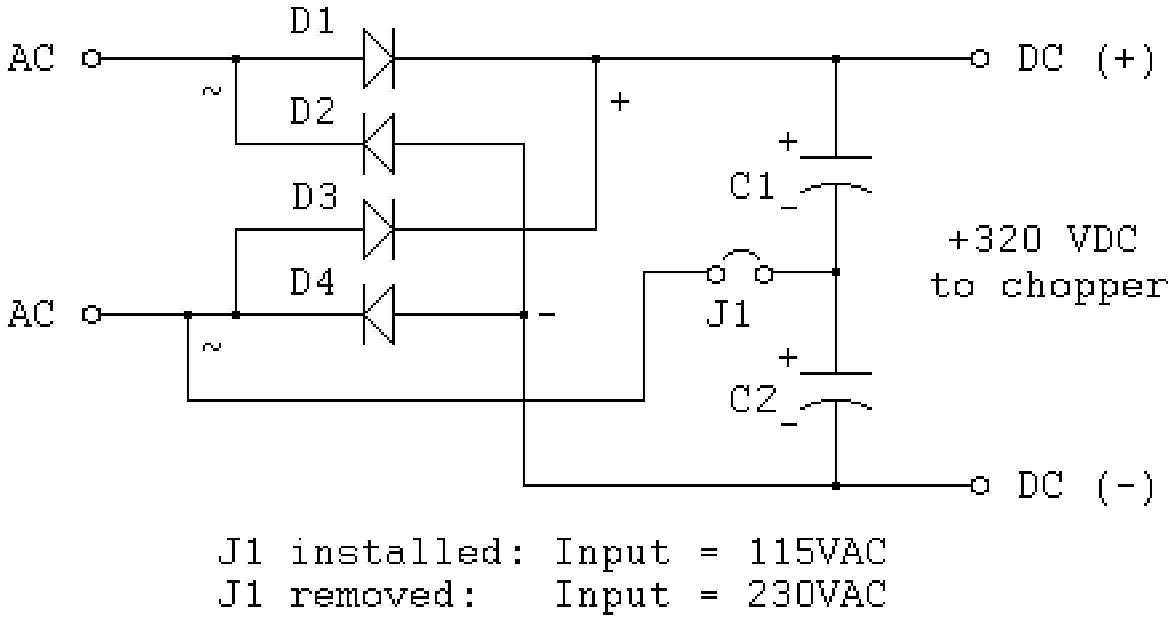
-- end V2.95 --



Typical SMPS Input Voltage Select Circuit

Sam's F-Lamp FAQ

Fluorescent Lamps, Ballasts, and Fixtures

Principles of Operation, Circuits, Troubleshooting, Repair
Version 2.09

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

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We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

Acknowledgements

Thanks to Don Klipstein (don@misty.com) for his comments and additions to this document. His Web site (http://www.misty.com/~don/) is a valuable resource for information relating to lighting technology in general and also includes additional articles dealing with fluorescent and other discharge lamps.

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Introduction

Fluorescent Lamp Basics

The fluorescent lamp was the first major advance to be a commercial success in small scale lighting since the tungsten incandescent bulb. Its greatly increased efficiency resulted in cool (temperature wise) brightly lit workplaces (offices and factories) as well as home kitchens and baths. The development of the mercury vapor high intensity discharge (HID) lamp actually predates the fluorescent (the latter being introduced commercially in 1938, four years after the HID). However, HID type lamps have only relatively recently become popular in small sizes for task lighting in the home and office; yard and security area lighting; and light source applications in overhead, computer, and video projectors.

Fluorescent lamps are a type of gas discharge tube similar to neon signs and mercury or sodium vapor street or yard lights. A pair of electrodes, one at each end - are sealed along with a drop of mercury and some inert gases (usually argon) at very low pressure inside a glass tube. The inside of the tube is coated with a phosphor which produces visible light when excited with ultra-violet (UV) radiation. The electrodes are in the form of filaments which for preheat and rapid or warm start fixtures are heated during the starting process to decrease the voltage requirements and remain hot during normal operation as a result of the gas discharge (bombardment by positive ions).

When the lamp is off, the mercury/gas mixture is non-conductive. When power is first applied, a high voltage (several hundred volts) is needed to initiate the discharge. However, once this takes place, a much lower voltage - usually under 100 V for tubes under 30 watts, 100 to 175 volts for 30 watts or more - is needed to maintain it.

The electric current passing through the low pressure gases emits quite a bit of UV (but not much visible light). The gas discharge's radiation is almost entirely mercury radiation, although the gas mixture is mostly inert gas and generally around something like 1 percent mercury vapor. The internal phosphor coating very efficiently converts most of the UV to visible light. The mix of the phosphor(s) is used to tailor the light spectrum to the intended application. Thus, there are cool white, warm white, colored, and black light fluorescent (long wave UV) lamps. There are also lamps intended for medical or industrial uses with a special envelope such as quartz that passes short wave UV radiation. Some have an uncoated envelope, and emit short-wave UV mercury radiation. Others have phosphors that convert shortwave UV to medium wave UV.

(Caution: Some specialty UV lamps emit shortwave or medium wave UV which is harmful and should not be used without appropriate protection or in an enclosure which prevents the escape of harmful UV radiation.)

Fluorescent lamps are about 2 to 4 times as efficient as incandescent lamps at producing light at the wavelengths that are useful to humans. Thus, they run cooler for the same effective light output. The bulbs themselves also last a lot longer - 10,000 to 20,000 hours versus 750 to 1,000 hours for a typical incandescent. However, for certain types of ballasts, this is only achieved if the fluorescent lamp is left on for long periods of time without frequent on-off cycles.

Over the years, fluorescent lamps in approximately the shape of incandescent lamps with built-in ballasts have been evolving. These "compact fluorescent lamps" or CFLs have all of the advantages of ordinary fluorescent lamps but fit into most table lamps and incandescent fixtures. Phosphors have been improved to the point where the color is very similar to that of incandescent lamps. While the initial cost is high ($5 to $20), this is easily recovered several times over in the energy savings over the long life of the lamp due to the much higher efficiency (typically 4X) since most of the lifecycle cost of an incandescent is in the electricity used (typically $10 for power versus $0.50 for the lamp) and not the lamp itself.

Fluorescent Lamp Labeling

The actual fluorescent tubes are identified by several letters and numbers and will look something like 'F40CW-T12' or 'FC12-T10'.

So, the typical labeling is of the form FSWWCCC-TDD (variations on this format are possible):

- F - Fluorescent lamp. G means Germicidal shortwave UV lamp.
- S - Style - no letter indicates normal straight tube; C for Circline.
- WW - Nominal power in Watts. 4, 5, 8, 12, 15, 20, 30, 40, etc.
- CCC - Color. W=White, CW=Cool white, WW=Warm white, BL/BLB=Black light, etc.
- T - Tubular bulb.
- DD - Diameter of tube in of eighths of an inch. T8 is 1", T12 is 1.5", etc.

For the most common T12 (1.5 inch) tube, the wattage (except for newer energy saving types) is usually 5/6 of the length in inches. Thus, an F40-T12 tube is 48 inches long.

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Safely Working with Fluorescent Lamps and Fixtures

There aren't many dangers associated with typical fluorescent lamps and fixtures:

- Electric shock. There is usually little need to probe a live fixture. Most problems can be identified by inspection or with an ohmmeter or continuity tester when unplugged.
  - Fluorescent lamps and fixtures using iron ballasts are basically pretty inert when unplugged. Even if there are small capacitors inside the ballast(s) or for RFI prevention, these are not likely to bite. However, you do have to remember to unplug the fixture before touching anything!

- However, those using electronic ballasts can have some nasty charged capacitors so avoid going inside the ballast module and it won't hurt to check between its outputs with a voltmeter before touching anything. Troubleshooting the electronic ballast module is similar to that of a switchmode power supply. See the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies

- Nasty chemicals: While the phosphors on the inside of fluorescent tubes are not particularly poisonous, there is a small amount of metallic mercury and contact with this substance should be avoided. If a tube breaks, clean up the mess and dispose of it properly and promptly. Of course, don't go out of your way to get cut on the broken glass!

And take care around sharp sheet metal!

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Fluorescent Fixtures and Ballasts

Fluorescent Fixtures

The typical fixture consists of:

- Lamp holder - the most common is designed for the straight bipin base bulb. The 12, 15, 24, and 48 inch straight fixtures are common in household and office use. The 4 foot (48") type is probably the most widely used size. U shaped, circular (Circline(tm).) and other specialty tubes are also available.

- Ballast(s) - these are available for either 1 or 2 lamps. Fixtures with 4 lamps usually have two ballasts. See the sections below on ballasts. The ballast performs two functions: current limiting and providing the starting kick to ionize the gas in the fluorescent tube(s).

- Switch - on/off control unless connected directly to building wiring in which case there will be a switch or relay elsewhere. The power switch may have a momentary 'start' position if there is no starter and the ballast does not provide this function.

- Starter (preheat fixtures only) - device to initiate the electrode preheating and high voltage "kick" needed for starting. In other fixture types, the ballast handles this function.

Fluorescent Lamp Ballasts

For a detailed explanation, check your library. Here is a brief summary.

1. Provide the starting kick.

2. Limit the current to the proper value for the tube you are using.

In the old days fluorescent fixtures had a starter or a power switch with a 'start' position which is in essence a manual starter. Some cheap ones still do use this technology.

The starter is a time delay switch which when first powered, allows the filaments at each end of the tube to warm up and then interrupts this part of the circuit. The inductive kick as a result of interrupting the current through the inductive ballast provides enough voltage to ionize the gas mixture in the tube and then the current through the tube keeps the filaments hot - usually. You will notice that a few iterations are sometimes needed to get the tube to light. The starter may keep cycling indefinitely if either it or one of the tubes is faulty. While the lamp is on, a preheat ballast is just an inductor which at 60 Hz (or 50 Hz) has the appropriate impedance to limit the current to the tube(s) to the proper value.

Ballasts must generally be fairly closely matched to the lamp in terms tube wattage, length, and diameter.

There are two general types of ballast: Iron ballasts consist of a core, windings, and maybe a few other passive components like capacitors. Electronic ballasts are basically switching power supplies.

Types of Iron Ballasts

Preheat ballasts require starters or manual starting switches. Instant start, trigger start, rapid start, etc. ballasts include loosely coupled high voltage windings and other stuff which does away with the starter:

1. The ballast for a preheat fixture (combined with a starter or power switch with a 'start' position) is basically a series inductor. Interrupting current through the inductor provides the starting voltage.

2. The ballast for a rapid start fixture has in addition small windings for heating the filaments reducing the required starting voltage to 250 to 400 V. There are probably the most common types in use today. Trigger start fixtures are similar to rapid start fixtures.

3. The ballast for an instant start fixture has a loosely coupled high voltage transformer winding providing about 500 to 600 V for starting in addition to the series inductor. The electrodes of "instant start" bulbs are designed for starting without preheating. In fact, they are shorted out internally and are thus incompatible with preheat and rapid start ballasts (and they have only a single pin at each end!). The electrodes still emit electrons due to thermal emission but since they are shorted out cannot be pre-heated. That is why they require a higher starting voltage from the ballast. They they light instantly, but this slightly reduces lamp life.

Starting voltage is either provided by the inductive kick upon interruption of the current bypassed through the starter for (1) or a high voltage winding in (2) and (3).

In all cases, the current limiting is provided primarily by the impedance of the series inductance at 60 Hz (or 50 Hz depending on where you live).

(From: Vic Roberts (Vic@RobertsResearchInc.com).)

The most basic ballast is nothing more than a current limiting device, such as an inductor, resistor or capacitor. For 50 and 60 Hz applications, the most common current limiting device is an inductor.

A simple current limiter works best when the line voltage is at least 2 times the lamp voltage. So, a simple inductor can be used in Europe, where the line voltage is 220 to 240 VAC, to operate a 4 foot lamp, which operates at 85 to 100 volts, depending upon design.

In the US and other places that use 120 VAC lines the ballast is a combination autotransformer (to raise the voltage) and inductor (the current limiter).

In addition, a Rapid Start ballast has additional windings to supply about 3.6 VAC to heat the filaments.

(From: Asimov (Asimov@juxta.mn.pubnix.ten).)

A ballast is a simple transformer with a very high impedance secondary winding which makes its current self-limiting. It also has windings for each lamp filaments. At startup the filaments get most of the power and heat up to facilitate ionization.

Meanwhile the secondary builds up a very high EMF which finally fully ionizes the plasma between both filaments. At this point the effective resistance of the conducting plasma is quite low and the current flow is limited by the secondary's impedance. This also partially saturates the core and as consequence reduces power to the filaments.

The usual failure in ballasts is that the secondary's insulation deteriorates and it starts leaking to ground. Often because the proper wiring polarity was not observed. The secondary can thus no longer generate the high EMF required to start the plasma conducting.

The KISS test method is to use a known good lamp. If it lights, the ballast is good too. The ballast can also be tested with the power off by checking for continuity in the filament windings and a very high resistance to ground for each filament. Don't try this with power on!

(From: Craig J. Larson (larson@freenet.msp.mn.us).)

Call Magnetek, a ballast manufacturer on 1-800-BALLAST. Ask for a copy of their Troubleshooting & Maintenance Guide for Linear Fluorescent Lighting Systems. Its a nice little guide book for teaching you the basics.

Electronic Ballasts

These devices are basically switching power supplies that eliminate the large, heavy, 'iron' ballast and replace it with an integrated high frequency inverter/switcher. Current limiting is then done by a very small inductor, which has sufficient impedance at the high frequency. Properly designed electronic ballasts should be very reliable. Whether they actual are reliable in practice depends on their location with respect to the heat produced by the lamps as well as many other factors. Since these ballasts include rectification, filtering, and operate the tubes at a high frequency, they also usually eliminate or greatly reduce the 100/120 Hz flicker associated with iron ballasted systems. However, this is not always the case and depending on design (mainly how much filtering there is on the rectified line voltage), varying amounts of 100/120 can still be present.

I have heard, however, of problems with these relating to radio frequency interference from the ballasts and tubes. Other complaints have resulted due to erratic behavior of electronic equipment using infra red remote controls.

There is a small amount of IR emission from the fluorescent tubes themselves and this ends up being pulsed at the inverter frequencies which are sometimes similar to those used by IR hand held remote controls.

Some electronic ballasts draw odd current waveforms with high peak currents. This is due to the fact that these ballasts (low-power-factor type) have a full-wave-bridge rectifier and a filter capacitor. Current can only be drawn during the brief times that the instantaneous line voltage exceeds the filter capacitor voltage.

Because of the high peak currents drawn by some electronic ballasts, it is often important to size wiring properly for these high peak currents. For wiring heating and fuse/circuit considerations, one should allow for a current of 4 to 6 times the ratio of lamp watts to line volts. For wiring voltage drop considerations (drop in voltage the ballast's filter capacitor gets charged to), the effective current is even higher, sometimes as high as 15 to 20 times the ratio of the lamp watts to RMS line volts.

For less than 50 watts, the current drawn by low-power-factor electronic ballasts is usually not a problem. For multiple ballasts or total wattages over 50 watts, it may be important to consider the effective current drawn by low-power-factor electronic ballasts.

If you want to get an idea of some typical modern electronic ballast designs, see the International Rectifier web site. Search for 'electronic ballasts' or download the following reference design notes:

- Linear Ballast
- Compact Ballast

Two typical commercial electronic ballasts compact fluorescent lamps are shown in:

- CFL Electronic Ballast 1 (Techna-Bright EDXR-38-16).
- CFL Electronic Ballast 2 (General Electric FLE26HT3/2/SW).

For additional info on these as well as a variety of simple inverters to operate fluorescent lamps on low voltage DC, see the collection in the document: Various Schematics and Diagrams.

Comments on CFL Ballasts

(From: Tony (tonyreo@ameritech.net).)

I work in a R&D lab for a VERY large corporation. We design CFLs (Compact Fluorescent Lamps).

Today, 90 percent of CFLs are electronic ballasted lamps and they come in two basic varieties: (1) High power factors (somewhere between .9 and very close to 1) and (2) Low power factor (usually less than .6).

The high power factor lamps require more components (or from the corporations point of view, cost) so there are more low power factor lamps on the market than high power factor. From what I understand using either will not make a difference in what your electric meter reads and bills you for.

Our typical electronic ballast has two FETs that switch at anywhere from 75 kHz to 105 kHz. And actually we have one product that runs at 2.5 MHz. In the power input section we use a full wave bridge followed by a electrolytic capacitor with a value of anywhere from 10 uF to 47 uF depending on the design of the lamp. There are also a few other components here that reduce EMI (Electro Magnetic Interference) that could be conducted back into the AC line. All of the input components, collectively, will have a part in the input characteristics of the lamp.

One more note that you may find interesting relates to the starting time of CFLs. The CFLs that do not start instantly (pre-heat types) will have a longer life than the "instant start" type. The pre-heat systems heat the cathodes for 150 milliseconds to 1 second (or more) before the lamp is allowed to light. This increases the cathode life which is one of the main factors in lamp life.

Notes on Bllast Compatibility

Can a 30 W lamp be run on a 27 W ballast? What about a 22 W ballast?

The answer is an absolutely possibly qualified maybe. :)

Any fluorescent lamp is expected to run at some specific current to produce its rated light output and life. (There is also the issue of preheat, instant, and rapid start types but that's for another discussion!) At the rated current, there will be a certain voltage across the lamp. The voltage drop is related to tube diameter, length, filament type, and gas fill. It goes up with length but is not directly proportional to length. Being gas discharge devices, the impedance of a fluorescent lamp is negative - its voltage actually goes down with increasing current, thus the need for a ballast to limit the current. Some iron ballasts are rated to handle more than one size lamp maintaining a nearly constant current over a range of lamp voltages - 12, 15, and 20 W, for example. What this means is that the voltage drop across all these lamps is similar enough that the current will be nearly the same and/or the ballast has a magnetic shunt to provide a quasi-constant current characteristic over a range of voltages.

The typical ballast will list compatible lamp types and wattages on its label. Wattage, starting type, and lamp diameter are all critical. With all the variations in lamps, there's no hard and fast rule that will determine whether a non-listed combination will work or even be safe. A higher wattage lamp may run and even be easier on the ballast since with its higher voltage drop, it will draw less current. Of course, there will also be less than rated light output. However, if the incompatibility is great enough, it may flicker, cycle on and off, or not start at all. A lower wattage lamp may burn out quickly and/or cause either type of ballast to overheat and fail.

Where the rated lamp current is known or where the same lamp could be run on a compatible ballast, it might be possible to measure the current with the ballast combination being tested to determine if it is acceptable. However, this is clearly above and beyond what is normally required when changing a light bulb. :)

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Fluorescent Fixture Wiring Diagrams

The following wiring diagrams are typical of fluorescent fixtures using iron ballasts. These do NOT generally apply directly to fixtures using electronic ballasts.

Wiring for Preheat Fluorescent Fixtures

The following is the circuit diagram for a typical preheat lamp - one that uses a starter or starting switch.

```
              Power Switch    +-----------+
 Line 1 (H) o------/ ---------|  Ballast  |-----------+
                              +-----------+           |
                                                      |
                      .---------------------------.   |
 Line 2 (N) o---------|-       Fluorescent      -|----+
                      | )         Tube         ( |
                  +---|-  (bipin or circline)   -|----+
                  |   '---------------------------'    |
                  |                                   |
                  |          +-------------+          |
                  |          |   Starter   |          |
                  +----------| or starting |----------+
                             |   switch    |
                             +-------------+
```

Where a three position switch (OFF-ON-START) is used to control the fixture (e.g., those circular magnifier lamps), there will be two pairs of contacts: One pair (Power) is connected in the ON and START positions, and the other (Start) is connected only in the START position. They are isolated from each-other.

```
              Power Switch    +-----------+
 Line 1 (H) o------/ ---------|  Ballast  |-----------+
              Closed for ON   +-----------+           |
                and START                             |
                                                      |
                      .---------------------------.   |
 Line 2 (N) o---------|-       Fluorescent      -|----+
                      | )         Tube         ( |
                  +---|-  (bipin or circline)   -|----+
                  |   '---------------------------'    |
                  |                                   |
                  +--------------o/ o-----------------+
                          Starting contacts (Closed for START only)
```

Here is a variation that some preheat ballasts use. This type was found on a F13-T5 lamp fixture. Similar types are used for 30 and 40 watt preheat lamps. This 3-lead preheat ballast is a voltage-boosting "high leakage reactance autotransformer" used if the voltage across the tube is much over approx. 60 percent of the line voltage. For technical details on why a fluorescent lamp will not work with ordinary ballasts if the tube voltage is only slightly less than the line voltage, look at Don Klipstein's Discharge Lamp Mechanics document.

```
              Power Switch   +-------------+
Line 1 (H) o------/ --------|A  Ballast   |
                 +----------|B          C|----------+
                 |          +-------------+          |
                 |                                   |
                 |   .---------------------------.   |
Line 2 (N) o-----+---|-       Fluorescent      -|----+
                     | )         Tube         ( |
                 +---|-  (bipin or circline)   -|----+
                 |   '---------------------------'   |
                 |                                   |
                 |          +-------------+          |
                 |          |   Starter   |          |
                 +----------| or starting |----------+
                            |   switch    |
                            +-------------+
```

Fluorescent Starter Operation

Starters may be either automatic or manual:

- Automatic - The common type are called a 'glow tube starter' (or just starter) and contains a small gas (neon, etc.) filled tube and an optional RFI suppression capacitor in a cylindrical aluminum can with a 2 pin base. While all starters are physically interchangeable, the wattage rating of the starter should be matched to the wattage rating of the fluorescent tubes for reliable operation and long life.

  The glow tube incorporates a switch which is normally open. When power is applied a glow discharge takes place which heats a bimetal contact. A second or so later, the contacts close providing current to the fluorescent filaments. Since the glow is extinguished, there is no longer any heating of the bimetal and the contacts open. The inductive kick generated at the instant of opening triggers the main discharge in the fluorescent tube. If the contacts open at a bad time - current near zero, there isn't enough inductive kick and the process repeats.

  Higher-tech replacements called 'pulse starters' may be available for the simple glow tube type starter. These devices are pin compatible devices and contain a bit of electronics that detect the appropriate time to interrupt the filament circuit to generate the optimal inductive kick from the ballast. So, starting should be more reliable with few/no blink cycles even with hard-to-start lamps. They will also leave used-up tubes off, without letting them blink annoyingly.

  A defective or incorrect starter is a common cause of erratic starting and possibly random restarts during operation.

- Where a manual starting switch is used instead of an automatic starter, there will be three switch positions - OFF, ON, START:

    - OFF: Both switches are open.
    - ON: Power switch is closed.
    - START (momentary): Power switch remains closed and starting switch is closed.

  When released from the start position, the breaking of the filament circuit results in an inductive kick as with the automatic starter which initiates the gas discharge.

Wiring for Rapid Start and Trigger Start Fixtures

Rapid start and trigger start fixtures do not have a separate starter or starting switch but use auxiliary windings on the ballast for this function.

The rapid start is now most common though you may find some labeled trigger start as well.

Trigger start ballasts seem to be used for 1 or 2 small (12-20 W) tubes. Basic operation is very similar to that of rapid start ballasts and the wiring is identical. "Trigger start" seems to refer to "rapid starting" of tubes that were designed for preheat starting.

The ballast includes separate windings for the filaments and a high voltage starting winding that is on a branch magnetic circuit that is loosely coupled to the main core and thus limits the current once the arc is struck.

A reflector grounded to the ballast (and power wiring) is often required for starting. The capacitance of the reflector aids in initial ionization of the gases. Lack of this connection may result in erratic starting or the need to touch or run your hand along the tube to start.

A complete wiring diagram is usually provided on the ballast's case.

Power is often enabled via a socket operated safety interlock (x-x) to minimize shock hazard. However, I have seen normal (straight) fixtures which lack this type of socket even where ballast labeling requires it. Circline fixtures do not need an interlock since the connectors are fully enclosed - it is not likely that there could be accidental contact with a pin while changing bulbs.

Wiring Diagram for Single Tube Rapid or Trigger Start Ballast

Below is the wiring diagram for a single lamp rapid or trigger start ballast. The color coding is fairly standard. The same ballast could be used for an F20-T12, F15-T12, F15-T8, or F14-T12 lamp. A similar ballast for a Circline fixture could be used with an FC16-T10 or lamp FC12-T10 (no interlock).

```
             Power Switch    +----------------------------+
 Line 1 (H) o----/ ----------|Black   Rapid/Trigger       |
                      +------|White       Start       Red|------+
                      |  +---|Blue       Ballast      Red|---+  |
```

```
                     |  |   +-------------+-------------+   |  |
                     |  |                 |                 |  |
                     |  |        Grounded | Reflector       |  |
                     |  |       ----------+----------       |  |
                     |  |    .-------------------------.    |  |
                     |  +----|-      Fluorescent      -|----+  |
                     +------x| )         Tube        ( |       |
Line 2 (N) o----------------x|-  (bipin or circline)  -|-------+
                             '-------------------------'
```

Wiring Diagram for Two Tube Rapid Start Ballast

The following wiring diagram is for one pair (from a 4 tube fixture) of a typical rapid start 48 inch fixture. These ballasts specify the bulb type to be F40-T12 RS. There is no safety interlock on this fixture. (A similar scheme could also be used on a dual tube Circline fixture though slightly different ratings may be needed for each tube since they would be of different sizes.)

```
            Power Switch    +--------------------------+
Line 1 (H) o----/ ----------|Black    Dual Tube     Red|-----------+
Line 2 (N) o----------------|White      Rapid       Red|--------+  |
                      +-----|Yellow     Start      Blue|-----+  |  |
                      |  +--|Yellow    Ballast     Blue|--+  |  |  |
                      |  |  +-------------+------------+  |  |  |  |
                      |  |                |               |  |  |  |
                      |  |       Grounded | Reflector     |  |  |  |
                      |  |      ----------+----------     |  |  |  |
                      |  |    .----------------------.    |  |  |  |
                      |  +----|-     Fluorescent    -|----+  |  |  |
                      |  |    | )      Tube 1      ( |       |  |  |
                      +-------|-       bipin       -|-------+  |  |
                      |  |    '----------------------'          |  |
                      |  |    .----------------------.          |  |
                      |  +----|-     Fluorescent    -|----------+  |
                      |       | )      Tube 2      ( |             |
                      +-------|-       bipin       -|-------------+
                              '----------------------'
```

Schematic of Typical Rapid/Trigger Start Single Lamp Ballast

This ballast is marked "Trigger Start Ballast for ONE F20WT12, F15WT12, F15WT8, or F14WT12 Preheat Start Lamp. Mount tube within 1/2" of grounded metal reflector". (Note that while labelled "Trigger Start", it does heat the filaments so I assume it is similar or identical to a rapid start ballast.)

Voltages were measured with no bulb installed with safety interlock bypassed.

Internal wiring has been inferred from resistance and voltage measurements.

The lossy autotransformer boosts line voltage to the value needed for reliable starting with the filaments heated. It is assumed that part of the magnetic circuit is loosely coupled so that putting the lamp between Red/Red and Blue/White results in safe current limited operation once the arc has struck.

A complete fixture wiring diagram like those shown in the section: [Wiring for Rapid Start and Trigger Start Fixtures](#) will probably be provided on the label.

Numbers in () are measured DC resistances.

```
               Red o--------------------------+
                       8.5 V               (5) )|| Filament 1
               Red o----------------------+---+ ||
                                          |     ||
                                          +     ||
                                           )||==|| Stepup winding/choke is
                      82.5 V          (37) )||  || loosely coupled to main
                                           )||==|| magnetic circuit
                                          +     ||
                                          |     ||
    +--> Black (H) o----------------------+---+ ||
    |                                          )|| Primary of starting
                     106.5 V              (31) )|| autotransformer
  115 V                                        )||
              Blue o--------------------------+ ||
    |                  8.5 V               (3) )|| Filament 2
    +--> White (N) o-----------o/o------------+  |
                            Interlock            |
         Green (G) o-----------------------------+
```

Schematic for Rapid Start Ballast with Isolated Secondary

As noted, rapid start fixtures do not have a separate starter or starting switch but use auxiliary windings on the ballast for this function. Here is the schematic for a typical 1-tube rapid start fixture including the internal wiring of the ballast.

This ballast includes separate windings for the filaments and a high voltage winding that is on a branch magnetic circuit that is loosely coupled and thus limits the current once the arc is struck. It is not known if this design is common. The isolated secondary and separate high voltage winding would make it more expensive to manufacture.

A complete fixture wiring diagram like those shown in the section: Wiring for Rapid Start and Trigger Start

Fixtures will probably be provided on the label.

```
                                   +-------+
          Power Switch ||======||(        |
Line 1 (H) o---/ ----+ ||      ||(   +----+---------o    to both pins
                      )||      ||(  ( filament winding   on one end
                      )||      ||(   +--------------o
                      )||      ||(     HV winding       Grounded reflector
                      )||      || +-----^^^^^^^-------------------------+
                      )||      ||(                                     _|_
                      )||      ||(   +--------------o                   -
                      )||      ||(  ( filament winding   to both pins
Line 2 (N) o---------+ ||      ||(   +----+---------o    on other end
                       ||======||(        |
                                   +-------+

         Loose magnetic coupling in the ballast core results
         in leakage inductance for current limiting.
```

Schematic of Rapid Start Dual Lamp Ballast

This ballast is marked "Rapid Start Ballast for TWO F40WT12 Lamps. Mount tubes within 1/2" of grounded metal reflector". This circuit was derived from the measurements listed in the section: Measurements of a Dual Tube Rapid Start Ballast.

The autotransformer boosts line voltage to the value needed for reliable starting with the filaments heated. The series capacitor of approximately 4 uF is used instead of leakage inductance to limit current to the tubes. Leakage inductance from loose magnetic coupling is used to smooth the waveform of current flowing through the tubes. The .03 uF capacitor provides a return path during starting to the yellow filament winding but is not really used during normal operation.

Numbers in () are approximate measured DC resistances.

```
             Red 1 o--------------------------+
                      8.5 V             (.5) )|| Tube 1 Filament 1
             Red 2 o---------------------+---+ ||
                                        _|_    ||
                                  4 uF ---     ||
                                         |     ||
                                         +---+ ||
                                              )||
                                              )||
                                              )|| HV winding
```

```
                                               )||
                                               )||
                                +---------+---+ ||
                                |        _|_    ||
                                | .03 uF ---    ||
                                |         |     ||
            Yellow o----------------------+---+ ||
                       8.5 V    |         (.5) )|| Tubes 1 and 2 filament 2
            Yellow o--------------------------+ ||
                                |               ||
                                |               ||
            Blue 1 o------------+-------------+ ||
                       8.5 V              (.5) )|| Tube 2 filament 1
            Blue 2 o--+-----------------------+ ||
                      |                         ||
    +--> Black (H) o--+-----------------------+ ||
    |                                          )|| Primary of
  115 V                                   (13) )|| autotransformer
    |                                          )||
    +--> White (N) o------------o/o-----------+ ||
                            Interlock           ||
                                                 |
         Green (G) o-----------------------------+
```

Measurements of Dual Tube Rapid Start Ballasts

One is a Universal, the other is a Valmont.

(Measurements made with Radio Shack multimeter)

Resistance:

Measurement	Universal	Valmont
White-Black	13	13
Between blues	.5	.55
Between reds	.5	.55
Between yellows	.5	.6
Black to closer blue	<.1	<.1
Blue-red	open	open
Blue-yellow	open	5 M
Red-yellow	open	20 M

Capacitance:

```
  Blue-red                                ~4 uF               ~3.5 uF
  Blue-yellow                           ~.03 uF
  Red-yellow                            ~.03 uF

Primary current, (not true RMS), various secondary load conditions:

  Secondary open                         .32 A                 .35 A
  60W 120V incandescent bulb             .75 A                 .63 A
  Short                                  .48 A                 .53 A

Heater voltage:                   not measured    approx. 8 V, unsteady
                                                  surprisingly independent
                                                  of secondary load
```

Open circuit output voltage voltage (from one red wire to one blue one, highest reading of four combinations):

```
  Red-Blue                              270 V                  275 V
```

Fluorescent Lamps in Series?

This is not possible where line voltage is 105 to 125 VAC because this is not sufficient to sustain the discharge where two lamps are in series. Special dual lamp ballasts are required.

However, where the line voltage is 220 VAC, it is possible:

(From: andrew@cucumber.demon.co.uk (Andrew Gabriel))

Here in UK (and probably all 220 to 250 V areas), this is common:

```
                    =======
        L o---+-----^^^^^^^-------+ +-----+
              |     Ballast       | |     |
              |   (Inductor)     +|-|+    |
              |                  | - |    |
              |                  |   |   +-+
              |           Tube 1 |   |   |S| Glow Starter
              |                  |   |   +-+
              |                  | - |    |
              |                  +|-|+    |
              |                   | |     |
             _|_ Power Factor     | +-----+
             ___ Correction       |
              |  Capacitor        | +-----+
              |                   | |     |
```

```
            |                  +|-|+     |
            |                  | - |     |
            |                  |   |    +-+
            |           Tube 2 |   |    |S| Glow Starter
            |                  |   |    +-+
            |                  | - |     |
            |                  +|-|+     |
            |                   | |      |
      N o---+-------------------+ +------+
```

Note that starters for a 230 VAC two tube fixture may NOT be the same as those for a 230 VAC single tube fixture. Installing single tube starters in a two tube fixture may result in no action at all since their breakdown voltage may be too high. Doing the reverse may result in damage.

Fluorescent Lamps in Parallel?

Like most gas discharge tubes, fluorescent lamps are negative resistance devices. Therefore, it isn't possible to put more than one lamp in parallel and get them both to light - additional components are needed. The following applies mostly to magnetic ballasted fixtures. Where electronic ballasts are used, all sorts of games can be played to implement wierd configurations!

Multiple lamp fixtures in countries with 110 VAC power usually have special ballasts with separate windings for this purpose. Where 220 to 240 VAC is available, it may be possible to put multiple lamps in series with individual starters. See the section: Fluorescent Lamps in Series?.

However, there is at least one application where putting two lamps is parallel makes sense: light fixtures in hard-to-reach or safety-critical areas where redundancy is desirable. With only minor modifications at most, a conventional single lamp ballast can be connected to a pair of lamps in such a way that only one will light at any given time. (Which one actually starts could be random without additional circuitry, however.) If either lamp burns out or is removed, the other will take over. The ballast must provide enough power to the filaments for starting but once started, the lamp that is on will operate normally and there should be no degradation in performance or expected lamp life (except to the extent that the unlit lamp's filaments might be kept hot).

The following is just a suggestion - I have not confirmed if or with which model ballasts these schemes will work!

For rapid start ballasts, this could be as simple as wiring all connections to the lamps in parallel - if the ballast has enough current available to power both sets of filaments for starting. For trigger start ballasts, the filament power is not an issue so it should be even easier:

```
             Power Switch   +----------------------------+
 Line 1 (H) o----/ ---------|Black   Rapid/Trigger       |
                      +-----|White       Start        Red|--------+
                      |  +--|Blue       Ballast       Red|-----+  |
                      |  |  +--------------+-------------+     |  |
```

```
                      |  |                 |                  |  |
                      |  |                 +---------------+  |  |
                      |  |       Grounded  | Reflector     |  |  |
                      |  |       ----------+----------     |  |  |
                      |  |    .-------------------------.  |  |  |
                      |  +----|-     Fluorescent       -|--|--+  |
                      |  |    | )       Tube          ( |  |  |  |
                      +--|----|-  (bipin or circline)  -|--|--|--+
                      |  |    '-------------------------'  |  |  |
                      |  |                 +---------------+  |  |
                      |  |        Grounded | Reflector        |  |
                      |  |       ----------+----------        |  |
                      |  |    .-------------------------.     |  |
                      |  +----|-      Fluorescent      -|-----+  |
                      |       | )        Tube         ( |        |
 Line 2 (N) o---------+-------|-  (bipin or circline)  -|--------+
                              '------------------------'
```

Note: The interlock normally present on most rapid/trigger start fixtures have been removed to permit one lamp to operate if other is removed.

For preheat ballasts, wiring the filaments in parallel would probably result in insufficient current to either lamp for it to start reliably. If the filaments were wired in series, one lamp would probably start, but if the filament of one lamp burned out or the lamp was removed, the fixture would cease to function kind of defeating the purpose of these gyrations!

Wiring Fluorescent Lamps to Remote Ballasts

For reasonable distances, this should work reliably and be safe provided that:

1. This is only attempted with iron ballasts. The fire safety and reliability of electronic ballasts that are not in close proximity to the lamps is unknown. The ballast may fail catastrophically either immediately or a short time later as the circuit may depend on a low impedance (physically short) path for stability.

   In addition, there will almost certainly be substantial Radio Frequency Interference (RFI) created by the high frequency currents in the long wires. The FCC police (or your neighbors) will come and get you! This may be a problem with iron ballasts as well - but probably of less severity.

2. Wire of adequate rating is used. The starting voltage may exceed 1 kV. Make sure the insulation is rated for at least twice this voltage. Use 18 AWG (or heavier) gauge wire.

3. There is no possibility of human contact either when operating or if any connectors should accidentally come loose - dangerous line voltage and high starting voltage will be present with tubes disconnected.

Note: one application that comes up for this type of remote setup is for aquarium lighting. My recommendation would be to think twice about any homebrew wiring around water. A GFCI may not help in terms of shock hazard and/or may nuisance trip due to inductive nature of the ballast (both depend at least in part on ballast design).

Wiring diagram of Low Power 220 VAC Fluorescent Lamp

(From: Manuel Kasper (mk@mediaklemm.com).)

The circuit in Low Power 220 VAC Fluorescent Lamp is from an AC line powered 'light stick'. So there's no fancy inverter circuit inside, but a simple ballast without any nasty coils - just capacitors, resistors, and diodes. A few modifications would probably be necessary to make it operate from 110 VAC. It runs the tube brighter than a similar lamp power from a 12 V inverter. (See the section: "Automotive Light Stick Inverter" in the document: Various Schematics and Diagrams. FWIW, the brand is "Brennenstuhl".

It was damn hard to open up because everything was made out of thick plastic with no screws (no wonder; it cost $6) - but thanks to a huge saw I managed to get at the guts without destroying the tube or the circuit.

Alternatives to Commercial Iron Ballasts?

While the circuit diagrams of iron ballasts may resemble those of common power transformers, I wouldn't recommend attempting to use these as ballasts unless you really know how to implement controlled impedance behavior in a non-current limited transformer. Ballasts are rather special and unless you are willing to blow a lot of fluorescent lamps, transformers, fuses, and circuit breakers, just go with commercial ballasts. :)

Even for small lamps using a glow starter or separate starting switche, while it's certainly possible to use an ordinary inductor rather than something labeled "ballast", it's still probably not a good idea from fire safety and liability considerations.

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Specialty Fluorescent Lamp Types

All Sorts of Less Conventional Lamps

In addition to the boring white ones (OK, well 'white' does come in various colors!), other interesting types of lamps include all sorts of real colors (red, green, blue, yellow), blacklight lamps, germicidal lamps in which there is no phosphor coating at all and a quartz tube to transmit short-wave UV light (e.g., EPROM erasers and PCB photoresist activation), sunlamps, plant lights and special purpose specific wavelength lamps such as reprography and copier lamps.

The basic technology is extremely flexible!

(From: Bruce Potter (s602531@aix2.uottawa.ca).)

There are also High Output and Very High Output types of lamps that have a discharge current of 0.8 A and 1.5 A instead of the standard 0.3 A. HO and VHO lamps are used when high light output is desired but are being outmoded by HID lamps like metal halide.

Blacklight Fluorescent Lamps

(From: Don Klipstein (don@misty.com).)

BL in the tube designation (e.g., F40T12BL) means "blacklight", which is a fluorescent lamp with a phosphor that emits the longest largely invisible UV wavelengths that are both efficiently and fairly cheaply possible. This phosphor seems to emit a band of UV mainly from 350 to 370 nanometers, in the UV-A range.

BLB means "blacklight-blue", which differs from "blacklight" only in that the glass tube of this lamp is darkly tinted with something with a dark violet-blue color to absorb most visible light. Most UV gets through this, along with much of the dimly visible deep-violet 404.7 nanometer line of mercury. Most of the violetish-blue 435.8 nanometer line is absorbed, but enough of this wavelength gets through to largely dominate the color of the visible light from this lamp. Longer visible light wavelengths do not significantly penetrate the BLB's very deep violet-blue glass, which is known as 'Wood's glass'. The UV is the same as that of the BL lamp, being mostly between 350 and 370 nanometers.

There is a 350BL blacklight lamp, using a different phosphor that emits a band of slightly shorter UV wavelengths in the UV-A range. The reasoning for this lamp is that it is supposedly optimized for attracting insects. These lamps are one variety of UV lamps used in electric bug killers.

There are other UV fluorescent lamps. There are at least two different UV/deep violet emitting fluorescent lamps used mainly in the graphic arts industry, emitting mainly wavelengths between 360 and 420 nanometers. Possibly one of these is also used in bug killers. I have noticed one kind of UV fluorescent lamp for bug killers with a broadish band phosphor with significant output from the 360 nanometer range (maybe also shorter) into visible wavelengths around 410 to 420 nanometers or so.

There is an even shorter UV-A lamp used for suntanning purposes. I would guess the phosphor emits mainly within the 315 to 345 nanometer range. One brand of such lamps is "Uvalux".

There is even a UV-B emitting fluorescent lamp. Its phosphor emits mostly at UV-B wavelengths (286 to 315 nanometers). It is used mainly for special medicinal purposes. Exposing skin to UV-B causes erythema, which is to some extent a burn reaction of the skin to a slightly destructive irritant. Use of UV-B largely limits this to outer layers of the skin (perhaps mainly the epidermis) and to parts of the body where skin is thinner. UV-A wavelengths just over 315 nanometers can also cause sunburn, but they are more penetrating and can affect the dermis. Please note that the deadliest varieties of skin cancer usually originate in the epidermis and are usually most easily caused by UV-B rays.

There are clear UV-emitting lamps made of a special glass that lets through the main shortwave UV (UV-C) mercury radiation at 253.7 nanometers. These lamps are marketed as germicidal lamps, and ones in standard fluorescent lamp sizes have part numbers that start with G instead of F. These lamps will work in standard fluorescent lamp fixtures.

Cold-cathode germicidal lamps are also in use; these somewhat resemble "neon" tubing.

Be warned that the shortwave UV emitted by germicidal lamps is intended to be dangerous to living cells and is hazardous, especially to the conjunctiva of eyes. Signs of injury by the UV are often delayed, often first becoming apparent several minutes after exposure and peaking out a half hour to several hours afterwards.

Please note that non-fluorescent (high pressure mercury vapor discharge) sunlamps generally emit more UV-B rays rather than the tanning-range UV-A rays. These lamps do have substantial UV-A output, but mainly at a small cluster of wavelengths around 365 nanometers. Tanning is most effectively accomplished by wavelengths in the 315-345 nanometer range. In addition, no UV suntanning is completely safe.

Compact Fluorescent Lamps

These are miniaturized fluorescent lamps that usually have premium phosphors which often come packaged with an integral ballast (either iron or electronic). They typically have a standard screw base that can be installed into nearly any table lamp or lighting fixture that accepts an incandescent lamp.

Compact fluorescent Lamps (CFLs) are being heavily promoted as energy savings alternatives to incandescent lamps. They also have a much longer life - 6,000 to 20,000 hours compared to 750 to 1,000 hours for a standard incandescent. While these basic premises are not in dispute, before replacing all the incandescent lamps in your house with CFLs, that there are some disadvantages and quirks:

1. CFLs are often physically larger than the incandescent bulbs they replace and simply may not fit the lamp or fixture conveniently or at all. However, they are getting smaller as the technology matures.

2. The funny elongated or circular shape may result in a less optimal lighting pattern.

3. The light is generally cooler - less yellow - than incandescents - this may be undesirable and result in less than pleasing contrast with ordinary lamps and ceiling fixtures. Newer models have been addressing this issue and color temperature of some are now very close to incandescent lamps.

4. Some types (usually iron ballasts) may produce an annoying 120 Hz (or 100 Hz) flicker.

5. Ordinary dimmers cannot be used with compact fluorescents and may result in immediate destruction of the CFL.

   In addition, CFLs should not be used with illuminated switches, electronic timers, or any other means of control that results in a small current in series with the lamp when it is supposed to be off. With some electronic ballast designs, the small current will slowly charge a filter capacitor inside the CFL until it reaches a critical threshold, at which point the lamp will flash on momentarily - perhaps every 5 seconds. This may be kind of cool and may not damage the CFL (at least not immediately) but probably isn't the intended effect in your home. :) For illuminated switches, the switch won't be affected (though it may pulse synchronously with the cycle of the flashing CFL), but for timers and the like, the non constant current is likely to result in erratic behavior if not actual damage to the control device.

6. Light output may depend somewhat on mounting orientation.

7. Some CFLs come on instantly while others may have a delay of a up to a second or more where nothing

appears to happen. They generally go off instantly. There characteristics may be annoying to anyone used to normal incandescent desk lamp behavior where which has a small but noticeable (and expected) delay as the filament heats or cools.

8. There will usually be a warmup time of a few seconds to a minute or more before full light output is produced even in warm temperatures.

9. Light output will decline slightly over the course of the life of the CFL.

10. Like other fluorescents, operation at cold temperatures (under around 50 to 60 °F) may result in reduced light output. Starting may also be erratic, although most compact fluorescent lamps seem to start OK at temperatures near freezing. Many types start OK near zero °F. Operation in an enclosed fixture often results in full light output in cool surroundings after the lamp warms up for a few minutes, as long as the initial temperature is high enough to permit a good start. However, enclosing compact fluorescents often impairs their ability to work well at higher temperatures.

11. CFLs should not be use in an unenclosed fixture outdoors since the electronics are really not always well protected. There may be additional specific environmental limitations stated on the package.

12. There may be an audible buzz from the ballast, especially the iron type.

13. CFLs may produce Radio Frequency Interference (RFI).

14. While their rated life may be 6,000 to 20,000 hours, a wayward baseball will break one of these as easily as a 25 cent incandescent as I've found out - but that's how I was able to trace the ballast schematics!

The prices of CFLs are dropping and $5 or $6 for one that does a decent job of replacing a 100 W incandescent lamp (in terms of color, light output, and fit) is now common. Depending on the cost of electricity in your area, these should pay for themselves over the number of hours equivalent to the lifetime of 1 to 2 incandescent lamps.

As an example, in 750 hours, a typical 26 W (consumed) CFL with a light output of 1,700 lumens (similar to a 100 W soft white incandescent) will use 19.5 kWh, compared to 75.0 kWh for the incandescent. At 10 cents/kWh, this represents a saving of $5.55. Add in $0.50 for the cost of the incandescent lamp and it's already just about break-even for a $6 CFL. And, most of the life of the CFL and continued savings on electricity lies ahead. With special discounts and promotions, CFL prices may be even lower resulting in quicker pay-back periods.

Identify locations where lamps or fixtures are left on for a significant number of hours on average per day. Or equivalently, where it seems you are always replacing bulbs (but they are actually lasting for their rated life, not burning out due to vibration or bad connections). It doesn't make sense to put a CFL in a closet or attic which isn't used much. Even a bathroom is typically a marginal location. Go for CFLs that will fit physically and and where their color and appearance is acceptable. Home centers may have better prices than corner hardware stores but not always. Shop around before buying (or at least before buying a bushel).

For more information, see the separate document on Compact Fluorescent Lamps.

If you're into recycling electronics to other uses, see Andrew Gabriel's D.I.Y. Electronic Gear Page for taking the electronic ballasts from compact fluorescents that died due to lamp failure and using them to drive normal fluorescent lamps as well as remotely connected CF lamps.

(From: Victor Roberts (Vic@RobertsResearchInc.com).)

One big difference between the low cost electronic ballasts designed for integral CFLs and the higher cost ballasts designed to be used with plug-in CFLs or linear fluorescent lamps, is that the former are usually not designed to survive if the lamp does not light or is not present. After all, for an integral system, once the lamp dies there is no reason why the ballast cannot also burn out. One reason external electronic ballasts are more expensive than the electronic ballasts used in integral CFLs is that external ballasts are designed to survive if the lamp does not light or is not present.

If you "harvest" an electronic ballast from an integral CFL, in addition to making sure you know what you are doing so you don't kill yourself or someone else, make sure that you never operate the ballast without a operating lamp attached. If you do, the ballast will most likely burn out in less than a few seconds.

Cold Weather Fluorescent Lamps

(From: Bruce Potter (s602531@aix2.uottawa.ca).)

There are special lamps with heavy glass jackets and/or with krypton gas filling for cold weather/freezer applications. They work best at below room-temperatures. It really annoys me when I go to the grocery store or see outside installations with dim, flickering tubes! What a waste of electricity!

Fluorescent Lamps which Operate from Low Voltage DC

These are now found in all sorts of equipment including laptop computers and all many other portable high tech devices to camping lanterns, boats, and RVs, All are based on an electronic ballast that converts the low voltage DC (anywhere from 3 V to 24 V depending on application) to high frequency high voltage AC to operate the fluorescent tube(s). Laptop computers and similar devices use special narrow tubes designed specifically to be run without heated filaments (cold cathode operation) and very narrow envelops to fit into very thin spaces. :) Most of the others use conventional fluorescent tubes and may or may not drive the filaments during starting or at any other time.

The ballasts for these lamps must generate the required voltages to start and operate the lamps reliably as well as to assure long life. See the section: Electronic Ballasts for more info and some links to sample circuits.

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Troubleshooting of Fluorescent Lamps and Fixtures

Problems with Fluorescent Lamps and Fixtures

In addition to the usual defective or damaged plugs, broken wires in the cord, general bad connections, fluorescent lamps and fixtures have some unique problems of their own. The following assumes a lamp or fixture with a conventional iron (non-electronic) ballast. Always try a new set of fluorescent tubes and starter (where used) before considering other possible failures.

If two tubes dim or flicker in unison, this means that both are powered by the same ballast. Often this means that one tube has failed, although the other tube may also be in poor condition or approaching the end of its life. Both tubes must be replaced with known good tubes in order to rule out a defective ballast.

1. Bad fluorescent tubes. Unlike incandescent lamps where a visual examination of the bulb itself will often identify a broken filament, there is often no way of just looking at a fluorescent tube to determine if it is bad. It may look perfectly ok though burned out fluorescents will often have one or both ends blackened. However, a blackened end is not in itself always an indication of a bad tube. Blackened ends are a somewhat reliable means of identifying bad tubes in 34 or 40 watt rapid start fixtures. Blackened ends are not as reliable an indicator in preheat or trigger start fixtures, or for tubes of 20 watts or less.

   Failure of the electrodes/filaments at one or both ends of the the fluorescent tube will usually result in either a low intensity glow or flickering behavior, or sometimes in no light at all. A broken filament in a fluorescent tube used in a preheat type fixture (with a starter) will almost always result in a totally dead lamp as there will be no power to the starter. A dim glow is rare in this case and would probably be confined to the region of the broken filament if it occurs. The best approach is to simply try replacing any suspect tubes - preferably both in a pair that are driven from a single ballast.

   One end glowing bright orange means the tube is dead - the filament has lost its electron-emitting coating. A working filament at that temperature will emit enough electrons to cause a discharge around it which will make the phosphor glow at that end (even without any voltage across the tube). The electron-emitting coating is normally to be found at this stage coating the inside of the glass, resulting in black tube ends.

   Before such complete failure, while the coating on one filament is much less effective that the other, this results in asymmetric current flow and 50/60 Hz flicker. This can have a bad psychological effect on people (even if they are not actually aware of the flicker), and is very bad news for anyone susceptible to epilepsy (50 Hz supplies are probably worse in this respect).

   In fixtures where a rapid start ballast runs two tubes, both tubes will go out when one fails. Sometimes one or both tubes will glow dimly and/or flicker. If one tube glows dimly and the other is completely dead, this does not indicate which tube has failed. The brighter tube may be the good one or the bad one. The bad tube usually has noticeable blackening at one end. It may pay to replace both tubes, especially if significant labor costs are involved. Also, prolonged dim-glowing may degrade the tube that did not initially fail.

   In trigger start fixtures that use one ballast to power two 20 watt tubes, sometimes both tubes will blink or intermittently dim. Replacing either tube with a known good tube may fail to fix this. The tubes may continue blinking or intermittently dimming until both are replaced with brand new tubes. This sometimes indicates borderline low line voltage ("brownout", etc.), nonideal temperatures, or a borderline (probably cheaply designed) ballast.

A simple test that will confirm that a tube is bad is to check the continuity between the pair of pins at each end. If either set are open, the tube is guaranteed bad if used in a preheat or rapid start fixture. It might still work in an instant or trigger start fixture. However, if there is continuity, the tube could still be bad as noted above.

2. Bad or incorrect starter (preheat fixtures only). The little starter can may go bad or be damaged by faulty fluorescent tubes continuously trying to start unsuccessfully. It is a good idea to replace the starter whenever tubes are replaced in these types of fixtures. One way that starters go bad is to "get stuck". Symptoms of this are the ends of the affected tube glowing, usually with an orange color of some sort or another but sometimes with a color closer to the tube's normal color if arcs form across the filaments. Occaisionally, only one end arcs and glows brightly, and the other end glows dimmer with a more orange color. This is hard on both the tube and the ballast. The defective starter should be immediately removed.

   A starter that is rated for a different wattage lamp can result not only in starting problems, but erratic behavior if the lamp does successfully start. For example, a starter rated for a lower wattage or shorter lamp (lower voltage drop) may be randomly activated resulting in flickering as it attempts (incorrectly) to restart.

   Should one or both ends glow with a bright yellowish orange color with no sign of any arc discharge surrounding each filament, then the emissive material on the filaments is probably depleted or defective. In such a case, the tube should be replaced regardless of what else is wrong. If both ends glow a dim orange color, then the filaments' emissive coating may or may not be in good shape. It takes approximately 10 volts to form an arc across a healthy fluorescent lamp filament.

3. Defective iron ballast. The ballast may be obviously burned and smelly, overheated, or have a loud hum or buzz. Eventually, a thermal protector built into many ballasts will open due to the overheating (though this will probably reset when it cools down). The fixture may appear to be dead. A bad ballast could conceivably damage other parts as well and blow the fluorescent tubes. If the high voltage windings of rapid start or trigger start ballasts are open or shorted, then the lamp will not start.

   Ballasts for fixtures less than 30 watts usually do not have thermal protection and in rare cases catch fire if they overheat. Defective fixtures should not be left operating.

4. Bad sockets. These can be damaged through forceful installation or removal of a fluorescent tube. With some ballasts (instant start, for example), a switch contact in the socket prevents generation of the starting voltage if there is no tube in place. This minimizes the possibility of shock while changing tubes but can also be an additional spot for a faulty connection.

5. Lack of ground. For fluorescent fixtures using rapid start or instant start ballasts, it is often necessary for the metal reflector to be connected to the electrical system's safety ground. If this is not done, starting may be erratic or may require you to run your hand over the tube to get it to light. In addition, of course, it is an important safety requirement.

WARNING: Electronic ballasts are switching power supplies and need to be serviced by someone qualified in their repair both for personal safety as well as continued protection from electrical and fire hazards.

Causes of Short Lamp Life

The following directly addresses issues with the common 4 foot 34 to 40 W fluorescent lamps and fixtures. However, most will apply to other wattages.

(From: Don Klipstein (don@Misty.com).)

There are two likely reasons for short lamp life:

1. **Bulb-ballast mismatch:** There are several different wattages of 4-foot fluorescent bulbs, two of which are called F40. The "energy saver" F40 is usually 34 watts but sometimes 35 watts but treatable as a 34. F40 with no mention of "energy saver" or "energy saving" is a true 40 watt.

2. **Subtle partial ballast failure:** Sometimes, usually in a 2-bulb magnetic rapid start ballast, a capacitor in series with the transformer's secondary winding fails. Excessive current flows through the lamp and the ballast can overheat. If you have or can borrow one of those "clamp-on" AC ammeters, clamp it around the black lead or the white lead (but not both, for a 120 VAC USA-usual ballast of this sort). A good ballast will draw approximately 0.8 A. A bad one will draw around 1.5 A.

Some less likely reasons:

3. **Excessive cycling:** You turn the lamps on and off a lot.

4. **The ballasts are cheap junk:** Replace them with "commercial grade" ballasts.

5. **Corroded contacts in the sockets:** Try twisting the bulbs around. Slight chance you need to clean the socket contacts with sandpaper (WITH POWER OFF - 280 volts is a popular output voltage of a 2-bulb F40 rapid start ballast.) Slight chance you need a new fixture - and then replace the cheapo-junko ballast with a proper "commercial grade" one, if the usually 2-inch-longer-length of the proper ballast is something the fixture will accept.

6. **Bulbs need to be cleaned:** More likely in humid coastal areas - a slightly conductive film of dust/salt/dirt on the bulbs can affect electric field distribution within bulbs that have not yet started and that can impair starting.

7. **The fixture may not be grounded:** It should be connected to the grounding conductor of the cable feeding it. This sometimes affects starting and sometimes unpredictably or in a manner varying with bulb age, temperature and humidity.

   But if the bulbs always start until some time when they act up and never start again, then grounding is probably not the problem.

Comments on Black Bands and Other Fluorescent Failure Issues

(From: Don Klipstein (don@Misty.com).)

Fluorescent tubes failing in this manner normally draw reduced current. The voltage across the tube is higher and the tube will sometimes draw more power, but the current flowing through the ballast is less.

Since the ends of the bulb usually burn out unequally, some "net DC" may try to flow through the ballast. My experience is that the feared core saturation effects do not occur. Furthermore, the common rapid start ballasts have a capacitor in series with the secondary windings which would block any DC.

There is a different problem that I once knew of causing a fire: Starters getting stuck in the "closed" state. The symptom is the ends of the tube glowing brightly, either yellow-orange or a color closer to the normal tube color, sometimes even one end glowing yellow-orange and one end glowing a more normal color. Excessive ballast current flows in this case. This is not a problem with "instant start", "rapid start", or "trigger start" fixtures. It is only a problem where there are starters.

A dim orange or red-orange glow more likely indicates dead tubes on a rapid start or trigger start ballast. If the fixture is a preheat type, dim orange end glow indicates less current than a brighter yellow-orange, and the ballast is less likely to overheat. Different brands of ballasts are designed a little differently.

If a preheat fixture has the tube glowing only in the ends, it is recommended to immediately remove the tube to stop the ballast from possibly overheating. You should replace both the tube and the starter. The starter is bad if this occurs, and the tube is usually bad also. Typically, the starter goes bad after too much time trying to start a bad tube. In the unlikely event the starter had the initial failure, the tube will be damaged by prolonged excessive end glow.

Why is a Grounded Fixture Needed for Reliable Starting?

Many fluorescent fixtures will not start reliably unless they are connected to a solid earth (safety) ground. This is most likely the case with rapid or trigger start magnetic ballasts. These will usually state on the label: "Mount tube within 1/2 inch of grounded metal reflector". If this is not done or if the entire fixture is not grounded, starting will be erratic - possibly taking a long or random amount of time to start or waiting until you brush your hand along the tube.

The reason is straightforward:

The metal reflector or your hand provides a capacitive path to ground through the wall of the fluorescent tube. This helps to ionize the gases inside the tube and initiate conduction in the tube. However, once current is flowing from end-to-end, the impedance in the ballast circuit is much much lower than this capacitive path. Thus, the added capacitance is irrelevant once the tube has started.

The reason that this is required is probably partly one of cost: it is cheaper to manufacture a ballast with slightly lower starting voltage but require the fixture to be grounded - as it should be for safety anyhow.

(From: Don Klipstein (don@Misty.com).)

Should one or both tubes glow dimly, then ionization is not the problem and poor grounding isn't the cause. In such a case, the problem is poor contact with the pins of the tubes, one or both tubes are bad, insufficient voltage, bulb/ballast mismatch (wrong bulbs may fit but not work especially for 4-footers which come in many wattages), or possibly just a bad case of the bulbs being much too cold. Wire or foil or other attachments to change the electric field distribution will not help dim glow make the transition to arc - only help with the tubes ionizing and glowing at all.

Why Do Fluorescent Lamps Buzz and What to Do About It?

The buzzing light is probably a mundane problem with a defective or cheap ballast. There's also the possibility of sloppy mechanical construction which lets something vibrate from the magnetic field of the ballast until thermal expansion eventually stops it.

First check for loose or vibrating sheetmetal parts - the ballast may simply be vibrating these and itself not be defective.

Most newer fixtures are of the 'rapid start' or 'warm start' variety and do not have starters. The ballast has a high voltage winding which provides the starting voltage.

There will always be a ballast - it is necessary to limit the current to the tube(s) and for starting if there is no starter. In older fixtures, these will be big heavy magnetic choke/transformer devices - hard to miss if you open the thing. Cheap and/or defective ones tend to make noise. They are replaceable but you need to get one of the same type and ratings - hopefully of higher quality. A new fixture may be cheaper.

The starter if present is a small cylindrical aluminum can, approximately 3/4" x 1-1/2" in a socket, usually accessible without disassembly. It twists counterclockwise to remove. They are inexpensive but probably not your problem. To verify, simply remove the starter after the lamp is on - it is not needed then.

The newest fixtures may use totally electronic ballasts which are less likely to buzz. Warning: electronic ballasts are basically switching power supplies and are maybe hazardous to service (both in terms of your safety and the risk of a fire hazard from improper repair) unless you have the appropriate knowledge and experience.

Where the buzzing started after replacing the ballast, assuming the replacement is of the same type as the original and it is tightly mounted, there is probably nothing really wrong - it is just not as quiet as your previous ballast. Make sure it is the ballast and not its mounting sheet metal vibrating. If the sound is coming from the ballast, there really isn't a lot that can be done other than to try another manufacturer or sample. Also see the section: Why do Fluorescent Lamps Buzz and What to Do About It?.

(From Brian Beck (jrdnut@utah-inter.net).)

There are 2 main types of ballasts; those for 'home' use and those for commercial use. The commercial type will last longer and the lamp life is better as well.

There are three sound ratings

- A - extremely quiet (e.g., libraries, churches).
- B - somewhat noisy (e.g., work areas, shops).
- C - outdoor noisy (e.g., 60 foot poles in parking lots).

My guess is you got a home rated ballast with a 'B' sound rating. There is nothing wrong with the ballast - it is just noisy. If the buzz bothers you, return it to the store you bought it and go purchase one at an actual electrical parts supplier (home centers and hardware stores may not have the highest quality components). For a 2 lamp F40/T12/CW/SS lamp fixture, you want an R2S40TP ballast.

Why Fluorescent Lamps are Sometimes Dimmer than Expected?

> "I recently replaced a kitchen overhead fixture with two 75 watt bulbs with a fluorescent one having two 20 W bulbs. Guess what? Not enough light!"
>
> Somehow I was under the impression that a watt of fluorescent lighting produced many more candles than a watt of incandescent lighting, but obviously, I overestimated the ratio."

A 20 watt fluorescent bulb of a higher light output color should make as much light as a 75 watt incandescent (1170 to 1210 lumens), BUT:

1. A few fluorescent lamp colors are dimmer, such as Deluxe versions of cool white and warm white, and a few others.

2. Fluorescent lamps only make full light output in a somewhat narrow temperature range. The fluorescents will probably not make full light when they first get started. They typically make more light after warming up for a few minutes, then may lose a bit of light output if they warm up past optimum temperature.

3. Some ballasts do not make fluorescent lamps produce full light. Some 20 watt fixtures use a multi-purpose ballast designed to be usable with a few different wattages of lamps, and which typically sends about 16 watts of power to a 20 watt tube. A few other ballasts send an inferior current waveform to the tube, impairing efficiency. I have found some fixtures by "Lights of America" to suffer slightly impaired efficiency from a less smooth current waveform generated by an instant-start ballast system that starts "preheat" tubes instantly without a starter. Some cheaper rapid start and trigger start ballasts produce slightly inferior current waveforms.

   Some of the slightly popular 2-tube 20 watt "trigger start" ballasts are cheap and "fussy", and only work well if everything is optimum. These ballasts often don't work well with cool temperatures, slightly low line voltages, or slightly weak lamps. Their best may not be too great anyway. The same may be true of some cheaper two-tube 40 watt "shop light" ballasts. Also, some "shop light" fixtures that you may think are dual 40 watt are actually dual 25 watt 4-foot fixtures.

4. Some fluorescent lamp colors (especially warm white, white, and cool white) have a spectral distribution that dims most reds and most greens. This may make things look dimmer. For details of this effect, look for the appropriate section in Some Bits of Discharge Lamp Theory andOther Technical Information!, (a web document related mostly to discharge lamp mechanics).

   > "What will happen if I replace the two T20s with higher powered lamps? (If some will burn out, can I replace it as well?"

The ballasts in nearly all 20 watt fixtures will not send much over 20 watts of power to any size tube. Sometimes even not much over 16 watts to any size tube. You need a different fixture, more fixtures/tubes, or possibly tubes of the same wattage but better brightness and/or color brightening (more modern '3000', 'D830', '3500', 'D835', '4100', or 'D841' tubes with higher lumen ratings but of wattage and size for the fixture).

Replacing fluorescent lamp or fixture components

Most of these parts are easily replaced and readily available. However, it is usually necessary to match the original and replacement fairly closely. Ballasts in particular are designed for a particular wattage, type and size, and tube configuration. Take the old ballast with you when shopping for a replacement. There may be different types of sockets as well depending on the type of ballast you have.

It is also a possible fire hazard to replace fluorescent tubes with a different wattage even if they fit physically. A specific warning has been issued about replacing 40 W tubes with 34 W energy saving tubes, for example. The problem is that the ballast must also be correctly sized for the new tubes and simply replacing the tubes results in excessive current flow and overheating of the ballast(s).

Rings or Swirls of Light in Fluorescent Lamps

Complaints are generally of the following form:

> "I just replaced my bulbs because they had the black bands at the end and finally went out altogether. The new bulbs light fine but they have subtle rings of light running down the inside of them."

or

> "My fluorescent tubes look like a they have a writhing snake inside trying to get out."

(From: Don Klipstein (don@Misty.com).)

The rings sometimes happens. I forget the name of this, but it is a sometimes normal feature of the main discharge column in low pressure lamps. In fluorescent tubes, it is more common if the bulb is cold or not fully warmed up, brand new or not-yet broken in, or if the ballast is of poor quality or there is a bulb/ballast mismatch.

Double check the label on the ballast and the lamp type to be sure they are compatible with each other.

If the bulb is an "energy saver" 34 or 35 watt model (part number usually begins with F40, which is the same for a normal 40 watt bulb), be sure the ballast is compatible with that bulb. If it is compatible with both 34's and 40's, it is compatible with 35's. Matching bulbs/ballasts is important for these models mainly to ensure long bulb life and to avoid overheating the ballast. 34 and 35 watt bulbs are prone to rings and flickering and being dim and being unusually sensitive to cold because of the nature of these bulbs and can do so no matter what ballast you use. They will normally behave properly after warming up, especially in ceiling fixtures where heat builds up.

Fluorescent tubes sometimes also "swirl" before being broken in, or if they are underpowered by an incorrect or low quality ballast.

Comments on Instant Start/Rapid Start Compatibility

(From: Ken Berg (goken@inreach.com).)

The problem with premature lamp failures using Instant Start ballast lies in the fundamental difference in the basic operating principles between Rapid Start and Instant Start lamps. It has really nothing to do with whether the ballast is magnetic or electronic. Instant Start ballasts are really designed to be used with the standard T12 single pin Slimline lamps. Instant Start ballasts deliver a higher striking voltage on starting than Rapid Start ballasts do. Slimline (the single pin) lamps have a slightly heavier cathode to tolerate the starting cycle. With Instant Start, the lamps are really started "cold cathode" style, and then they of course run as hot cathode.

On occasion, even the standard T12 Slimlines refuse to "die like gentlemen" and flash and swirl wildly. Maintenance guys have known for decades that they need to replace Slimlines promptly if they start doing this. They will need to keep this in mind when dealing with the F32T8 lamps as well. Even though the lamps are bi-pin, and so look like the old Rapid Start T12's, they are more than likely running on an Instant Start circuit, and will sometimes go like this.

The cathodes in most bi-pin lamps are made for Rapid Start, which is a starting method that is easier on the filaments. The lamp manufacturers are supposed to have already taken the starting characteristics of the new F32T8 Instant Start ballasts into account, but some might just be going on the cheap, and skimping of the lamp filaments.

Premature Cathode Failure in Dimmed Fluorescent Lamps

> "I have been experimenting with 15 W T8 lamps running from a dimmable electronic ballast. I have found that if set to a low light level after a few days of being left on, one of the cathodes in the tube often goes open circuit."

(From: Clive Mitchell (clive@emanator.demon.co.uk).)

The only explanation that I can come up with is that there isn't enough current flow to keep the cathodes warm and this is causing the discharge to be concentrated on a small point. The discharge will tend to stay on that point since it's the only warm bit, and as such is emitting electrons, making it the easiest path for current flow.

The voltage drop across this point will be higher than normal since the heat being generated is being dissipated by the rest of the cathode and this means that more power than normal is being dissipated from that point causing sputtering. This could be causing the early burn-out.

The best way to validate this would be with a clear tube to see the cathode discharge activity.

I've seen a phenomenon like this when I've lit a halide lamp at low level with a small voltage multiplier circuit. The glow discharge led to a white hot point on the electrode that caused sputtering.

If this is the case, then the cure is to use a ballast that can supply a continuous heating current to the cathodes.

Replace Preheat Ballasts with Rapid or Trigger Start Type?

When a ballast fails in a preheat fixture, should the bad preheat ballast be replaced with a more modern type? Advantages of a rapid or trigger start ballast are that the starter (a high failure part) is eliminated and the fluorescent lamps may last longer as a result of less stress during starting. Disadvantage include cost of the ballast and possibly space limitations inside the fixture. However, since a defective starter may ruin the lamp controlled by it, the potential cost of replacement lamps may offset the additional cost of the ballast. All in all, this is probably not a decision affecting the future of the Universe but in certain cases, changing ballast types may make sense.

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Items of Interest

All Those Different Wattage 4-Foot and F40 and "Shop Light" Lamps?

The original 4-foot fluorescent lamp was the F40T12, which is 47.75 inches (approx. 121.3 cm) long from pin tip to pin tip and 1.5 inches (approx. 4 cm) in diameter and designed to consume 40 watts. Not too many years ago, this was the most common and least expensive fluorescent lamp.

There is the "HO" (high output) 4-foot tube and the "SHO" (super high output) 4-foot tube. These are not common and are only used where there is not enough room to fit enough standard F40 tubes to make enough light. These lamps are slightly less efficient than standard fluorescent lamps. These tubes require more current than standard 4-foot tubes and require special ballasts. These tubes should only be used with their respective ballasts, and these ballasts should only be used with the tubes they were designed for.

In response to the energy shortages of the 1970's, the 34 watt lamp with the same physical dimensions was introduced. It works in most 40 watt fixtures and draws 34 watts in these fixtures. However, some 40 watt ballasts can overheat with this lamp. The ballast should say that it is rated for use with 34 watt lamps. Please note that a 34 watt tube can say F40 and still be a 34 watt tube and not be a 40 watt tube. It will in some way say near the F40 designation that it is an energy-saving tube. There have also been a few 35 watt tubes, which are similar enough to 34 watt tubes to work anywhere both 34 and 40 watt tubes can work. 34 watt lamps sometimes produce noticeably less light than 40 watt lamps, especially in cooler environments.

Nowadays, there is the 25 watt "shop light" lamp. The 25 watt tubes should only be used with appropriate 25 watt shop light ballasts, and these ballasts should only be used with these tubes. Please do not confuse these with other wattage tubes/fixtures of the same physical dimensions which are also sometimes called "shop lights".

A more recent development is the 32 watt T8 lamp, which is 4 feet long but only one inch (2.5 cm) in diameter. These require ballasts made for them. Many of the ballasts made for these lamps are electronic ballasts.

The confusion has increased in recent years now that the USA has an energy-conservation law against manufacturing and importing standard 40 watt white fluorescent lamps. Specialty lamps and white ones with a color rendering index of at least 82 (out of a maximum of 100) are exempt and are still available in the USA as true 40 watt lamps.

Again, be sure that you are not mismatching the bulb and the ballast. If the ballast is not rated to operate the bulb type being used, the bulb life will probably be shortened and the ballast life may be shortened. In a few cases, the ballast may catch fire after failing.

What's with All Those Different Shades of White?

At one time, most fluorescent lamps were "cool white" which is a plain-old white with a color like that of of average sunlight.
One bad thing about "cool white" is that the spectrum of "cool white" has a surplus of yellow and a shortage of green and red. Since mixing red light with green light makes yellow, the white light of a cool white lamp still looks white. Since yellow objects usually reflect green through red, they look yellow as usual in this light.
But red objects reflect mainly red light and green objects reflect mainly green light, and look dim and dull due to the shortage of red and green wavelengths in "cool white". Impure reds and greens will look less red and less green as well as darker - making them look more brown.

Other early whites were "warm white" and "daylight". Warm white is a color similar to that of incandescent lamps, although it usually looks slightly less yellow and more white-pink. A warm white lamp's spectrum has a surplus of yellow and violet-blue, and a shortage of red, green, and green-blue. Like cool white, warm white can distort colors in unflattering ways.
Both "warm white" and "cool white" are obtained using "halophosphate" phosphors. The surplus of yellow and shortage of red and green is a general characteristic of halophosphate phosphors.
"Daylight" is a bluish white, and does not have as bad a surplus of yellow as the other halophosphate whites. But it is also slightly dimmer.

Next were the "deluxe" versions of cool white and warm white. These have "improved" halophosphate phosphors and are sometimes known as "broad spectrum" lamps. They have a less severe yellow surplus and red/green shortage than standard halophosphate lamps. They also produce slightly less light.

Another slightly common halophosphate white is "white", which is between "cool white" and "warm white" in color.

Other halophosphate whites, whether of differing spectral quality or different shade of "warmth/coolness" include "supermarket white", "sign white", "north light", "merchandising white", etc. Please note that some of these are not made by all fluorescent lamp manufacturers, and some of the less standard color names are trademarks of their respective manufacturers.

One earlier fluorescent lamp color with enhanced red spectral content is the "natural". This lamp has "cool white" halophosphate phosphor with a red-glowing phosphor of a different type added in. These lamps look slightly pinkish in color, sometimes purplish when compared to warmer colored light such as incandescent light. "Natural" fluorescent lamps make skin tones look pinkish, unlike the usual halophosphate types which make skin tones look green-yellowish. Some meat displays have "natural" fluorescent lamps to make the meat look more red.

Nowadays, there are "triphosphor" fluorescent lamps. These have a spectrum very different from that of the halophosphate lamps. Triphosphor lamps have their spectral content mostly in distint bands and lines: Orangish red, slightly yellowish green, green-blue, and violet-blue. For cooler color lamps, there is an additional band in the mid-blue. Triphosphor lamps do not distort colors as badly as halophosphate lamps, and triphosphor's color distortions are usually not as unpleasant as those of halophosphate. Also, triphosphor lamps often make reds and greens look slightly brighter than normal, unlike halophosphate lamps which usually make these colors look dimmer than normal.

Most compact fluorescent lamps and most 4-foot T8 (1-inch diameter) lamps are triphosphor lamps.

Triphosphor lamps come in various warm and cool shades, usually designated by "color temperature". This is the temperature that an ideal incandescent radiator would be heated to in order to glow with a similar color. Color codes on fluorescent lamps may include the color temperature or 1/100 of the color temperature. Osram/Sylvania brand lamps often have D8 immediately preceding the color code.

2700 or 27 - orangish shade common for compact fluorescent lamps, similar to many incandescent lamps.

3000 or 30 - "warm white", similar to whiter shades of incandescent.

3500 or 35 - between warm white and cool white, similar to the whitest halogen lamps and projector lamps.

4100 or 41 - "cool white" or the color of average sunlight.

5000 or 50 - an icy cold pure white like that of noontime tropical sunlight.

6500 or 65 - slightly bluish white or "daylight".

There are still other specialty whites, including ones with a mixture of "broad spectrum" and "triphosphor" phosphor formulations to get a spectrum more like that of daylight. Some others have particularly good "broad spectrum" phosphors, sometimes mixed with other phosphors for a tailored spectrum. Many of these, like most triphosphor lamps, have color temperature designations.

Why Small Fluorescent lamps Cost More than 4-Foot Ones

Can you say 'supply and demand' and 'economies of mass production'. You are comparing the price of the common F40CW-T12 lamp manufactured by the zillions and sold in home centers for about $1 with specialty bulbs used in a relatively few devices like battery powered fluorescent lanterns and makeup mirrors. These little bulbs may indeed cost up to ten times as much as the much larger ones.

By any measure of materials and manufacturing cost, the 4 foot bulb is much much more expensive to produce. There is nothing special involved.

Energy Consumption and Wear-And-Tear due to Starting

(From: John Gilliver (g6jpg@gmrc.gecm.com).)

The amount of energy used in starting isn't worth worrying about. However, in addition to the turn on/off deterioration, there is also the steady-state `on' deterioration (they don't last for ever even if left on), so...

As far as turn-on deterioration:

I can't give it as a percentage, but for ordinary striplights I heard a figure of 15 minutes (about 15 years ago), i. e. turning it on stresses it as much as leaving it on for that long. Things have perhaps changed by now (and there are so many kinds these days as well).

For low-energy use, I'd go for fluorescents any day, unless size is a major factor (Bosch [I think] and others have been trying to get some sort of discharge lamp for headlights for some time, but I haven't seen any yet). You might also look into LEDs, but I doubt they will match the efficiency; certainly only the high-effificiency types (all seem to consume about 10, 20, or 30 mA, but the output power in light seems to vary widely, from a few millicandelas to about three candelas!). They are narrow band (i. e. coloured) as well of course.

What Happens when Fluorescent Lamps Wear Out?

(From: Charles R. Sullivan (charless@crissy.EECS.Berkeley.EDU).)

The usual failure mode is depletion of the emission mix on the filaments. Then they do not emit electrons, and the arc can't be sustained. Unless the ballast supplies a high enough voltage that very high field can be set up near the electrode. Then the ions bombarding the electrode have a high enough energy to knock electrons out of the metal even with no emission mix, or to heat the metal to the point it emits electrons. The high field is also sufficient to ionize the argon fill gas---normally only mercury is ionized. The argon radiation is of a more purple color. That is probably what you see.

Blackening at Ends of Fluorescent Tubes

This is a common phenomenon with most common fluorescent tubes as they age. However, frequent or repeated starting can accelerate the process. The black areas in themselves don't affect operation except to slightly reduce the amount of light available since the phosphor in that area is dead. However, they do represent a loss of metal from the electrodes (filaments).

The cause is sputtering from the filaments, mostly when cold. Thus. this happens mostly when starting or with a defective rapid start ballast which doesn't heat the filament(s) or a ballast or starter that continuously cycles. When the filament is cold and is the cathode (on the negative half of the AC cycle for that end of the tube), the work function is higher and ions have a higher velocity when impacting, knocking off metal atoms in the process. This is greatly reduced once the filament is up to normal operating temperature (though even then, some sputtering is inevitable).

(From: Greg Grieves (ggrieves@home.com).)

Lamps with the longest lifetimes typically use the heavier noble gasses as the buffer gas, (Xenon or Krypton instead of Argon) because the sputtering that occurs at the cathode is due to fast ion bombardment from the ionized gasses in the tube. the heavier atoms have a smaller velocity for a given kinetic energy of acceleration. its not the total energy of the ion that sputters but its the momentum at impact that knocks other atoms loose. I presume thats why Kr and Xe bulbs can run brighter, because they can crank up the power and still have about the same lifetime. Some tubes use a "hollow cathode" design in which the shape of the cathode is designed to deflect impacting ions rather than be sputtered by them. That's my understanding, anyway, theres much more to the story...

(From: PBerry1234 (pberry1234@aol.com).)

I recall one brand of lamp that positioned shields around the electrodes to prevent the blackening. I suppose this improved the appearance in exposed lamp applications, but don't know of any other benefits.

Hot Cathode Versus Cold Cathode Operation

The cathode is the negative electrode of a vacuum tube or gas filled discharge tube. Current flows by way of electrons emitted from the cathode and attracted to the positive electrode, the anode.

A hot cathode is one which must be heated to operate properly - to emit sufficient electrons to be useful. Examples: TV and monitor CRTs, most vacuum tubes (or valves), vacuum fluorescent displays (like those on your VCR). This is called thermionic emission - the boiling off of electrons from the surface of the cathode. Normal fluorescent lamps are hot cathode devices - partially maintained by the discharge current itself. They all have some sort of warmup period (though it can be quite short).

(From: Phil Rimmer (primmer@tunewell.com).)

A cold cathode is one where operation takes place without depending on heating of the surface above ambient. There are all sorts of devices that use 'cold' cathodes - neon lamps and signs, fluorescent backlight tubes, and helium neon laser tubes. Naturally, cold cathode devices don't have much of a warmup requirement.

The purpose of a cathode is to feed electrons into the negative end of the positive column (the discharge) so they can variously excite and ionise gas or vapour atoms.

Electrons are released from cathodes by the action of the positive ions being accelerated towards them due to an electric field in the vicinity of the cathode.

Electrons are broadly released in two ways: Thermal emission and secondary emission.

- Thermal emission is the primary process used in "hot cathode" lamps which include standard fluorescent tubes. The ions are accelerated towards the cathode through a small cathode voltage (less than 10 volts) and gain just enough energy to heat a small part of the very fine wire electrode when they collide with it. They heat it until it glows dully and electrons are "boiled off", liberated by the thermal energy. This process is very efficient in producing lots of electrons and results in efficient lamps.

- Secondary emission is a more brutal process for generating electrons. It requires an accelerating voltage drop of 130 to 150 volts. It is used in cold-cathode lamps that have relatively huge cylinders of iron for electrodes. These massive electrodes require much too much energy input to make them into thermal emitters. The energetic ions simply "knock" electrons off the metal surface. In so doing they also knock some of the metal off as well, a process called sputtering. The big electrodes have enough material to last before other effects cause lamp failure.

Hot cathode lamps operate in cold cathode mode if the cathode receives too little energy to keep it glowing. The colliding ions are thirty times more energetic than usual and soon sputter enough metal off the tiny electrodes to destroy them.

Moral: Pre-heat the electrodes before starting the discharge and maintain auxiliary current in the electrodes if the discharge current is low (e.g, when dimming).

Failure Mechanisms of Cold Cathode Fluorescent Lamps

(Portions from: Victor Roberts (Vic@RobertsResearchInc.com).)

- All fluorescent lamps, be they hot cathode, cold cathode or electrodeless will suffer from phosphor degradation. The rate of this degradation is a function of the type and amount of phosphor, the type of glass used for the tube, the temperature of the phosphor & glass and the intensity of the UV flux from the discharge. If these parameters are the same, then the type of electrodes does not make any difference, except perhaps at the ends of the tube.

- For heated filament lamps (which means most of those in residential and commercial lighting), the usual failure mode is depletion of the emission mix on the filaments. Then they do not emit electrons, and the arc can't be sustained.

- Many hollow cold cathodes contain a coating on the inner surface to improve operation. When this coating is degraded the lamp will be harder to start and therefore might not start if the starting voltage is not high enough.

- Due to their high cathode fall voltages, there will often be significant sputtering of cathode material from the surface of a cold cathode. Depending upon the design of the lamp and cathode, this sputtered material can end of up the walls of the lamp where it is unsightly at best, and may absorb significant light at worst.

- Cold cathodes tend to "consume" the active gas in a discharge. Due to the reasonably high cathode fall voltages, ionized gas atoms get buried in the surface of the cathode at a slow rate. In fact, this phenomena is used to make a very effective high vacuum pump. Also, in many HeNe lasers that use cold cathodes, a gas reservoir was added so that the loss of Ne, the dominant excited species, would not significantly change the He:Ne balance which is essential for proper laser action. In a modern fluorescent lamp, where the amount of excess mercury is reduced to prevent disposal problems, consumption of mercury by a cold cathode could be another life-limiting factor.

Comments on Small Inverter Powered Fluorescent Lamps

(From: Paul Bealing (paul@pmb.co.nz).)

Many small low cost inverters use a 2 transistor (one quite small) self oscillating circuit. Simply minimum function, low cost. These circuits can be quite efficient at low power levels. I have seen them used up to 50 watts.

Losses are usually in the transformer and the switching transistors. As the currents increase, the losses usually increase for a given power output.

The lamp requires a high voltage, usually 300 to 500 V, to strike. The voltage depends on the length/wattage of the lamp. Once struck, the current through the lamp is limited to achieve the wattage. The voltage across a small running lamp will be in the order of 60 to 100 volts AC.

Many simple inverters use a series resonant circuit to generate the high strike voltage, which is disabled by the run current.

A couple of years ago I designed an inverter for a PL11 11 Watt lamp based on a switchmode power supply controller IC, 2 power mosfets, and a push-pull transformer, running at about 200 kHz. The main application was in diesel locomotives running from 75 V DC. I've had the circuit operating down to 10V DC (different transformer winding). The primary current rises and the dissipation increases.

Fluorescent Lamp Voltage and Frequency Considerations

For those using iron ballasts, both voltage and frequency will be significant. Though it may be possible to come up with a formula which incorporates both, the best thing to do is to only use the line voltage for which the unit was designed.

Where the frequency isn't the same, the current through the lamp may differ, most likely too high in going from 60 Hz to 50 Hz, too low the opposite way. If the current is too high, there could be shortened lamp life at the very least or even a serious fire hazard. If the current is too low, the lamp may not remain on in a stable manner, flickering, or constantly restarting. Initial starting could also be affected.

If they use electronic ballasts, the frequency probably won't matter. Some "universal" types, can accommodate an input voltage from 90 to 250 VAC up to 400 Hz or even DC.

In all cases, it is best to consult with the manufacturer if the product label doesn't explicitly indicate "50/60 Hz" operation. When in doubt, leave them behind since there is really no way to be sure of the safety issues.

Operating a Fluorescent Lamp on DC

> "I have a application in mind that will use a DC power source around 100 volts and fluorescent lighting. What kinds of voltage do I need to sent the fluorescent? Are there any good sources of info. for the circuitry I would need?"

(From: Don Klipstein (don@Misty.com).)

If it is a preheat tube of 22 watts or less, the cheap-and-dirty way to do it is to use a normal preheat fixture. The only change is to add a resistor in series with the ballast. This resistor should be maybe 100 ohms for 20 and 22 watt lamps, slightly higher for lower wattage ones. It should be able to safely dissipate a wattage comparable to that of the lamp. Of course, you are now wasting significantly more power as heat.

The above includes most simple "PL"/twin-tube compact fluorescent lamps with removable bulbs with two pins, as well as most compact fluorescent bulbs with "choke" type ballasts running from 120 volts AC.

Should you need anything more energy-efficient than this, then there is the world of electronic ballasts.

BTW, most low-power-factor screw-in 120 VAC compact fluorescent lamps with electronic ballasts work fine "as-is" with about 160 volts DC or squarewave.

Ballasts and PCBs (The Hazmat Type)

(From: David Morris (allane@ix.netcom.com).)

Ballasts that were made after the late 70's do not contain PCB's. I spoke with an Advance and GE ballast rep. a few years ago about this and I was told the only sure-fire method to tell that there are no PCB's is if the ballast says no PCB's. Any ballast that doesn't say that has a better than 80% chance of having it. The amount in the ballast is VERY minute. Less than a thimble full. It is used to cool a capacitor in the ballast. Since he said the light is about 12 years old, I am quite certain that the ballast does not contain PCB's. In our state, it is legal to dispose of these ballasts in a limited quantity in your local landfill or throw them in the trash. Larger quantities require Hazmat disposal methods. Our company policy is to leave any old ballasts that is not marked 'no PCB's" with the customer for their disposal.

As a side note, I read in one of the Electrical trade rags that the liquid that replaced PCB's is testing out to be more dangerous than PCB's themselves. Go figure!! :-)

As for catching fire, ballasts contain a thermal protector that will cut the power if the ballast gets too hot. Only real old ballasts do not have this feature. Ballasts marked Class P have this protection. It is very rare for one of these ballasts to actually catch fire, although it does happen. More often, they will smoke up the house if they overheat and the thermal protector fails.

Driving Cold Cathode Fluorescent Lamps

(From: David VanHorn (dvanhorn@cedar.net).)

Linear Technology has several extremely detailed app notes written by Jim Williams on this topic. It's more complicated than you might imagine to do it right. Just making the tube light is perhaps only 10% of the job. The rest includes keeping it running a long time without blackening, providing the ability to set the brightness, not loosing all your energy to wiring capacitance, and not creating an EMI nightmare.

Definitely read and understand those app notes, even if you go to another vendor! The good news is that the actual circuit isn't that bad!

What is the E-Lamp?

The E-Lamp is one of those inventions that sounds like a really good idea but still hasn't (as far as I know) made it into wide scale production. In essence, it is an RF excited compact fluorescent lamp. Some of the E-lamp's basic characteristics include.

- Fits into standard household light bulb bases.
- Radio frequency radiation was emitted, then converted to light.
- Dimmable using standard phase control dimmer - no special devices needed.

- Very efficient so runs cool and consumes much less power than incandescent lamps (don't know how it compares to compact fluorescents).
- Desirable white spectral characteristics.
- No filament to wear out (and no wires through glass) so potentially very long life.

Aside from cost issues, there could also be concerns with respect to RF emissions effects on health and interference with other household appliances and electronics.

(Victor Roberts (Vic@RobertsResearchInc.com).)

E-lamps are electrodeless fluorescent lamps. They use a high frequency or RF magnetic field to create a time varying electric field which in turn drives a discharge which is very similar to the discharge in an ordinary fluorescent lamp. Except for the means by which the discharge is created, these E-lamps and identical to all other fluorescent lamps. There is no magic other than the fact that electrodeless excitation allows for the elimination of the electrodes, so electrode failure and wear out are no longer a problem. Also, electrodeless excitation removes the requirement that the lamp be long and thin to achieve high efficacy. Proof of this is beyond the scope of this note. :) Hence, an electrodeless fluorescent lamp can be more easily made in the shape of an incandescent lamp.

There are also electrodeless metal halide lamps and, of course, the electrodeless sulfur lamp.

Notes on Dimming of Fluorescent Lamps

The following provides a variety of dimming methods, some better than others.

Sam's dimming experiments:

OK, I did some experiments using both a dual-lamp Circline fixture and a typical dual-40 W bulb shop light - both with magnetic (rapid start probably) ballasts.

The common wisdom is not entirely correct. You can dim fluorescents. I do not know about the long term reliability or stress on the ballasts but I could achieve dimming down to around 30 to 50 percent brightness (using my standard-issue eye-balls, calibrated annually) with a relatively stable light output - no excessive flicker and no tendency to go out (though to get down to the low end requires starting high and backing off).

I tried both a Variac and a cheap light dimmer with similar results.

(If you want to go below the 30 to 50 percent threshold reliably, however, some means must be provided to keep the filaments hot.)

How about long term reliability?

This was a 'quick' experiment. All I did was observe the light output. A cheap light dimmer just means the kind you get at a home center for $4 or so. Long term reliability is certainly not known. The purpose was simply to show that just because something is stated to be impossible does not always mean that it is - not a suggestion that it is.

Dimming fluorescents 1:

(From altavoz@azstarnet.com).

48" tubes can glow at microamps if fired with 400 volts and require no heater current at all. The mercury is still probably 99% liquid!! I did this with a 9 V transistor battery and an inverter. As you fire them from lower impedances, still using 400 volts and no heaters, you'll see that you can turn down the current and get a better efficiency (output doesn't drop) but you reach a threshold and it drops light output suddenly. When I was working with 12 VDC ballasts, and 24" tubes I had to fire them at 0.65 amps then drop that to 0.4 A. But below 0.4 A they would dim suddenly to a less efficient point.

Of course this is at warm temperatures. At cooler temps you must have the heaters drawing current to boil the mercury.

I have used the cheap dimmers on many inductive loads and as long as you derate them, they will work fine.

I disassemble standard dual 48" fixtures and put the tubes in line to make a 96" fixture that puts out more light! you only need to put the ballast close to one end of the "starter" tube (the one that always starts first) or put the line Neutral close to the tube (they hook together at the ballast).

Dimming fluorescents 2:

(From: John Shotton (J.A.Shotton@bnr.co.uk)).

I have been running four 5 foot (1.5 inch diameter) tubes like this for 15 years.

The circuits (4 off) are resonant start - i.e., there is a second winding on the ballast which connects across the tube in series with an 8 uF capacitor (remember in the UK the supply is 230 VAC). Thus the heaters are energised at all times.

I originally experimented with a moving iron wattmeter (measures true RMS power), a photodetector, and a variac. Allowing for ballast loss (computed from current and resistance), the light output was directly proportional to power consumption. The lamps would dim to around 10% but they wouldn't start at this level.

The permanent installation used a mains transformer connected as an autotransformer with several taps so that I can get around 6 light levels, though they will not start on the two lowest settings and is slow at starting on the next two settings. I can't remember offhand what light output they will self start on, but it must be around 30 to 40%.

As for tube life, the lights are on most of the time when it is dark - from around 5 pm till 1 am. I fitted my third set of tubes about two years ago, and this was not because the second set had failed but because we wanted a change from daylight color-matching to tri-phosphor 2700 °k - I've still got the second set should we decide to revert to the daylight effect.

When I did my original experiments I also tried it with normal ballast circuits, i.e., with a starter across the tubes. I can't remember the results, but I didn't pursue it so they can't have been good. I believe it would work if the heaters were energised at all times from a separate winding.

Dimming fluorescents 3:

(From: David Gibson (dgibson@microconsultants.com)).

My company designed a fluorescent dimmer some years ago. It dims 40 x 40W tubes fitted with high power factor inductor/capacitor control gear as used in Australia and other 220 to 240 VAC countries. Its main claim to fame is that it can cope with the highly capacitive nature of power factor corrected luminaires, and is hence easily retrofitted. A number of large office buildings in Australia are fitted with our/my dimmer.

Unfortunately, the standard ballast used in the U.S.A. (and I presume other 120 VAC countries) uses, I believe, a resonant circuit which cannot be dimmed with our design.

The luminaires it does work with contain basically a tube/choke series combination across the line, plus a power factor correction cap also across the line. The lamp filaments are heated only during turn-on by a starter switch that completes an additional circuit at startup.

The purpose of these dimmers is energy saving. A photocell measures the ambient light, and maintains a reasonable constant light level in the office. Energy saving is possible because lighting systems must be overdesigned to allow for lumen depreciation due to lamp aging, plus the fact that daylight allows lower levels of electric light.

Performance is as follows:

Dimming range: We budget for 40% of light output (60% reduction). In the lab we have achieved down to 26%.

Power saving: At 40% light power is about 35% (yup, you win twice)

Lamp savings: In a 26 story building in Sydney, for which good figures are available, lamp replacement rate was reduced to about 40%, i.e., we more than doubled lamp life.

Overall power savings: Same building, independently audited figures, lighting bill was reduced by 45%. This included secondary savings from reduced air conditioning and a time switching system integral to our design which ensures lights are off at night etc.

Power factor improvement. Undimmed tubes have a power factor of typically 0.85 to 0.9. At 40% light this is 0.99. This is true power factor (see article on power factor on our Web site, URL below).

Line harmonics: During dimming the percentage of harmonics increases as current drops, but the absolute level (total amps) decreases.

(The power companies love it!).

Our design uses a hard-won, patented proprietary dimming method which has nothing to do with triacs. It uses high frequency switching and some very fast and smart firmware.

The same lamps can be dimmed using triacs, but the power factor correction caps must be removed from every fitting. The required triac circuit is slightly modified; the patents belong to a competitor. Its power factor is lousy.

Dimming fluorescents 4:

(From: Andrew Gabriel (andrew@cucumber.demon.co.uk)).

I have made a dimming fluorescent fitting out of a standard fitting (which started out as a switch-start series ballast), and an ordinary phase control (triac) dimmer.

My only reservation is that this is all for standard 200-250 V switch-start fluorescents - when I've seen American books describing fluorescent lamp control gear, it is quite different, presumably because of the lower mains voltage being unsuitable without more complex control gear.

There are three significant things you have to do:

1. The lamp extinguishes at around half power because the filaments at each end are no longer heated sufficiently during one half cycle's bombardment with electrons to emit electrons in the following half-cycle. I overcame this by supplying the filaments with a few volts from a miniature mains transformer with a pair of isolated low voltage secondaries, around 4 volts IIRC for a 5 foot 80W fitting (it doesn't need to be anywhere near enough voltage for a visible glow from them). Also, with this transformer fitted (and the switch- starter removed), the tube actually fires up all by itself without flashing, since it is now really rapid start fitting.

   I also have a switch to disable the dimmer, and when disabled, it also switches the filament transformer's primary to be across the tube rather than the mains. Thus initially when the tube is non- conducting and the tube voltage is 240 V, the filaments are heated, but as the tube starts up and its voltage drops to its running value of around 100 V, the additional filament heating provided by the transformer, which is unnecessary when the lamp is running normally, is all but disabled.

2. The second problem is that all cheap triac dimmers fire the triac with a pulse and expect the triac to continue conducting until the zero crossing point (or more strictly, zero current). However, an inductive load takes time to start conducting, and at the end of the triac firing pulse, the current through the triac will not have reached the minimum holding current when the dimmer is set low, which also results in sudden extinguishing of the tube when dimming down. To overcome this, I added a small incandescent lamp to the output load on the dimmer, in my case it's a 40W spotlight pointing at a painting, so it's a useful additional feature.

   This also allows the lamp to be dimmed completely down to zero. At very dim levels just above zero, some tubes exhibit Faraday rings, rings of alternate light and dark along the tube which might remain still or move along the tube.

   I was expecting the current phase shift due to the inductor to be a problem with a cheap dimmer, but it wasn't.

3. Ensure the power factor correction capacitor is before the dimmer, or you'll destroy the triac. In a

commercial environment, I think I would also include some protection against typical triac failure modes of a one-way open or short, which would result in high levels of DC through the inductor which will overheat it and/or destroy the lamp.

BTW, I did all this 20 years ago as a teenager. However, the fitting in question is still running, and has never required a lamp change in that time, nor is there any blackening at the ends of the tube. It is normally run at full brightness with the dimmer disabled.

Dimming fluorescents 5:

(From: Peter Miller (p.miller@elec.gla.ac.uk)).

I've tinkered a bit... the trick is to keep the filaments at the ends of the tubes warm. You will NOT be able to dim down to zero - probably about 25% at best.

Here is a possible circuit:

```
                        Dimmer
                         +--+  Choke
    AC Live/hot o--------|  |--^^^^^^^^--+--------------+
                         +--+            |              |
                                         |              |
                   +---------------------+              |
                   |                     |              |
                   +-+   +---------------+  +-------+   |
                      )|(                   |       |   |
        Filament      )|(                   |      -|---|-
      Transformer     )| +------------------+     |  ^^^  | Tube
      2 * 6.3V 2A     )|                          |       |
                      )|                          |       |
                      )| +------------------+     |  ^^^  |
                      )|(                   |      -|---|-
                      )|(                   |       |   |
                   +-+   +---------------+  +--------   |
                   |                     |              |
AC Neutral/cold o--+---------------------+--------------+
```

The lamp must be in a earthed / grounded reflector fitting. The metal end caps of the tube must be connected to the reflector. The dimmer MUST be a 'hard fired' dimmer capable of operating an inductive load. The choke is a standard type for the tube in use. Play with an inexpensive everyday tube before using expensive aquaria ones. with a 240 VAC supply a 4 foot 40W tube operates ok. The main difficulty with this circuit is in getting the tube to start - starting is greatly helped by a grounded reflector fitting and connecting the metal end caps of the tube to the reflector (Don't ask - it works!). The transformer can be a standard valve filament transformer - use a separate transformer for each end of the tube if you are unsure of the insulation between the secondaries of any transformer that you buy. As the tube draws less current the voltage across it rises, turning up the heat in the filaments. At start up, maximum voltage is across the lamp and so the filaments are fully on. All dimming ballasts/chokes use some scheme to add extra heat to the filaments at dim running. An undimmed tube draws enough current to keep the filaments warm by itself. There is no glow starter or other starting device in the circuit, so the lamps tend to come on smoothly with no flickering. Shorter tubes are easier to start. New slimline tubes are a real pain to start.

Dimming fluorescents 6:

(From: Bruce G. Bostwick (llbgb@utxdp.dp.utexas.edu)).

This applies to rapid start fixtures.

If the fixture says "RAPID START" somewhere on it or on the package it came in, the internal schematic will be roughly as follows:

```
                       || +-------+---------o
AC line H o---------+ ||(   +----+             to both pins on
                      )||(  (  <-6.3VAC        one end
                      )||(   +--------------o
                      )||(
                      )|| +=---- 2kVAC* -------------------------+
                      )||(                                      _|_
                      )||(   +--------------o                  ///
                      )||(  (  <-6.3VAC        to both pins on
AC line N o---------+ ||(   +----+             the other end
                       || +-------+---------o
```

*The high voltage winding of the secondary is on a branch magnetic circuit that limits the output current to the mercury discharge. Most of the 48" 40W "shop light" type of bulbs use this. Open circuit voltage will be in the kilovolt range, while the voltage across a lighted tube will be somewhat less than that and *exceedingly* non-sinusoidal.

If you're using the big bulbs (F96T12's for example) the ballast will only have the high voltage winding and the cathodes are heated by ionic bombardment from the mercury arc. These take a bit longer to light up when the power is turned on.

If you want instantaneous on/off control, I'd suggest using 4-footers and linking up two ballasts in such a way that the cathode heaters are driven from one which is always on, and the arc is driven from the other which is turned on and off as you desire. They won't last too long that way, but it will work better for show effects. The cathodes could be driven from a pair of low-voltage filament transformers, but be sure to isolate them well -- or you could use a ballast with a blown HV secondary ...

Another suggestion: Use solid-state relays to drive the ballast primaries. These are fairly cheap and provide clean current-zero-crossing switching even with very reactive loads (I've used them for such! ;-) and provide a neat and rugged way to connect the lights to logic controls such as your computer -- great for light sequencing.

Dimming fluorescents 7:

(From: a-freak@freenet.de.)

The magazine "Elektor" developed a dimming circuit for fluorescent lamps running at 230 V which is wired in *parallel* to the lamp at the place where usually the glow starter is located. I tried it and it works well for short lamps of the 18W-type but very unstable with the large ones.

In my opinion this circuit is especially nice if you want to dim up a lamp from zero brightness (lamp shorted, full preheating and maximum current) to full operation (usual values), for example to simulate a sunrise.

Dimming fluorescents 7:

(From: Charles R. Patton (patton@dt.wdc.com)).

Advance (and probably others) made special ballasts for 60 Hz (non-electronic such as with a Variac) dimming. One of the main characteristics was the extra wire for the Variac (or symmetrical electronic dimmer) input. The trick was to keep the filaments warm on the tube, therefore the separate filament power which doesn't get varied so that a larger dimming range was possible. This also makes for much longer lifetimes for the tube because cold electrodes are subject to heavy ion bombardment until they heat up from the normal current (which doesn't exist on a dimmed tube.) As I understand it, some electronic ballasts will power the filament separately for a period of time to get it to temperature, then apply high voltage excitation to light the tube.

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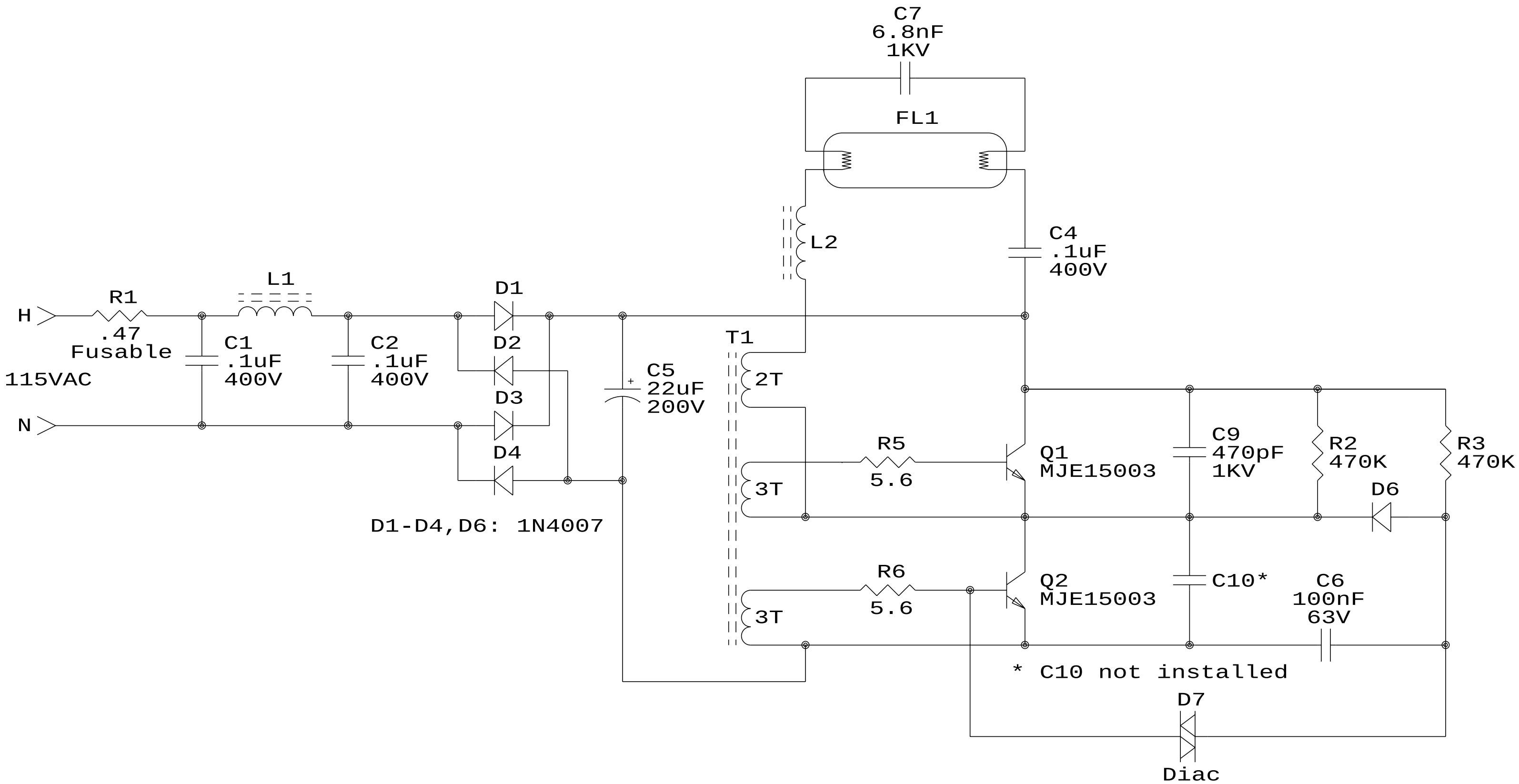
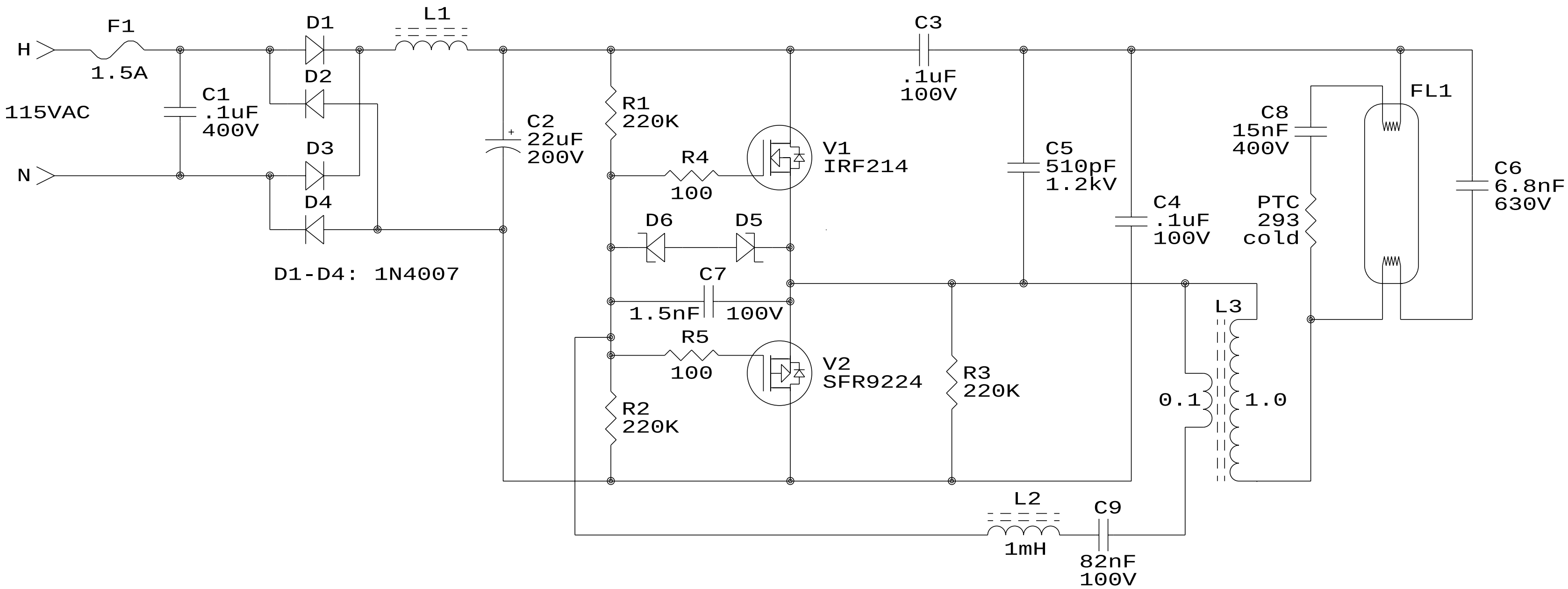


Compact Fluorescent Lamp Electronic Ballast 1
Techna-Bright EDXR-38-16

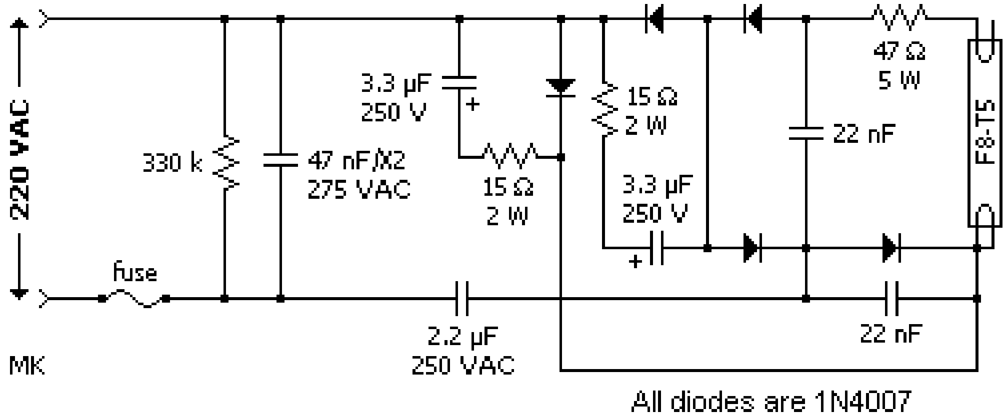
Drawn by: Samuel M. Goldwasser sam@repairfaq.org		
Title Techna-Bright EDXR-38-16 CF-Lamp Ballast		
Size A	Document Number CFLAMP1-SCH	REV 1.0
Date: August 20, 2002	Sheet 1 of 1	



Compact Fluorescent Lamp Electronic Ballast 2
General Electric Helical 26 W
120VAC, 60Hz, 390 mA, Model FLE26HT3/2/SW

Drawn by: Samuel M. Goldwasser
sam@repairfaq.org

Title	GE Helical 26 W CF-Lamp Ballas	
Size: A	Document Number: CFLAMP2-SCH	REV: 1.0
Date: June 14, 2003	Sheet 1 of 1	



Low Power 220 VAC Fluorescent Lamp

Sam's and Don's D-Lamp FAQ

Gas Discharge Lamps, Ballasts, and Fixtures

Principles of Operation, Circuits, Troubleshooting, Repair
Version 1.35

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Authors and Copyright

Authors: Samuel M. Goldwasser and Donald L. Klipstein

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

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Introduction

Gas discharge lamp basics

The use of electrically excited gas discharges significantly predates the invention of the incandescent lamp. Physics labs of yesteryear as well as today have use of a variety of gas filled tubes used for numerous purposes involving light generation including spectroscopy, materials analysis, studies of gas dynamics, and laser pumping. Look through any scientific supply catalog and you will see many different types of gas filled tubes in all shapes and sizes.

Gas discharge lamps are used in virtually all areas of modern lighting technology including common fluorescent lighting for home and office - and LCD backlights for laptop computers, high intensity discharge lamps for very efficient area lighting, neon and other miniature indicator lamps, germicidal and tanning lamps, neon signs, photographic electronic flashes and strobes, arc lamps for industry and A/V projectors, and many more. Gas discharge automotive headlights are on the way - see the section: "HID automotive headlights".

Because of the unusual appearance of the light from gas discharge tubes, quacks and con artists also have used and are using this technology as part of expensive useless devices for everything from curing cancer to contacting the dead.

Unlike incandescent lamps, gas discharge lamps have no filament and do not produce light as a result of something solid getting hot (though heat may be a byproduct). Rather, the atoms or molecules of the gas inside a glass, quartz, or translucent ceramic tube, are ionized by an electric current through the gas or a radio frequency or microwave field in proximity to the tube. This results in the generation of light - usually either visible or ultraviolet (UV). The color depends on both the mixture of gasses or other materials inside the tube as well as the pressure and type and amount of the electric current or RF power.

(At the present time, this document only deals with directly excited gas discharge lamps where an AC or DC electric current flows through the gas.)

Fluorescent lamps are a special class of gas discharge lamps where the electric current produces mostly invisible UV light which is turned into visible light by a special phosphor coating on the interior of the tube. See: Fluorescent Lamps, Ballasts, and Fixtures for more info.

The remainder of this document discusses two classes of gas discharge lamps: low pressure 'neon' tubes used in signs and displays and high intensity discharge lamps used for very efficient area and directional lighting.

Safely Working with Gas Discharge Lamps and Fixtures

Fixtures for gas discharge lamps may use up to 30,000 V while starting depending on technology. And, they are often not isolated from the power line. Neon signs are powered by transformers or electronic ballasts producing up to 15,000 V or more. Thus, the only safe way to work with these is to assume that they are potentially lethal and treat them with respect.

Hazards include:

- Electric shock. There is usually little need to probe a live fixture. Most problems can be identified by inspection or with an ohmmeter or continuity tester when unplugged.

  - Discharge lamps and fixtures using iron ballasts are basically pretty inert when unplugged. Even if there are small capacitors inside the ballast(s) or for RFI prevention, these are not likely to bite. However, you do have to remember to unplug them before touching anything!

    Neon signs using iron transformers are also inert when unpowered - just make sure they are off and unplugged before touching anything!

  - However, those using electronic ballasts can have some nasty charged capacitors so avoid going inside the ballast module and it won't hurt to check between its outputs with a voltmeter before touching anything. Troubleshooting the electronic ballast module is similar to that of a switchmode power supply. See the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies

  - The pulse starters of some high intensity discharge lamps may produce up to 30 kV during the starting process. Obviously, contact with this voltage should be avoided keeping in mind that 30 kV can jump over an inch to anyplace it wants!

- Nasty chemicals: Various toxic substances may be present inside high pressure discharge lamps (sodium and mercury) and neon signs (some phosphors). Contact with these substances should be avoided. If a lamp breaks, clean up the mess and dispose of it properly and promptly. Of course, don't go out of your way to get gut on the broken glass! WARNING: Metallic sodium reacts with water to produce hydrogen gas, an explosive. However, it is unlikely that the inner tube of a sodium vapor lamp would break by accident.

- Ultra-Violet (UV) light: High intensity discharge lamps generate substantial UV internally, often the particularly nasty UV-B variety. Unless designed to generate UV (for medicinal purposes, photoengraving, or whatever), the short wave radiation will be blocked by the outer glass envelope and/or phosphor coating. However, should the outer envelope break or be removed, the lamp will still operate (at least for a while - some have a means of disabling themselves after a few hours or less of exposure to air). DO NOT operate such a lamp preferably at all but if you do, at least take appropriate precautions to avoid any exposure to the UV radiation.

And take care around sharp sheet metal!

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Neon Technology

Neon Lights and Signs

Neon technology has been around for many years providing the distinctive bright glowing signs of commerce of all kinds before the use of colored plastics became commonplace.

Neon tubes have electrodes sealed in at each end. For use in signs, they are formed using the glass blower's skill in the shape of letters, words, or graphics. Black paint is used to block off areas to be dark. They are evacuated, backfilled, heated (bombarded - usually by a discharge through the tube at a very high current) to drive off any impurities, evacuated and then backfilled with a variety of low pressure gasses.

Neon is the most widely known with its characteristic red-orange glow. Neon may be combined with an internal phosphor coating (like a fluorescent tube) to utilize neon's weak short-wave UV emissions. A green-emitting phosphor combines with neon's red-orange glow to make a less-red shade of orange. A blue-emitting phosphor may be used to result in a hot-pink color. Neon may be used in tubing made of red glass to produce a deep red color.

Other colors are usually produced by tubing containing argon and mercury vapor. The mercury is the active ingredient, the argon produces negligible radiation of any kind but is important for the "neon" tubing to work. Clear tubing with mercury/argon glows a characteristic light blue color.

Such tubing is often phosphor-coated on the inside, to utilize the major short-wave UV emission of low-pressure mercury. In this way, much of the "neon" tubes in use are a kind of fluorescent lamp.

Phosphor-coated tubing with mercury can glow blue, blue-green, slightly white-ish green, light yellow, bright pink, light purple, or white.

Use of mercury vapor with colored tubing (with or without phosphors) can provide a lime-green or deep blue or deep violet-blue.

Nowadays, nearly all "neon" tubing contains neon or mercury vapor (with argon), whether with or without phosphors and/or colored glass. Well in the past, various colors were obtained (generally at reduced efficiency) by using different gases.

For example, helium can produce a white-ish orange light in shorter length, smaller diameter tubing. Hydrogen in this case makes a lavender-hot-pink color. These gases glow more dimly with duller color shades in larger tubing. Krypton makes a dull greenish color. Argon makes a dimmish purple color. Nitrogen (generally in shorter length tubing) makes a grayish purple-pink color. Xenon, which is expensive, generally glows with a dim bluish gray color, along with the glass tubing giving a slight dim blue fluorescence from very short wave UV from the xenon discharge. Krypton also often causes a dim blue glass fluorescence.

For general information on neon signs and technology including a neon FAQ, see:

- The Internet's Neon Shop
- Neon and Lighting Channel Page

Power Supplies for Neon

Extremely high voltage power supplies are used to power neon signs. In the past, this was most often provided by a special current limited HV line transformer called a neon sign or luminous tube transformer. The output is typically 6,000 to 15,000 VAC at 15 to 60 mA. One such unit can power 10s of feet of tubing. This transformer acts as its own ballast providing the high voltage needed for starting and limiting the running current as well. Warning: the output of these transformers can be lethal since even the limited current availability is relatively high.

As with everything else, the newest neon sign power supplies use an electronic AC-AC inverter greatly reducing the size and weight (and presumably cost as well) of these power supplies by eliminating the large heavy iron transformer.

Small neon lamps inside high-tech phones and such also use solid state inverters to provide the more modest voltage required for these devices.

(From Jeff Zurkow (jeff@atrox.com).)

In the course of looking for a neon sign transformer, I discovered the following line of flyback-type HV power supplies:

- Evertron High Voltage Neon Power Supplies. (Ordering via Neon Central.

For example: the Evertron 2610 is rated at 10 kVAC, 10 mA for $45.50. The model 2610D has dimming for $56.50. There are also 3.5 kVAC and 6 kVAC models that are somewhat less expensive. The 3.5 kV unit runs on 12 VDC, the others on 115 VAC.

The neon bender I visited was kind enough to give me a couple of older units - one made by Evertron (Everbrite Electronics, model 3210) and the other by Transfotek international. One of these (the Evertron) works, but he had a whole pile of dead ones from various makers. He considers all of the electronic ones unreliable (compared to conventional NSTs), but that's probably in 24/7 service. They ought to be OK for intermittent use in laser and HV projects if the output voltage and current are sufficient.

Evertron Model 3210 Gas Tube Power Supply shows the schematic of this unit. It has a pair of power MOSFETs driving a flyback style high voltage transformer, with a whole bunch of open-wound primaries and a potted secondary.

I did plug the thing in and was rewarded with an impressive arc at about 1 cm electrode spacing (bare wires).

The Transfotek unit is completely potted, except for the AC input and on-off switch. And completely dead.

Neon Sign Installation

(From: Clive Mitchell (clive@emanator.co.uk)).

The voltage required to light a run of neon tube is variable according to diameter, gas type, pressure and number of tubes in circuit.

For a 15 kV transformer and neon gas you could run:

- 33 feet of 10 mm tube,
- 45 feet of 12 mm tube,
- 60 feet of 15 mm tube,
- 78 feet of 20 mm tube,
- 102 feet of 25 mm tube.

- Deduct one foot of tube for every pair of electrodes (tube section).

These figures are based on a chart in "Neon Techniques And Handling" which is the traditional neon reference.

The larger the diameter of the tube, the lower the voltage required, and the dimmer it will be. Transformers come with different current ratings. For larger diameter tubes, you can increase brightness by using a higher current.

- Don't attempt to run too much tube on a transformer, since it can cause breakdown of the insulation and destroy the transformer.

- Don't attempt to run too little tube on a transformer, since it can cause overheating and burn-out.

It is absolutely imperative that proper neon sign cabling and insulators are used, and that all local regulations are strictly followed. If you are intending to work with neon tubing, you should learn as much as possible first, since neon poses both a shock and serious fire risk if installed incorrectly.

The lengths quoted above may vary according to the transformer you use. The transformer manufacturers usually provide their own loading charts on request.

Anyone using this information does so at their own risk, and I cannot be held responsible for any horrible smouldering deaths experienced by incompetent dabblers, etc.

(From: Kenny Greenberg (kenny@neonshop.com)).

The neon circuit is not so simple. In a standard AC circuit neon acts like a diac - high breakover voltage followed by fast drop in resistance. Neon sign transformers are designed to 'leak' and thus self-regulate. You have a combined resistive and reactive circuit.

But take heart, it's all been figured out. :-)

There are a few variables:

1. A 'purely' neon filled tube (generally in the red range) has a higher voltage requirement than an argon-mercury tube (whose discharge is usually providing UV for phosphor with a wide range of colors.

2. The voltage requirement varies inversely with the tubing diameter. That is large diameters of a lower voltage requirement than small diameters.

3. The voltage requirement varies directly with tubing length.

4. The number of units (or pairs of electrodes) increases the voltage requirement because the electrodes have a voltage drop.

5. Wiring methods and length will also contribute to the formula but that's a whole 'nuther discussion.

You can download a free Neon Voltage Calculator for Windows.

An old tech method for determining the voltage requirement is to use a Variac on a large neon transformer. Bring the voltage down to where the neon just flickers. This should be at a point approximately 78% of the required voltage.

A better way involves using a milliameter to measure open circuit and closed circuit current and an rms voltmeter to measure actual operating voltage.

Problems With Neon

These fall into two categories:

1. Power supply - like fluorescent ballasts, the high voltage transformers can fail resulting in reduced (and inadequate) voltage or no power at all. Since they are already current limited, overheating may not result and any fuse or circuit breaker may be unaffected. The use of a proper (for safety if nothing else) high voltage meter can easily identify a bad transformer. If a high voltage probe is not available, position (with power off!) the ends of well insulated wires connected to the outputs of the transformer a fraction of an inch apart (about 1/32" per 1,000 V of transformer rating) and apply the power from a safe distance. If a hot arc results, the transformer is likely good (at least when cold).

2. Neon tubes - these may lose their ability to sustain a stable discharge over time as a result of contamination, gas leakage, or electrode damage (either from normal wear or due to excessive current). Check for obvious damage such as a cracked tube or cracked seals around the electrodes or badly deteriorated electrodes. A previously working tube that now will not strike or maintain a stable discharge on a known good transformer will need to be replaced or rebuilt.

Comments on Little Neon Bulbs and Tubes

The comments below relate to the little neon bulbs used as indicators, for voltage regulation or limiting, and other applications in all sorts of electronic equipment.

(From: Mark Kinsler (kinsler@frognet.net).)

Neon lamps can be used for voltage limiters and oscillator elements and just about anywhere else that a non-linear element is needed. The tremolo circuit in the classic Fender guitar amplifier uses a neon lamp relaxation oscillator. The neon lamp is heat-shrinked to a CdS photocell in the volume control circuit.

Less well-known is the fact that you can make a pretty reasonable computer logic element out of them: I believe that this was tried sometime in the 1940's.

Another cool use is as a radiation sensor: you bias the lamp so that it almost turns on, after which any incident radiation: radio waves (as in police radar), light, or gamma radiation will kick the lamp on. There were various circuits in the 1950's that used neon lamps to detect uranium, fight nuclear destruction, or escape the newly-developed police radar guns.

And finally, there's the mystery elevator button. Again, you bias the lamp so that it almost, but not quite, turns on. If you enclose the lamp properly, it'll stay off until you touch it. The electric field variation from your touch will turn the thing on, and it'll stay on. Such lamps are used in some self-service elevators: once the lamp is fired, the low voltage across it is sensed by the ancient logic circuits of the elevator controller and it'll send the elevator to the appropriate floor. These were a lot of fun in the 1960's. I think the controllers used vacuum tubes.

The problem with neon lamps is that they're not so reliable. Their turn-on voltage isn't particularly stable. This means that oscillators have a tendency to drift as the lamps age or when ambient radiation changes. I suspect that the computers are slow and cranky, and the radiation detector isn't anything you'd wish to stake your life or drivers' license on.

Still, they're great fun, and I have a fine time with them. One other use: hang a neon lamp across a telephone line to detect the ring signal. Place it in series with a piezo beeper, and you've got a reliable telephone ringer.

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High Intensity discharge Lamps

High Intensity Discharge (HID) Lamp Technology

These have been used for a long time in street, stadium, and factory lighting. More recently, smaller sizes have become available for home yard and crime prevention applications. Like other gas discharge lamps, these types require a special fixture and ballast for each type and wattage. Unlike fluorescents, however, they also require a warmup period.

There are three popular types:

- High pressure mercury vapor lamps contain an internal arc tube made of quartz enclosed in an outer glass envelope. A small amount of metallic (liquid) mercury is sealed in an argon gas fill inside the quartz tube. After the warmup period, the arc emits both visible and invisible (UV) light. High pressure mercury vapor lamps (without color correction) produce a blue-white light directly from their discharge arc. Phosphors similar to those used for fluorescent lamps can be used to give these a color closer to natural light. (Without this color correction, people tend to look like cadavers). Mercury vapor lamps have the longest life of this class of bulbs - 10,000 to 24,000 hours. The technology was first introduced in 1934 and was the first of the commercially viable HID lamps.

- Metal halide lamps are constructed along similar lines to mercury vapor lamps. However, in addition to the mercury and argon, various metal halides are included in the gas fill. The most popular combination is sodium iodide and scandium iodide. A few versions of this lamp have lithium iodide as well. A much less common version has sodium iodide, thallium iodide, and indium iodide. The use of these compounds increases the luminous efficiency and results in a more pleasing color balance than the raw arc of the mercury vapor lamp. Thus, no phosphor is needed to produce a color approaching that of a cool white fluorescent lamp with more green and yellow than a mercury vapor lamp (without correction). Some metal halide lamps have a phosphor that adds some orange-ish red light, but not much, since the metal halide arc does not emit much UV.

- High pressure sodium vapor lamps contain an internal arc tube made of a translucent ceramic material (a form of aluminum oxide known as "polycrystalline alumina"). Glass and quartz cannot be used since they cannot maintain structural strength at the high temperatures (up to 1300 degrees C) encountered here, and hot sodium chemically attacks quartz and glass. Like other HID lamps, the arc tube is enclosed in an outer glass envelope. A small amount of metallic (solid) sodium in addition to mercury is sealed in a xenon gas fill inside the ceramic arc tube. Some versions of this lamp use a neon-argon mixture instead of xenon. Basic operation is otherwise similar to mercury or metal halide lamps. High pressure sodium vapor lamps produce an orange-white light and have a luminous efficiency much higher than mercury or metal halide lamps.

  Since hot liquid sodium often eventually leaches through things and can get lost this way, sodium lamps have a surplus of sodium in them. Proper lamp operation depends on the sodium reservoir being within a proper temperature range.

Mercury vapor lamps are roughly as efficient as fluorescent lamps. Metal halide lamps are much more efficient, generally around 50 to 75 percent more efficient than fluorescent lamps. High pressure sodium lamps are roughly twice as efficient as fluorescent lamps.

Unlike fluorescent lamps, HID lamps will give full light output over a wide range of temperatures. This often makes HID lamps more suitable than fluorescent lamps for outdoor use.

When cold, the metallic mercury or sodium in the arc tube is in its normal state (liquid or solid) at room temperature. During the starting process, a low pressure discharge is established in the gases. This produces very little light but heats the metal contained inside the arc tube and gradually vaporizes it. As this happens, the pressure increases and light starts being produced by the discharge through the high pressure metal vapor. A quite noticeable transition period occurs when the light output increases dramatically over a period of a minute or more. The entire warmup process may require up to 10 minutes, but typically takes 3 to 5 minutes. A hot lamp cannot be restarted until it has cooled since the voltage needed to restrike the arc is too high for the normal AC line/ballast combination to provide.

Problems With High Intensity Discharge Lamps

While HID lamps have a very long life compared to incandescents (up to 24,000 hours), they do fail. The ballasts can also go bad. In addition, their light output falls off gradually as they age. For some types, light output may drop to half its original value towards the end of their life.

A lamp which is cycling - starting, warming up, then turning itself off - is probably overheating due to a bad bulb or ballast. A thermal protector is probably shutting down the fixture to protect it or the arc is being extinguished on its own. However, make sure that it is not something trivial like a photoelectric switch that is seeing the light from the lamp reflected from a white wall or fence and turning the fixture off once the (reflected) light intensity becomes great enough!

Sodium lamps sometimes "cycle" when they have aged greatly. The arc tube's discolorations absorb light from the arc, causing the arc tube to overheat, the sodium vapor pressure becomes excessive, and the arc cannot be maintained. If a sodium lamp "cycles", the first suspect is an aging bulb which should be replaced. Sodium lamp "cycling" used to be very common, but in recent years the lamp manufacturers have been making sodium lamps that are less prone to cycling.

If you have more than one fixture which uses **identical** bulbs, swapping the bulbs should be the first test. If the problem remains with the fixture, then its ballast or other circuitry is probably bad. Don't be tempted to swap bulbs between non-identical fixtures even if they fit unless the bulb types are the same.

Warning: do not operate an HID lamp if the outer glass envelope is cracked or broken. First, this is dangerous because the extremely hot arc tube can quite literally explode with unfortunate consequences. In addition, the mercury arc produces substantial amounts of short wave UV which is extremely hazardous to anything living. The outer glass normally blocks most of this from escaping. Some lamps are actually designed with fusable links that will open after some specified number of hours should air enter the outer envelope. Thus, an undetected breakage will result in the lamp dying on its own relatively quickly.

Troubleshooting a Discharge Lamp Fixture

(From: Greg Anderson (a3a30878@bc.sympatico.ca).)

The following applies directly to high pressure sodium lamps. It may also also be used for metal halide and mercury vapour lamp problems as long as references to the starter are ignored. (Metal halide and mercury vapour lamps do not have starters, except for "instant re-light" metal hhalide lamps.)

The starter produces about 2 to 5 kV spikes to ionize the gas in the lamp. The starter normally has a triac across the ballast and a diac trigger cct. When open cct voltage is across the lamp, the diac fires the triac to short the ballast, the triac then opens. This "kick" produces the voltage spike. Once the gas ionizes, the lamp impedance drops then gradually increases as the lamp warms up. The lamp running voltage is about 1/2 of the open cct voltage

With the lamp removed and power on, you can normally hear a good starter "ticking".

The open circuit voltage is stamped on the ballast and is between about 150 and 350 Vac, depending on lamp wattage and ballast. Also, a capacitor is often connected in series with lamp to improve peaking and ballast action.

Steps to follow:

1. Bypass the photo cell - It may be bad
2. Check connections - water, salt, and bird poop are not good for wiring
3. Check the capacitor, if installed - normally they blow-up when bad
4. Check for open/shorted ballast.
5. Power up and check for starter "ticking"
6. REMOVE starter from cct and measure open cct volts
7. Check/Replace lamp
8. Check/replace lamp socket
9. Replace starter
10. Replace complete fixture.
11. Replace electrician. :)

Repairing a starter is not economically viable and often proves that electronic devices contain smoke and sometimes fire.

Ballasts and Bulbs Should be Matched!

HID bulbs generally need specific ballasts, and any given ballast can usually safely and effectively operate only one type or a few types of HID bulbs.

The bulb wattage must be matched to the ballast. A smaller bulb will usually be fed a wattage close to what the proper bulb takes, and will generally overheat and may catastrophically fail. Any catastrophic failures may not necessarily happen quickly. A larger bulb will be underpowered, and will operate at reduced efficiency and may have a shortened lifetime. The ballast may also overheat from prolonged operation with an oversized bulb that fails to warm up.

See The Discharge Lamp Mechanics Document (rather technical) for why it can be bad to underpower an arc discharge lamp.

Even if the ballast and bulb wattages match, substitutions can be limited by various factors including but not limited to different operating voltages for different bulbs. Examples are:

1. Pulse-start sodium lamps often have a slightly lower operating voltage than metal halide and mercury lamps of the same wattage, and ballasts for these sodium bulbs provide slightly more current than mercury and metal halide ballasts for the same wattage would. The higher current provided by the pulse-start sodium ballast can overheat mercury and metal halide lamps. Mercury and metal halide lamps may also "cycle" on and off in lower voltage sodium ballasts, such as many 50 to 100 watt ones.

2. Metal halide lamps have an operating voltage close to that of mercury lamps in many wattages, but have stricter tolerances for wattage and current waveform. Metal halides also usually need a higher starting voltage. Most metal halide lamps 100 watts or smaller require a high voltage starting pulse around or even over 1,000 volts.

   175 to 400 watt metal halide lamp ballasts can power mercury lamps of the same wattage, but the reverse is not recommended. Mercury lamps 50 to 100 watts will work on metal halide ballasts, but hot restriking of mercury lamps 100 watts or smaller on metal halide lamps may be hard on the mercury lamp since the starting pulse can force current through cold electrodes and the starting resistor inside the mercury lamp.

3. 1,000 watt mercury lamps come in two operating voltages, one of which is OK for 1,000 watt metal halide ballasts. A few wattages of pulse-start sodium (150 watts?) come in two voltages.

   A low voltage lamp in a high voltage ballast will be underpowered, resulting in reduced efficiency, possible reduced lamp life, and possible ballast overheating. A high voltage lamp in a low voltage ballast will usually cycle on and off, operate erratically, or possibly overheat. This will usually result in greatly reduced lamp life in any case.

4. One class of sodium lamps is made to work in mercury fixtures, but these only work properly with some mercury ballasts, namely:

   - 'Reactor' (plain inductor) ballasts on 230 to 277 volt lines.

   - 'High leakage reactance autotransformer' ballasts, preferably with an open circuit voltage around 230 to 277 volts. NOT 'lead', 'lead-peak' nor any metal halide ballast!

   These sodium lamps may suffer poor power regulation and accelerated aging in the wrong mercury ballasts, especially after some normal aging changes their electrical characteristics. Also, these lamps may overheat and will probably have shortened life with pulse-start sodium ballasts.

5. Many sodium lamps require a high voltage starting pulse provided only by ballasts made to power such lamps.

Operation of Discharge Lamps on DC

Sometimes, one may want to run a discharge lamp on DC. There are two possible reasons:

- Only DC power is available.

- To reduce flicker. Sometimes, the lamp performs differently for electricity flowing in one direction than the other. In addition, the positive and negative ends of the arc can make different amounts of light, resulting in a flicker rate equal to the AC frequency rather than twice the AC frequency.

However, end flicker is usually not significant. In HID lamps, the total arc size is generally small. Only if the fixture has a reflector that causes some areas to receive light from only one end of the arc should end flicker be significant. In most multi-tube fluorescent fixtures, the tubes are usually in series pairs with the two tubes in any pair oriented in opposite directions. This generally reduces end flicker effects, especially in fixtures with diffusing lenses.

Bulbs should perform close enough to identically in both directions, unless the bulb is near the end of its life. In such a case, one electrode deteriorates enough to affect performance before the other does. However, this generally indicates a need to replace the bulb rather than to attempt to make it flicker less.

If you want to rectify the AC to provide the bulb with DC, use a bridge rectifier after the ballast. Most ballasts, including all "iron" types, require AC of the proper voltage and frequency to work. Do this only if only two wires feed the bulb. Otherwise, diodes in the bridge rectifier may short parts of the ballast to each other, at least for half the AC cycle. Problems can also occur with fluorescent ballasts with filament windings. Only fully isolated filament windings or separate filament transformers should be used if you rectify the output of a ballast with filament windings. Also, the bridge rectifier must withstand the peak voltage provided by the ballast.

If the power supply is DC of adequate voltage, you need a resistor ballast or an electronic ballast specifically designed to run your lamp from the available DC voltage. "Iron" ballasts only limit current when used with AC. Preheat fluorescent lamps operated from DC supplies and without special ballasts need both the usual "iron" ballast to provide the starting "kick" and a resistor to limit current.

In addition, most discharge lamps are only partially compatible with DC, and some are not compatible at all.

Mercury vapor and fluorescent lamps generally work on DC. However, the life may be shortened somewhat by uneven electrode wear.

Fluorescent lamps may get dim at one end with DC. Since the mercury vapor ionizes more easily than the argon, some of it exists as positive ions. This can cause the mercury to be pulled to the negative end of the tube, resulting in a mercury shortage at the positive end. This is more of a problem with longer length and smaller diameter tubes.

Some fluorescent fixtures made for use where the power available is DC have special switches to reverse polarity every time the fixture is started. This balances electrode wear and reduces mercury distribution problems.

Mercury vapor lamps generally work OK with DC, but some may only reliably work properly if the tip of the base is negative and the shell of the base is positive. This is because the starting electrode does its job best when it is positive.

In addition, if the nearby main electrode is positive, it may cause a thin film of metal condensation that shorts the starting electrode to the nearby main electrode. This may make some brands, models, and sizes of mercury lamps unable to start after some use. The negative main electrode will not release as much vaporized electrode material, since the electrode material easily forms positive ions making the electrode material vapor tend to condense on the electrode rather than condense on nearby parts of the arc tube.

Metal halide and sodium lamps should not get DC. Use these only with ballasts that give the bulb AC. In metal halide lamps, ions from the molten halide salts can leach into hot quartz in the presence of a DC electric field. This can cause strains in the quartz arc tube. At the ends of the arc tube, electrolysis may occur, releasing chemically reactive halide salt components that can damage the arc tube or the electrodes. The arc tube may crack as a result.

There are a few specialized metal halide lamps that are made to work on DC. These often have asymmetrical electrodes and/or short arc lengths. These lamps often also must be operated only in specific positions, and only with the type of current they were designed for in order to achieve the proper distribution of active ingredients within the arc tube and to achieve proper electrode usage. For example, some of these lamps may go wrong in some way or another with AC.

In high pressure sodium lamps, which contain both sodium and mercury, the sodium forms positive ions more easily than the mercury does and drifts towards the negative electrode. The positive end can go dim from a lack of sodium. In addition, if any part of the arc tube is filled with a mixture containing excessive sodium and a lack of mercury, heat conduction from that part of the arc to the arc tube will increase. Furthermore, the hot arc tube may suffer electrolysis problems over time in the presence of sodium ions and a DC electric field.

Low pressure sodium lamps should not get DC for the same reasons. The sodium is likely to drift to the negative end of the arc tube, and hot glass will almost certainly experience destructive electrolysis problems if exposed to hot sodium or sodium ions and a DC electric field.

Special purpose HID lamps such as xenon and HMI

The usual general purpose HID lamps are mercury vapor, metal halide, and high pressure sodium. You can get these at home centers, although usually only in wattages up to 400 watts. These versions of HID lamps are optimized for high efficiency, long life, and minimized manufacturing cost.

However, the arc surface brightness of these lamps is roughly equal to the surface brightness of incandescent lamp filaments and general purpose halogen lamp filaments. For some applications such as endoscopy and movie projection, it is necessary to have a much more concentrated light source. This is where specialized HID lamps such as short arc lamps and HMI lamps come in.

Short arc lamps consist of a roughly spherical quartz bulb with two heavy duty electrodes spaced only a few millimeters apart at the tips. The bulb may contain xenon or mercury or both. Mercury short arc lamps have an argon gas fill for the arc to start in.

In a short arc lamp, the arc is small and extremely intense. The power input is at least several hundred and more typically a few thousand watts per centimeter of arc length. The operating pressure in the bulb is extremely high - sometimes as low as 20 atmospheres, more typically 50 to over 100 atmospheres. These lamps are an explosion hazard!

Mercury short arc lamps are used when a compact, intense source of UV is needed or where one cannot have the high voltage starting pulses needed for xenon short arc lamps. Mercury short arc lamps are slightly more efficient than xenon ones. The pressure in a mercury short arc lamp does not need to be as high for good efficiency as in a xenon one, but is still tremendous.

Xenon short arc lamps are more common than mercury ones, since they do not require time to warm up the way mercury lamps do and have a daylight-like spectrum. A disadvantage of xenon is the requirement of a very high voltage starting pulse - sometimes around 30 kilovolts!

Xenon short arc lamps are used for movie projection and sometimes for searchlights. Lower wattage ones are used in specialized devices such as endoscopes.

HMI lamps are metal halide lamps with a more compact and more intense arc. The arc is larger and less intense than that of a short arc lamp. Typical power input is hundreds of watts per centimeter of arc length, but gets to a few kilowatts per centimeter in the largest ones.

HMI lamps are used in some spotlights. They are used in some endoscopes and projection applications where the intensity of the HMI arc is adequate since they cost less and last longer and are more efficient than true short arc lamps.

There are all sorts of HMI and similar lamps, including HTI lamps and the lamps used in HID auto headlights.

HID Automotive Headlights

First there were gas lamps, then there were electric bulbs, then sealed beam, then halogen. Now, get ready for - drum roll please! - high intensity discharge lamps with sophisticated controllers. High-end automobiles from makers like BMW, Porsche, Audi, Lexus, and now Lincoln are coming equipped with novel headlight technology. No doubt, such technology will gradually find its way into mainstream automobiles - as well as other applications for mortals.

Among the potential advantages of HID headlights are higher intensity, longer life, superior color, and better directivity:

- Light intensity - HID lamps are about 3 times as efficient as halogen lamps. Thus, even when the efficiency of the DC-DC converter is taken into consideration, the lower power input can actually result in much brighter headlights than are possible with halogen bulbs.

This reduced power also leads to cooler operation and less drain on the battery and alternator.

- Lifespan - an HID lamp can be expected to last 2,700 hours or more and thus covered under the bumper to bumper warranty for 100,000 miles. As a practical matter, the HID lamp may outlast the automobile. Since warranty replacement of headlights turns out to be a significant expense, there is strong incentive to see this long lived technology take off.

- Spectral output - the light from the HID lamp is richer in blue (and more like daylight) than halogen bulbs. This turns out to enhance reflectivity of signs and road markings.

- Beam pattern - the small arc size of the HID lamp permits the optical system to be optimized to direct light more effectively to where it is needed and prevent it from spilling over to where it is not wanted.

In order to make this practical - even for a $40,000 Lexus - special DC-DC converter chips have been designed specifically with automotive applications in mind. These, along with a handful of other basic electronic components, implement a complete HID headlight control system.

The HID bulb itself is similar in basic design to traditional HID lamps: Two electrodes are sealed in a quartz envelope along with a mix of solids, liquids, and gasses. When cold, these materials are in their native state (at room temperature) but are mostly gases when the lamp is hot. Starting of these lamps may require up to 20 KV to strike an arc but only 50 to 150 V to maintain it. Lamps may be designed to operate on either AC or DC current depending on various factors including the size and shape of the electrodes. A unique set of ballast operating parameters must be matched to each model HID bulb.

Of all the problems that had to be addressed for HID headlights to become practical (aside from the cost), the most significant was the warmup time. As noted in the section: "High intensity discharge (HID) lamp technology", common HID lamps require a warmup period of a few minutes before substantially full light output is produced. This is, of course, totally unacceptable for an automotive headlight both for cold start (imagine: "Honey, I have to go cook the headlights") as well as when they need to be blinked. The warmup problem was solved by programming the controller to deliver constant power to the lamp rather than the more common nearly constant current that would be provided by a traditional ballast. With this twist along with a special lamp design, the lamp comes up to at least 75% of full intensity in under 2 seconds. The controller also provides 'hot strike' capability for blinking (recall that HID lamps typically cannot be restarted when hot). Thus, restarting a hot lamp is absolutely instantaneous.

While this technology is just beginning to appear, expect inroads (no pun intended) into household, office, store, factory, and other area and work lighting. The combination of high efficiency, long life, desirable spectral characteristics, small size, and solid state reliability should result in many more applications in the near future. The nearly instant starting capability addresses one of the major drawbacks of small HID lamps.

If you have some time and money to spare:

(From: Declan Hughes (hughes@aero.tamu.edu).)

Check out: OSRAM Sylvania Products Inc.

They have a "sample" for sale at $250.00 for one lamp including the 12 VDC electronic ballast. 42 W total power, 35 W light power, 3,200/2,800 lm output (there are two types, D2S and D2R), 2,000 hours rated lifetime, 91/80 lm/W luminous efficacy, 4,250/4,150 K color temperature, 6,500 cd/cm^2 average luminance, 4.2 mm arc length, burning position horizontal +/- 10 deg., luminous flux after 1 sec. = 25%, max. socket temp. = 180 deg C, any errors are mine.

Substitution of Metal Halide Lamps?

The following was prompted by a request for info on replacing an (expensive) 250 watt metal halide lamp in a video projector with something else.

I would not substitute this lamp, for many reasons below:

The metal halide lamp requires a ballast. The ballast should only run a 250 watt metal halide lamp of the same arc voltage. You will have to measure the arc voltage yourself after the lamp warms up, and do this without exposing yourself to the nasty UV that some of these things emit but which does not pass through glass. Arc voltages of many specialized metal halide lamps are not widely published and may or may not be available from the lamp manufacturer.

WARNING: The strike voltage on these may be several kV which will probably obliterate your multimeter should the arc drop out and attempt to restart while you are measuring it! Either the operating or strike voltage may obliterate you should you come in contact with live terminals! (Special metal halides probably usually only need a couple to a few kV. Xenon metal halide automotive lamps need 6 to 12 kV to strike and 15 to 20 kV for hot restrike. The worst are short arc xenon that may use up to 30 kV or more.)

Most metal halide lamps are AC types and some are DC and you can only use AC lamps on AC output ballasts and DC lamps on DC output ballasts. Different metal halide lamps may have different requirements for starting voltage also.

If you match arc voltage, AC/DC type, and the ballast will start the lamp, you might be in business but good chance not. Many projector lamps have specific cooling requirements and some have specific burning position requirements. Metal halide lamps may prematurely fail (possibly violently!) if they overheat, in addition to being off-color. If overcooled, they are more like mercury lamps and will be off-color and have reduced light output. In addition, some metal halide lamps have a halogen cycle in them to keep the inner surface of the bulb clean, and that may not work if the lamp is overcooled and not enough of the chemicals in the bulb get vaporized. This could also even make the lamp fail.

If you get the alternate lamp to operate satisfactorily, the arc may be in a different location from that of the original lamp. The arc may be of a different shape or size than that of the original lamp. This can affect your projection. Your projection may not get much light or may have illumination of only part of the picture.

The arc may have a different color or spectrum, which can affect the color rendering of what's being projected. Metal halide arcs are often not of uniform color, and if the alternate lamp has a less color-uniform arc than the original lamp then your pictures may have strange color tints in them.

As for using a halogen instead of metal halide? You will get less light, as well as problems from the filament having a different shape or size than the original metal halide arc does. Most likely, the filament is larger or longer than the arc and this will reduce the percentage of the light being utilized. Should you try a halogen lamp hack, you will almost certainly have to bypass the metal halide ballast. And halogen lamps emit more infrared than metal halide lamps of the same wattage - you might overheat the source of your image (e.g., LCD panel or transparency).

I would not recommend substituting a projector lamp for all of these reasons. This should only be tried at your own risk and only by those that are very familiar with all of the characteristics of the lamps in question - including being familiar with burning position requirements, cooling requirements, shape and size of the light-emitting region, etc.

Projector lamps in general, and especially specialized HID lamps, should be used only in equipment made specifically to use the particular lamps in question, or by those who know about these things well enough to make their own ballasts and know the other messy things about these lamps. And you may not save much by using a different lamp - specialized metal halide lamps are all expensive.

And for anyone shopping for any sort of projector - look into price, availability, and life expectancy of lamps!

---

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Low Pressure Sodium Lamps

(Portions from: Bruce Potter (s60231@aix2.uottawa.ca))

Low pressure sodium lamps are the most efficient visible light sources in common use. These lamps have luminous efficacies as high as 180 lumens per watt.

A low pressure sodium lamp consists of a tube made of special sodium-resistant glass containing sodium and a neon-argon gas mixture. Since the tube is rather large and must reach a temperature around 300 degrees Celsius, the tube is bent into a tight U-shape and enclosed in an evacuated outer bulb in order to conserve heat. As an additional heat conservation measure, the inner surface of the outer bulb is coated with a material that reflects infrared but passes visible light. This material has traditionally been tin oxide or indium oxide.

The electrodes are coiled tungsten wire coated with thermionically emissive material, and somewhat resemble the electrodes of fluorescent lamps. Unlike most fluorescent lamps, low pressure sodium lamps have only one electrical connection to each electrode and the electrodes cannot be preheated.

The gas mixture is a "Penning" mixture, consisting mainly of neon with a small amount of argon. Depending on who you listen to, this mixture is .5 to 2 percent argon, 98 to 99.5 percent neon. More argon-rich mixtures around 98-2 may be favored today since hot glass has some ability to absorb argon from a low pressure electric discharge. Ideally the mixture should be only a few tenths of a percent argon, in order to ionize most easily and do so much more easily than pure neon or pure argon.

A significant surplus of sodium is contained in the glass arc tube since the glass may absorb or react with some of the sodium. The sodium vapor pressure is controlled by the temperature of the coolest parts of the arc tube. When the arc tube reaches a proper temperature, further heating is reduced by the lamp's efficiency at producing light instead of heat.

The arc tube has dimples in it, which are normally slightly cooler than the rest of the arc tube. This causes the sodium metal to collect in the dimples instead of covering a larger portion of the arc tube and blocking light.

The low pressure sodium lamp usually requires 5 to 10 minutes to warm up.

The light of low pressure sodium consists almost entirely of the orange-yellow 589.0 and 589.6 nm sodium lines. This light is basically monochromatic orange-yellow. This monochromatic light causes a dramatic lack of color rendition - everything comes out in an orange-yellow version of black-and-white! This can cause some confusion in parking lots since cars become more alike in color.

Some basically red and reddish color fluorescent inks, dyes, and paints can fluoresce red to red-orange from the yellow sodium light and these will stand out in sodium light with color differing from that of the sodium light.

Another disadvantage of low pressure sodium light is that many objects will look darker than they would with an equal amount of other light. Red, green, and blue objects look dark under low pressure sodium light. Most other sources of light of sodium-like color such as "bug bulbs" have significant red and green output and will render red and green objects at least somewhat normally.

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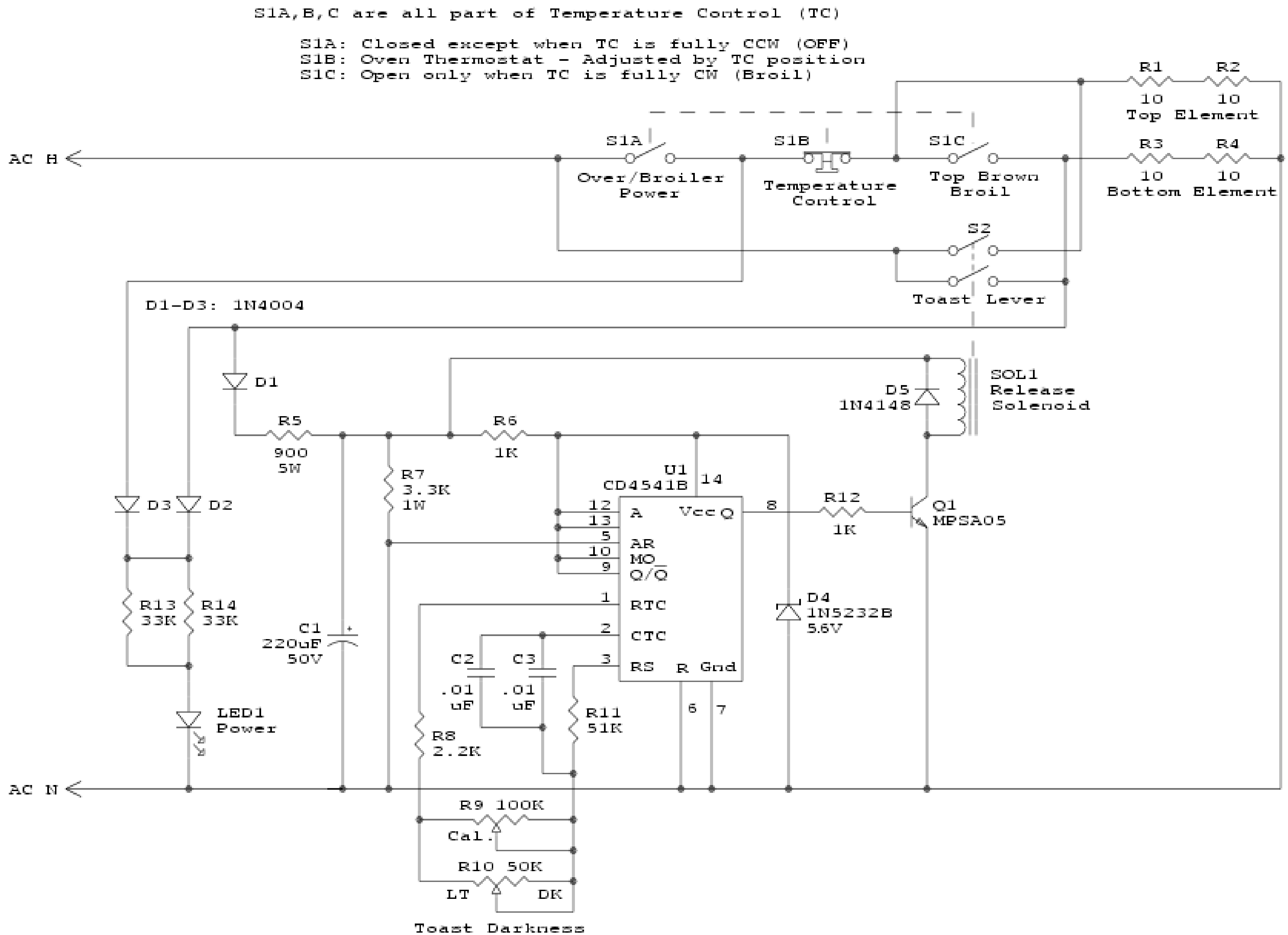
-- end V1.35 --



Toasmaster Toaster Oven/Broiler

Engineering, Science, and Other (Pretty Clean) Jokes Collection

Version 2.09

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Introduction

This is a collection of jokes and other humorous stories I have collected off the Net over the past few years. Most relate to engineering or science but some on other topics were just too good to pass up.

These should be mostly suitable for general audiences (unless you have a lawyer in the family. :-) They are in no particular order. I just add new ones to the end of the file (most of the time) and bump the version number (when I remember).

In most cases, the actual authors are unknown but I have at least provided attribution to the person who posted or emailed the article where available.

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DISCLAIMER

While every effort has been made - really! - to keep this collection of hopefully humorous articles pretty clean and unlikely to offend most people, there is always a chance something slipped through. My apologies in advance for any offense that might be taken. In the several years that most of this collection has been available, I have only received one (1, 0000001, I) complaint which I offered to remedy but never heard back so it can't be all that unsavory!

Having said that, I will not be responsible for any direct or consequential damage that may result from the reading of this collection including but not limited to: complaints from neighbors over excessive noise, costs associated with hernia operations resulting from prolonged and intense belly-laughs, destruction of property caused when the dog, cat, spouse, or other relation was thrown across the room from the couch and landed in the entertainment center, or the time and expense of finding another place of employment having been fired from your former one due to continuous Web page reading and inattention to the duties associated with your official job description.

As you can tell, lawyers had nothing whatsoever to do with the wording of this disclaimer. :-)

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A Brief Guide to Scientific Literature

(From: Chris Taylor (chris@labtam.labtam.oz.au).)

Here is an old collection that I rediscovered recently:

```
Phrase                                Translation
-------------------------------------------------------------------------------


It has been long known                I haven't bothered to check the references


It is known                           I believe


It is believed                        I think


It is generally believed              My colleagues and I think


There has been some discussion        Nobody agrees with me


It can be shown                       Take my word for it


It is proven                          It agrees with something mathematical


Of great theoretical importance       I find it interesting


Of great practical importance         This justifies my employment


Of great historical importance        This ought to make me famous
```

Some samples were chosen for study	The others didn't make sense
Typical results are shown	The best results are shown
Correct within order of magnitude	Wrong
The values were obtained empirically	The values were obtained by accident
The results are inconclusive	The results seem to disprove my hypothesis
Additional work is required	Someone else can work out the details
It might be argued that	I have a good answer to this objection
The investigations proved rewarding	My grant has been renewed

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Carnot is dead ! Schaeffer disproves 2nd Law

(From: Brandon Davis (HUEP35B@prodigy.com).)

The First Law of Thermodynamics: "You can't get something for nothing"

The Second Law of Thermodynamics: "As a matter of fact, you can't even break even."

Newton's first Law of Motion: "If you kick a can, it will move."

Newton's Second Law of Motion: "If you kick it harder, it will move faster."

Perhaps others know of similar restatements of other important Laws?

The best summary of the first and second laws of thermodynamics I have seen (in 3 statments):

- You can't win.
- You can't break even.
- You can't quit the game.

But surely simple things grow more complex as the cosmos implodes in retrograde time toward the initial collapse of the singularity? Er, or is it that complex things break down to constituent particles as the cosmos eXplodes along linear time lines towards chaos (i.e., entropy). Wait. Where is my local closed system where heat/energy/complexity can make a muddle of the metaverse's puddle? Oh --i know, I will just sink into the quandary of the 19th century, where the only part of probability that was important was babil (babbel) and ...oh, dear, where IS lewis carrol when he's needed?: The

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Canonical Collection of Light Bulb Jokes

(From: Clay Belcher (cbelcher@kuhub.cc.ukans.edu).)

Time for a little levity, lighting fans. Or should I say a little light humor. This collection of jokes was originally attributed to: Kurt Guntheroth (kurt@tc.fluke.COM).)but I've been unable to raise him at that address. I've taken the liberty to post this here in a somewhat sterilized version (as the original contained some pretty offensive stuff). Enjoy, and feel free to contribute additional ones.

```
Q:  How many Californians does it take to change a light bulb?
A:  Six.  One to turn the bulb, one for support, and four to
    relate to the experience.


Q:  How many Oregonians does it take to screw in a light bulb?
A:  Five.  One to change the bulb and four more to chase off
    the Californians who have come up to relate to the experience.
A': Nine.  One to change the bulb, and eight to protest the
    nuclear power plant that generates the electricity that powers it.


Q:  How many New Yorkers does it take to screw in a light bulb?
A:  None of your business!
A': 50.  50?  Yeah 50; its in the contract.


Q:  How many Virginians does it take to change a light bulb?
A:  Twelve: one to replace it and eleven to talk about how much
    better the old one was.


Q:  How many yuppies does it take to change a light bulb?
A:  Two.  One to call the electrician and one to mix the martinis.


Q:  How many Psychiatrists does it take to change a light bulb?
A:  Only one, but the bulb has got to really WANT to change.
A': None; the bulb will change itself when it is ready.


Q:  How many software people does it take to screw in a light bulb?
```

```
A:  None.  That's a hardware problem.
A': One, but if he changes it, the whole building will probably fall down.
A": Two.  One always leaves in the middle of the project.


Q:  How many hardware folks does it take to change a light bulb?
A:  None.  That's a software problem.
A': None.  They just have marketing portray the dead bulb as a feature.


Q:  How many Unix hacks does it take to change a light bulb?
A:  As many as you want; they're all virtual, anyway.


Q:  How many Bell Labs Vice Presidents does it take to change a light bulb?
A:  That's proprietary information.  Answer available from AT&T on payment of
    license fee (binary only).
A': Nearly unanswerable, since the one who tries to change it usually drops
    it, and the others call for a planning session.
A": Three.  One to get the bulb and two to get the phone number of one of
    their subordinates to actually change it.


Q:  How many graduate students does it take to screw in a light bulb?
A:  Only one, but it may take upwards of five years for him to get it done.


Q:  How many `Real Men' does it take to change a light bulb?
A:  None:  `Real Men' aren't afraid of the dark.


Q:  How many `Real Women' does it take to change a light bulb?
A:  None:  A 'Real Woman' would have plenty of real men around to do it.


Q:  How many Marxists does it take to screw in a light bulb?
A:  None:  The light bulb contains the seeds of its own revolution.


Q:  How many Russian leaders does it take to change a light bulb?
A:  Nobody knows.  Russian leaders don't last as long as light bulbs.


Q:  How many nuclear engineers does it take to change a light bulb?
A:  Seven.  One to install the new bulb and six to figure out what to do with
    the old one for the next 10,000 years.


Q:  How many pre-med students does it take to change a light bulb?
A:  Five:  One to change the bulb and four to pull the ladder out from under
    him.
```

Q: How many jugglers does it take to change a light bulb?
A: One, but it takes at least three light bulbs.

Q: How many Feminists does it take to change a light bulb?
A: That's not funny!!!

Q: How many supply-siders does it take to change a light bulb?
A: None. The darkness will cause the light bulb to change by itself.

Q: How many economists does it take to screw in a light bulb?
A: Two. One to assume the ladder and one to change the bulb.
A': None. If the government would just leave it alone, it would screw itself in.

Q: How many Valley Girls does it take to change a light bulb?
A: Oooh, like, manual labor? Gag me with a spoon! For sure.

Q: How many data base people does it take to change alight bulb?
A: Three:
One to write the light bulb removal program,
one to write the light bulb insertion program, and
one to act as a light bulb administrator to make sure
nobody else tries to change the light bulb at the same time.

Q: How many Carl Sagans does it take to screw in a light bulb?
A: Billions and billions.

Q: How many Zen masters does it take to screw in a light bulb?
A: A tree in a golden forest.
A': Two: one to change the bulb and one not to change it.
A": One to change and one not to change is fake Zen. The true Zen answer is Four. One to change the bulb.
A'":None. Zen masters carry their own light.

Q: How many folk singers does it take to screw in a light bulb?
A: Two. One to change the bulb, and one to write a song about how good the old light bulb was.

Q: How many surrealists does it take to change a light bulb?
A: Two, one to hold the giraffe, and the other to fill the bathtub with brightly colored machine tools.

Q: How many gorillas does it take to screw in a light bulb?
A: Only one, but it takes a truckload of light bulbs!

Q: How many doctors does it take to screw in a light bulb?
A: Three. One to find a bulb specialist, one to find a bulb installation
    specialist, and one to bill it all to Medicare.

Q: How many [IBM] Technical Writers does it take to change a light bulb?
A: 100. Ten to do it, and 90 to write document number GC7500439-0001,
    Multitasking Incandescent Source System Facility, of which 10% of the
    pages state only "This page intentionally left blank", and 20% of the
    definitions are of the form "A:...... consists of sequences of non-blank
    characters separated by blanks".
A': Just one, provided there's an engineer around to explain how to do it.

Q: How many professors does it take to change a light bulb?
A: Only one, but they get three publications out of it.

Q: How many people from New Jersey does it take to change a light bulb?
A: Three. One to change the light bulb, one to be a witness, and the third
    to shoot the witness.

Q: How many cops does it take to screw in a light bulb?
A: None. It turned itself in.

Q: How many lawyers does it take to change a light bulb?
A: How many can you afford?

Q: How many football players does it take to change a light bulb?
A: The entire team! And they all get a semester's credit for it!

Q: How many thought police does it take to screw in a light bulb?
A: None. There never was any light bulb.

Q: How many Federal employees does it take to screw in a light bulb?
A: Sorry, that item has been cut from the budget!

Q: How many psychics does it take to screw in a light bulb?
A: ---- You should have hit "n"!

Q: How many sorority sisters does it take to change a light bulb?
A: 51. One to change the bulb, and fifty to sing about the bulb
    being changed.

Q: How many frat guys does it take to screw in a light bulb?
A: Three: One to screw it in, and the other two to help him
    down off the keg.
A': Five: One to hold the bulb, and four to guzzle beer until the room spins.

Q: How many Harvard students does it take to screw in a light bulb?
A: Just one. He grabs the bulb and waits for the world to revolve around him.

Q: How many bureaucrats does it take to screw in a light bulb?
A: Two. One to assure the everything possible is being done while the other
    is incomplete pending resolution of some action items. It will be
    continued next week.   Meanwhile...

Q: How many brewers does it take to change a light bulb?
A: About one third less than for a regular bulb.

Q: How many WASP Princesses does it take to screw in a light bulb?
A: Two. One to get a Tab and one to call Daddy.

Q: How many accountants does it take to screw in a light bulb?
A: What kind of answer did you have in mind?

Q: How many civil servants does it take to change the light bulb?
A: 45. One to change the bulb, and 44 to do the paperwork.

Q: How many junkies does it take to screw in a light bulb?
A: Oh wow, is it like dark, man?

Q: How many consultants does it take to change a light bulb?
A: I will have an estimate for you a week from Monday.

Q: How many U.S marines does it take to screw in a light bulb
A: 50. One to screw in the light bulb and the remaining 49 to guard him.

Q: "How many Romulans does it take to screw in a light bulb?"
A: "151, one to screw the light-bulb in, and 150 to self-destruct the ship

out of disgrace."

Q: How many dull people does it take to change a light bulb?
A: one.

Q: How many editors of Poor Richard's Almanac does it take to replace a light bulb?
A: Many hands make light work.

Q: How many Vulcans does it take to change a light bulb?
A: "Approximately 1.000000000000000000000000"

Q: How many members of the U.S.S. Enterprise does it take to change a light bulb?
A: 7. Scotty will report to Captain Kirk that the light bulb in the Engineering Section is burnt out, to which Kirk will send Bones to pronounce the bulb dead. Scotty, after checking around, notices that they have no more new light bulbs, and complains that he can't see in the dark to tend to his engines. Kirk must make an emergency stop at the next uncharted planet, Alpha Regula IV, to procure a light bulb from the natives. Kirk, Spock, Bones, Sulu, and 3 red shirt security officers beam down. The 3 security officers are promptly killed by the natives, and the rest of the landing party is captured. Meanwhile, back in orbit, Scotty notices a Klingon ship approaching and must warp out of orbit to escape detection. Bones cures the native king who is suffering from the flu, and as a reward the landing party is set free and given all of the light bulbs they can carry. Scotty cripples the Klingon ship and warps back to the planet just in time to beam up Kirk et. al. The new bulb is inserted, and the Enterprise continues with its five year mission.

Q: How many efficiency experts does it take to replace a light bulb?
A: None. Efficiency experts replace only dark bulbs.

Q: How many actors does it take to change a light bulb?
A: Only one. They don't like to share the spotlight.

Q: How many Chinese Red Guards does it take to screw in a light bulb?
A: 10,000 - to give the bulb a cultural revolution.

Q: Do you know how many musicians it takes to change a light bulb?
A: No, big daddy, but hum a few bars and I will fake it.
A': Twenty. One to hold the bulb, two to turn the ladder, and seventeen in on the guest list.

Q: How many mystery writers does it take to screw in a light bulb?
A: Two, one to screw it almost all the way in and the other to give it a surprising twist at the end.

Q: How many bikers does it take to change a light bulb?
A: It takes two. One to change the bulb, and the other to kick the switch.

Q: How many running-dog lackeys of the bourgeoisie does it take to change a light bulb?
A: Two. One to exploit the proletariat, and one to control the means of production!

Q: How many existentialists does it take to screw in a light bulb?
A: Two: One to screw it in and one to observe how the light bulb itself symbolizes a single incandescent beacon of subjective reality in a netherworld of endless absurdity reaching out toward a maudlin cosmos of nothingness.

Q: How many light bulbs does it take to change a light bulb?
A: One, if it knows its own Goedel number.

Q: How many dadaists does it take to screw in a light bulb?
A: To get to the other side.

Q: How many mathematicians does it take to screw in a light bulb?
A: None. It's left to the reader as an exercise.
A': One. He gives it to six Californians, thereby reducing the problem to an earlier joke.
A": One. He gives it to five Oregonians, thereby reducing the problem to an earlier joke.
A'": In an earlier article, zeus!bobr writes:

Q: How many mathematicians does it take to screw in a light bulb?
A: One. He gives it to six Californians, thereby reducing the problem to an earlier joke...

In earlier work, Wiener [1] has shown that one mathematician can change a light bulb. If k mathematicians can change a light bulb, and if one more simply watches them do it, then k+1 mathematicians will have changed the light bulb. Therefore, by induction, for all n in the positive integers, n mathematicians can change a light bulb.

Bibliography:

[1] Weiner, Matthew P., <11485@ucbvax>, "Re: YALBJ", 1986

Q: How many consultants does it take to change a light bulb?
A: We don't know. They never get past the feasibility study.

Q: How many Ukrainians does it take to screw in a light bulb?
A: They don't need to, they glow in the dark.

Q: How many poets does it take to change a light bulb?
A: Three. One to curse the darkness, one to light a candle...
... and one to change the bulb.

Q: How many stock brokers does it take to change a light bulb?
A: Two. One to take out the bulb and drop it, and the other to try and sell it before it crashes (knowing that it's already burned out).

Q: How many aides does it take to change the President's light bulb?
A: None, they like to keep him in the dark.

Q: How many magicians does it take to change a light bulb?
A: Depends on what you want to change it into.

Q: How many Macintosh users does it take to change a light bulb?
A: None. You have to replace the whole motherboard.

And a couple more:

(From: Don Klipstein (don@misty.com).)

Q: How many straight male West Hollywood residents does it take to change a light bulb?

A: Either of them could probably do it themselves.

Q: How many journalists does it take to change a lightbulb?

A: Three. One to report on the inspired program to bring light, one to report on the sinister government plot to deprive the poor of darkness, and one to report on the light bulb manufacturer assassinating the old light bulb.

(From: WB or CM Hilbrich (hilbrich@antares.cloudnet.com).)

Q: How many mailing list subscribers does it take to change a light bulb?

A: 1,331:

- 1 to change the light bulb and to post to the list that the light bulb has been changed.

- 14 to share similar experiences of changing light bulbs and how the light bulb could have been changed differently.

- 7 to caution about the dangers of changing light bulbs.

- 27 to point out spelling/grammar errors in posts about changing light bulbs.

- 53 to flame the spell checkers.

- 156 to write to the list administrator complaining about the light bulb discussion and its inappropriateness to this mail list.

- 41 to correct spelling in the spelling/grammar flames.

- 109 to post that this list is not about light bulbs and to please take this e-mail exchange to alt.lite.bulb.

- 203 to demand that cross posting to alt.grammar, alt.spelling and alt.punctuation about changing light bulbs be stopped.

- 111 to defend the posting to this list saying that we all use light bulbs and therefore the posts ARE relevant to this mail list.

- 306 to debate which method of changing light bulbs is superior, where to buy the best light bulbs, what brand of light bulbs work best for this technique, and what brands are faulty.

- 27 to post URLs where one can see examples of different light bulbs.

- 14 to post that the URLs were posted incorrectly, and to post corrected URLs.

- 3 to post about links they found from the URLs that are relevant to this list which makes light bulbs relevant to this list.

- 33 to summarize all posts to date, then quote them including all headers and footers, and then add "Me Too."

- 12 to post to the list that they are unsubscribing because they cannot handle the light bulb controversy.

- 19 to quote the "Me Too's" to say, "Me Three".

- 4 to suggest that posters request the light bulb FAQ.

- 1 to propose new alt.change.lite.bulb newsgroup.

- 47 to say this is just what alt.physic.cold_fusion was meant for, leave it here.

- 143 votes for alt.lite.bulb.

(From: Dan Hicks (danhicks@millcomm.com).)

You forgot:

- 37 empty posts.

- 250 debating the merits of magnetic light bulb filters.

```
- 3 giving you URLs for really sexy adult light bulbs.
```

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Pentium Bug Jokes

(From: Henry G. Baker (hbaker@netcom.com).)

The 0.000000000001th new Intel slogan for the Pentium

We give you the most megaflops.

On the tee-shirt of an inline skater in Mountain View: :-)

(Intel Inside logo)

"I asked for a refund on my Pentium, and all I got was this lousy T-shirt"

Some Pentium Q & A and Random Comments

Q: What is Intel's follow-on to the Pentium?

A: Repentium.

Q: What does the element Pentium decay into?

A: Inert silicon with the emission of a press release.

The Pentium doesn't have bugs or produce errors; it's just Precision-Impaired.

Intel business executives have been so stressed by staying up late at night trying to figure out what to do about the Pentium Problem, that they're past the floating point.

I heard that Intel lost one of its divisions today...

(From: Mark Thorson (eee@netcom.com).)

INTEL INSIDE

Intel Inside sat on a wall.
Intel Inside had a great fall.
All the king's lawyers
and all the king's men
couldn't put Intel Inside
back together again.

PENTIUM PROCESSOR

Pentium Processor, puddin' and pie.
Pentium Processor, price real high.
When the bugs came out to play,
Pentium Processor ran away.

(From: John Cooley (jcooley@world.std.com).)

"Here's some of the hardware humor I've had mailed to me since the Intel Pentium floating point divide bug came out that's been such big news lately. It's not every day that we hardware designers get national recognition for *anything* either positive or negative! (Thought I'd post it as a refreshing diversion from the 100,000 serious hardware design oriented posts we see here all year through.)"

John Cooley
- Part Time Sheep & Goat Farmer
- Part Time EDA Consumer Advocate
- Full Time ASIC, FPGA & EDA Design Consultant

The Top Ten Reasons to Buy a Pentium Machine

10. You current computer is too accurate.

9. Want to get into the Guinness Book as "owner of the most expensive paperweight".

8. Math errors add zest to life.

7. You need an alibi for the IRS.

6. You want to see what all the fuss is about.

5. You've always wondered what it would be like to be a plaintiff.

4. The "Intel Inside" logo matches your decor perfectly.

3. You no longer have to worry about the CPU overheating.

2. You got a great deal from JPL.

And the #1 reason to buy a Pentium machine:

1. It'll probably work.

Q&A: The Pentium FDIV bug

```
Q:  How many Pentium designers does it take to screw in a light bulb?
A:  1.99904274017, but that's close enough for non-technical people.

Q:  What do you get when you cross a Pentium PC with a  research grant?
A:  A mad scientist.

Q:  What's another name for the "Intel Inside" sticker they put on Pentiums?
A:  The warning label.

Q:  Complete the following word analogy:  Add is to Subtract as Multiply
    is to:
        1)  Divide
        2)  ROUND
        3)  RANDOM
        4)  On a Pentium, all of the above
A:  Number 4.

Q:  What algorithm did Intel use in the Pentium's floating point divider?
A:  "Life is like a box of chocolates." (Source: F. Gump of Intel)

Q:  Why didn't Intel call the Pentium the 586?
A:  Because they added 486 and 100 on the first Pentium and got 585.999983605.
```

Top Ten New Intel Slogans for the Pentium

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  9.9999973251   It's a FLAW, Dammit, not a Bug
  8.9999163362   It's Close Enough, We Say So
  7.9999414610   Nearly 300 Correct Opcodes
  6.9999831538   You Don't Need to Know What's Inside
  5.9999835137   Redefining the PC -- and Mathematics As Well
  4.9999999021   We Fixed It, Really
  3.9998245917   Division Considered Harmful
  2.9991523619   Why Do You Think They Call It *Floating* Point?
  1.9999103517   We're Looking for a Few Good Flaws
  0.9999999998   The Errata Inside
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Things They Never Taught in School

(From: Jim Weir (rst-engr@oro.net).)

And for those of you who went through school thinking that everything above 30 MHz was powdered bat wings and mouse milk,

1. 2 #24 PVC hookup wires twisted tightly is about 10 pf per inch.
2. A file and a disk ceramic capacitor is the original one-set variable capacitor.
3. A wire is just some inductance, capacitance, and resistance floating in a loose formation.
4. A file and a carbon COMPOSITION resistor is the original one-set variable resistor.
5. A 50 ohm line on green glass PC board is about the thickness of the board material.
6. Don't tug on Superman's cape, don't piss into the wind, and don't mess around with The Man.

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Virus Jokes

Immediately scan your computer for the following viruses:

- PAT BUCHANAN VIRUS: Your system works fine, but it complains loudly about foreign software.
- COLIN POWELL VIRUS: Makes it presence known, but doesn't do anything. Secretly you wish it would.
- HILLARY CLINTON VIRUS: Files disappear, only to reappear mysteriously a year later, in another directory.
- O.J. SIMPSON VIRUS: You know it's guilty of trashing your system, but you just can't prove it.
- BOB DOLE VIRUS: Could be virulent, but it's been around too long to be much of a threat.
- STEVE FORBES VIRUS: All files are reported as the same size.
- PAUL REVERE VIRUS: This revolutionary virus does not horse around. It warns you of impending hard disk attack: Once if by LAN; twice if by C.
- POLITICALLY CORRECT VIRUS: Never identifies itself as a virus, but instead refers to itself as an electronic micro-organism.

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The Fable of the Fox's FAX

(From: Frank Reid (reid@indiana.edu).)

THE FABLE OF THE FOX'S FAX
by Frank
Based *very* loosely on a true story.
(G-rated version; use your imagination.)

Fox faced a fix; Fox couldn't fax, for Fox's fax was fried. "Fax failure forfeits fortunes faxing flax futures," figured Fox, frantically phoning Phoebe the Frugal Fax Fixer from Phoenix, who features fast fax fixes for flat fees of fifty French Francs. "Fix my freaking fax!" Fox fumed furiously.

Phoebe's fastest field fax-fixer, Pheasant, flew to Fox's flat. Pheasant found flocks of faulty fuses, a familiar foible of funky faxes from Formosa. Fetching fistfuls of fresh fuses forced Fox's fax to function with flawless finesse, faithfully focusing phalanxes of photons in phase with faraway photoelectron flux.

"Phooey!" Fox fussed, flipping Pheasant the finger. "I fail to fathom fifty French francs for fifteen-pfennig fuses. Forget fiscal funds for fallacious fax-fix!"

Pheasant fervently feared fowl finagling, for Pheasant failed to find her father following the forementioned fox's fax-fix fiasco four fortnights from February. Pheasant found feathers festooning Fox's foyer, and feared Fox feasted on Father. Pheasant flew forthwith, fleeing Fox's flat.

Pheasant fingered Fox, forwarding fiendishly-forged fax to feds. Federal fuzz ferreted Fox's fingerprints and fined Fox for filching fuses, fomenting forest fires, fencing foreign freon, fleecing folks with fraudulent faxed flax-futures, and felonious failure to file flat flax-fax tax. Fox filibustered futilely, and finally fell afoul of a frizzy female fed who fired flintlocks and fancied fox fur.

Moral: Fare fixers fairly or face fur-fetched frustration.

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Fixing a Flux Capacitor

Here is one that hasn't been posted to sci.electronics.repair yet:

Newsgroups: sci.electronics.repair
Subject: Flux Capacitor broken

Greetings:

We found what appears to be a Flux Capacitor that fell out of an alien spaceship in their haste to depart after being approached by BIG BIRD.

The plutonium supply seems to be adequate but plugging the 3 wire cord into 115 VAC doesn't produce any response. However, probing the logic circuits with our HP 16500 analyzer indicates that the P9-1000 they are apparently using to control the display is functional. (It also passes the FDIV bug test - must not be genuine Intel.)

Upon further examination, we note the device marked @@#$%-@#%@$#-11 appears to be burnt. Would like to know of source for this device or equivalent. It seems to be in-line with the main power relay.

We would really like to get our infinite energy/time machine going but are hesitant to jump across this device if it is not just a fuse or if there are further problems. A black hole in the middle of our back yard would be really bad for property values.

Thanks in advance for any assistance.....:-)

--- us

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Beware Those Transformers

(From: William Letendre (WJLServo@worldnet.att.net).)

Engineerin' Department of our company is on 3rd floor; company's main power XFMR is on utility pole right outside window. This mornin', Scott, engineer (ME) whose desk is next to window asked, "Hey, Bill, how much power is that transformer carryin'?"

Thought it over, answered, "Ah, with a full shift in the machine shop, should be about 200, 300 kW. Why?"

"Hmmmm. So, how strong are the electromagnetic fields from that?"

"Not very. Transformer designers go to fair pains to keep fields inside transformers!"

"Oh. Well, what about those high tension wires? What if one broke? Would that be dangerous? Or, couldn't the transformer just explode?"

"Well, yeah, I guess. Transformers do fail, once in a while. And the high voltage lines are probably up around 4400 volts, IIRC." Was gettin' a little irritated at this point, so added, "Guess if the transformer blew, or, if one of those lines broke and smashed through the window, coroner's report on you would read 'burned beyond recognition,' or maybe, 'grilled like a chop!' So what does this have to do with anything?"

Scott shook his head. "I dunno, boss. I'm not real comfortable sittin' that close to machine carryin' that kind of power. There's an empty desk by the back wall. Mind if I move?"

Rolled my eyes, said, "Sure, go ahead!"

Just about time Scott had his CAD terminal moved, plugged into LAN drop next to back wall, one of the other guys pointed out window, "Hey, check out the transformer!" Damned thing had blue sparks, smoke, comin' out of one of the porcelain terminals. Consolidated Edison was out in about an hour with 3 trucks, overhaulin' transformer.

Dunno what to make of this, but, do know one thing; if we're ever standin' on sidewalk, and Scott sez, "Gee, could we stand a little further from curb?" I won't ask why; I'll just do it!

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Engineers Explained

(Forwarded by: Jim Rauchut (rauchut@repairfaq.org), apparently by Scott Adams (from his book: The Dilbert Principle).)

People who work in the fields of science and technology are not like other people. This can be frustrating to the nontechnical people who have to deal with them. The secret to coping with technology-oriented people is to understand their motivations. This chapter will teach you everything you need to know. I learned their customs and mannerisms by observing them, much the way Jane Goodall learned about the great apes, but without the hassle of grooming.

Engineering is so trendy these days that everybody wants to be one. The word "engineer" is greatly overused. If there's somebody in your life who you think is trying to pass as an engineer, give him this test to discern the truth.

ENGINEER IDENTIFICATION TEST

You walk into a room and notice that a picture is hanging crooked. You...

- A. Straighten it.

- B. Ignore it.

- C. Buy a CAD system and spend the next six months designing a solar-powered, self-adjusting picture frame while often stating aloud your belief that the inventor of the nail was a total moron.

The correct answer is "C" but partial credit can be given to anybody who writes "It depends" in the margin of the test or simply blames the whole stupid thing on "Marketing."

SOCIAL SKILLS

Engineers have different objectives when it comes to social interaction.

"Normal" people expect to accomplish several unrealistic things from social interaction:

- Stimulating and thought-provoking conversation
- Important social contacts
- A feeling of connectedness with other humans

In contrast to "normal" people, engineers have rational objectives for social interactions:

- Get it over with as soon as possible.
- Avoid getting invited to something unpleasant.
- Demonstrate mental superiority and mastery of all subjects.

FASCINATION WITH GADGETS

To the engineer, all matter in the universe can be placed into one of two categories: (1) things that need to be fixed, and (2) things that will need to be fixed after you've had a few minutes to play with them. Engineers like to solve problems. If there are no problems handily available, they will create their own problems. Normal people don't understand this concept; they believe that if it ain't broke, don't fix it. Engineers believe that if it ain't broke, it doesn't have enough features yet.

No engineer looks at a television remote control without wondering what it would take to turn it into a stun gun. No engineer can take a shower without wondering if some sort of Teflon coating would make showering unnecessary. To the engineer, the world is a toy box full of sub-optimized and feature-poor toys.

FASHION AND APPEARANCE

Clothes are the lowest priority for an engineer, assuming the basic thresholds for temperature and decency have been satisfied. If no appendages are freezing or sticking together, and if no genitalia or mammary glands are swinging around in plain view, then the objective of clothing has been met. Anything else is a waste.

LOVE OF "STAR TREK"

Engineers love all of the "Star Trek" television shows and movies. It's a small wonder, since the engineers on the starship Enterprise are portrayed as heroes, occasionally even having sex with aliens. This is much more glamorous than the real life of an engineer, which consists of hiding from the universe and having sex without the participation of other life forms.

DATING AND SOCIAL LIFE

Dating is never easy for engineers. A normal person will employ various indirect and duplicitous methods to create a false impression of attractiveness. Engineers are incapable of placing appearance above function.

Fortunately, engineers have an ace in the hole. They are widely recognized as superior marriage material: intelligent, dependable, employed, honest, and handy around the house. While it's true that many normal people would prefer not to date an engineer, most normal people harbor an intense desire to mate with them, thus producing engineer-like children who will have high-paying jobs long before losing their virginity.

Male engineers reach their peak of sexual attractiveness later than normal men, becoming irresistible erotic dynamos in their mid thirties to late forties. Just look at these examples of sexually irresistible men in technical professions:

- Bill Gates.
- MacGyver.
- Etcetera.

Female engineers become irresistible at the age of consent and remain that way until about thirty minutes after their clinical death. Longer if it's a warm day.

HONESTY

Engineers are always honest in matters of technology and human relationships. That's why it's a good idea to keep engineers away from customers, romantic interests, and other people who can't handle the truth.

Engineers sometimes bend the truth to avoid work. They say things that sound like lies but technically are not because nobody could be expected to believe them. The complete list of engineer lies is listed below.

> "I won't change anything without asking you first."
> "I will return your hard-to-find cable tomorrow."
> "I have to have new equipment to do my job."
> "I'm not jealous of your new computer."

FRUGALITY

Engineers are notoriously frugal. This is not because of cheapness or mean spirit; it is simply because every spending situation is simply a problem in optimization, that is, "How can I escape this situation while retaining the greatest amount of cash?"

POWERS OF CONCENTRATION

If there is one trait that best defines an engineer it is the ability to concentrate on one subject to the complete exclusion of everything else in the environment. This sometimes causes engineers to be pronounced dead prematurely. Some funeral homes in high-tech areas have started checking resumes before processing the bodies. Anybody with a degree in electrical engineering or experience in computer programming is propped up in the lounge for a few days just to see if he or she snaps out of it.

RISK

Engineers hate risk. They try to eliminate it whenever they can. This is understandable, given that when an engineer makes one little mistake, the media will treat it like it's a big deal or something.

EXAMPLES OF BAD PRESS FOR ENGINEERS

- Hindenberg.
- Space Shuttle Challenger.
- SPANet(tm)
- Hubble space telescope.
- Apollo 13.
- Titanic.
- Ford Pinto.
- Corvair.

The risk/reward calculation for engineers looks something like this:

- RISK: Public humiliation and the death of thousands of innocent people.

- REWARD: A certificate of appreciation in a handsome plastic frame.

Being practical people, engineers evaluate this balance of risks and rewards and decide that risk is not a good thing. The best way to avoid risk is by advising that any activity is technically impossible for reasons that are far too complicated to explain.

If that approach is not sufficient to halt a project, then the engineer will fall back to a second line of defense: "It's technically possible but it will cost too much."

EGO

Ego-wise, two things are important to engineers:

- How smart they are.
- How many cool devices they own.

The fastest way to get an engineer to solve a problem is to declare that the problem is unsolvable. No engineer can walk away from an unsolvable problem until it's solved. No illness or distraction is sufficient to get the engineer off the case. These types of challenges quickly become personal -- a battle between the engineer and the laws of nature.

Engineers will go without food and hygiene for days to solve a problem. (Other times just because they forgot.) And when they succeed in solving the problem they will experience an ego rush that is better than sex--and I'm including the kind of sex where other people are involved.

Nothing is more threatening to the engineer than the suggestion that somebody has more technical skill. Normal people sometimes use that knowledge as a lever to extract more work from the engineer. When an engineer says that something can't be done (a code phrase that means it's not fun to do), some clever normal people have learned to glance at the engineer with a look of compassion and pity and say something along these lines: "I will ask Bob to figure it out. He knows how to solve difficult technical problems."

At that point it is a good idea for the normal person to not stand between the engineer and the problem. The engineer will set upon the problem like a starved Chihuahua on a pork chop.

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The Sex Life of an Electron

(From: Tom The sparky (martinm@wic.net).)

One night when his charge was pretty high Micor Farad decided to get a cute little coil to help him discharge. He picked up Millie Amp and took her for a ride on his megacycle. They rode across Wheatstone Bridge, around by the sine wave, and stopped in a magnetic field by a flowing current.

Micor Farad, attracted by Millie Amp's characteristic curve, soon began to lower her resistance to minimum and his field was fully excited. He laid her on the ground potential, raised her frequency, lowered her capacitance, and plugged in his high voltage probe. He inserted it into her socket, connected them in parallel, and began to short circuit her shunt. Fully excited Millie cried "ohm, ohm, ohm".

With his tube operating at a maximum peak, and her ciol vibrating from current flow, she soon reached her maximum peak. The excess current flow had gotten her hot and Micro Farad was rapidly discharging having drained off every electron.

They fluxed all night trying different connections and sockets until his bar magnet had lost all its field strength. Afterwords, Millie Amp tried self-induction and damaged her solenoid. With his battery fully discharged, Micro Farad was unable to excite her generator. So they ended up by reversing polarity and blowing each other's fuses

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About Sears Shop Vac HP Ratings

(From: Kevin AstirCS "1U" KO0B (kferguson@aquilagroup.com).) I note that air compressor manufacturers have taken after the vacuum sweeper folks, and are re-inventing the horsepower. Imagine, 6HP at 15A, 115VAC!

(From: sam).

Have you seen Sears shop vacs lately? I think they are also up to 6 HP. Every week or so, they seem to come out with one that is a little higher in their HP ratings - I guess internal cold fusion or something.

(From: Pin 2 Hot (pinksnd@io.com).)

Let's see, RPM X Torque = Horsepower.

Thus: No-load RPM X Locked-rotor Torque = Sears Horsepower

Notes:

1. testing done at 177V DC, equal to peak of 120V AC (AC-DC motors).
2. Sears Horsepower: How "hoarse" you get trying to talk over one of their shop-vacs while it's on.

Or maybe it's got something to do with vacuuming performance out at the stables.

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So You Want a Vacation Day?

(From: contributor's name withheld so HR won't find out :-)). So you want a day off, let's take a look at what you are asking for:

- There are 365 days per year available for work. There are 52 weeks per year in which you already have two days off per week, leaving 261 day available for work.
- Since you spend 16 hours each day away from work, you have used up 170 days, leaving only 91 days available.
- You spend 30 minutes each day on coffee break that accounts for 23 days each year, leaving only 68 days available. with a one hour lunch period each day, you have used up another 46 days, leaving only 22 days available for work.
- You normally spend 2 days per year on sick leave. This leaves you only 20 days available for work.
- We are off for 5 holidays per year, so your available working time is down to 15 days.
- We generously give you 14 days vacation per year which leaves only 1 day available for work, and I will be damned if you're going to take that day off!!!

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Sources of Demos (Bill Gates Computer Joke)

(From: Carter B. Schroy (CBS970@AOL.COM).)

Bill Gates died. He was sent to the Afterlife Waiting Room. He was met by St. Peter, who asked him if he wanted to go to Heaven or Hell, and if he'd like to see them before he decided. Bill said yes, and St. Peter snapped his fingers. They appeared on a sunny beach, with people dancing, swimming, and playing volleball. Just basically having a wonderful time. Good food, good music, good people. Bill turns to St. Peter and says, "Wow, Heaven is great!" St. Peter says, "This isn't Heaven, it's Hell. Want to see Heaven?" Mr. Gates nods yes, and they appear in a shady park, with a few old people sitting on benches feeding birds. A gentle breeze blows by, and all is quiet and serene. St. Peter asks Bill, "Well, which would you like?" Bill thinks for a minute, and says, "Well, if this is Heaven, then I will take Hell." Instantly, he was plunged up to his neck in red-hot lava, the screams of other tortured souls filling his ears. He looks up, and sees St. Peter in the waiting room. Bill calls out to him, and said, "Hey! What's going on? Where's the beach? The bikini-clad women? The party?" St. Peter turns from his Macintosh to face Bill, and says, "That was just the demo."

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Knowledge, Power, Time and Money Equation...

For all you mathematicians...

After applying some simple algebra to some trite phrases and cliches a new understanding can be reached of the secret to wealth and success.

Here it goes.

> Knowledge is Power
> Time is Money and as every engineer knows,
> Power is Work over Time.

So, substituting algebraic equations for these time worn bits of wisdom, we get:

> K = P (1)
> T = M (2)
> P = W/T (3)

Now, do a few simple substitutions:

> Put W/T in for P in equation (1), which yields:
> K = W/T (4)

Put M in for T into equation (4), which yields:

> K = W/M (5).

Now we've got something. Expanding back into English, we get:

> Knowledge equals Work over Money.

What this MEANS is that:

1. The More You Know, the More Work You Do, and
2. The More You Know, the Less Money You Make.

Solving for Money, we get:

> M = W/K (6)
> Money equals Work Over Knowledge.

From equation (6) we see that Money approaches infinity as Knowledge approaches 0, regardless of the Work done.

What THIS MEANS is:

> The More you Make, the Less you Know.

Solving for Work, we get

> W = M x K (7)
> Work equals Money times Knowledge

From equation (7) we see that Work approaches 0 as Knowledge approaches 0.

What THIS MEANS is:

> The stupid rich do little or no work.

Working out the socioeconomic implications of this breakthrough is left as an exercise for the reader.

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You Know You Are Too Serious About Computers If...

- If you did an error-free installation of Windows 95.
- When your modem starts smoking.
- If no one can reach you by phone since your computer is always online.
- If you log-off your system because it's time to go to work.
- If you call in sick because you found a great new WWW site.
- If you can type your top 10 favorite web sites....by heart.
- If you can locate a particular home page without using a search engine.
- If you can write your own html page.
- If you can access more than 20 erotic no-pay sites.
- If you download more than 20Mb from a binary newsgroup...in one session.
- If while reading a magazine, you look for the Zoom icon for a better look at a photograph.
- You comment, while watching a sunset, that the image would be enhanced with 10% more magenta and a higher resolution.
- If while driving down the street, you are confused by the numbers on the houses... they do not appear to be legitimate WWW addresses.
- When someone tells you to remember something, and you look for File/Save command.
- When you discover there is no little car icon with a forward arrow on the dashboard of your car, to make it go.
- When you think the File/Kill command should apply to your system administrators.
- When you find it easier to dial-up the National Weather Service: Weather/your_town/now.html than to simply look out the window.

- When you start using phrases like: Hungry.must-eat.food.now@home.
- If you have a heart attack when you forgot to pay your phone bill and receive a "pending disconnection of service" notice.
- When you order most of what you buy.....online.
- If your fingers quit moving because you've been online for 36 hours.
- When you find yourself engaged to someone you've never actually met, except through E-mail.
- When you log-off from a session in your favorite newsgroup, and your log reads: Online time: 56 hours 24 minutes.
- If your net provider suggests you try a competitor, because you're exceeding 300 hours a month, connect time.
- When you add your third modem and dedicated phone line.
- You access Microsoft's Web page every Sunday morning from Brother Bill's sermon.
- When that 112 GB hard drive is full.
- If 300 Mhz is simply too slow.
- When your desk collapses under the weight of your computer peripherals.
- If you have an "online" light installed on your car to tell you when the engine is running.
- When you discover that in order to drive your car somewhere, you do not have an http:// or ftp:// address.
- If you can actually talk to the computers in your new car, and understand what they say.
- When you modify the programming of your car's computers and actually get better mileage.
- When you can access the Net, via your portable and cellular phone.
- If on the way home from work, you use your portable and cellular phone in your car, to reprogram a Tomahawk missile, in flight, and redirect it to take out the joker in the Cadillac who cut you off.
- If you try to press Alt-F4 to close your car window.
- When you put a CD-ROM in your car's player.
- When someone tells you about a great new program and you're very disappointed to find it's on TV.
- If every sentence you utter begins with, "On the Net..."

- If you put your e-mail address in the upper left-hand corner of envelopes.
- If you have your e-mail address printed on your stationery.
- When you insist on seeing the movie "The Net" for the 63rd time.
- If magazine like "InternetWorld" are of greater interest than "Playboy" or "Playgirl".
- If you maintain more than 6 e-mail addresses.
- If you use more than 20 passwords.
- If you set up your own Web page.
- If you set up a Web page for each of your kids...and your pets.
- If, instead of a phone number, you ask someone for their e-mail address.
- If you don't know anyone who DOESN'T have an e-mail address.
- If, to you, "safe sex" means doing it online.
- If you convince your mom that she HAS to get online because e-mail is so much cheaper than long distance phone charges.
- If you can write a list like this.
- If you can relate to a list like this.

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How Mil Specs Live Forever!

(From: Jeff Wisnia, W1BSV (jwisnia@110.net).)

How Mil Specs Live Forever:

The US Standard Railroad Gauge (the distance between the rails) is 4 feet, 8.5 inches. That is an exceedingly odd number; Why was that gauge used?

Because that was the way they built them in England, and the US railroads were built by English expatriates.

Why did the English people build them that size? Because the first rail lines were built by the same people who built the pre-railroad tramways, and that was the gauge they used.

Why did "they" use that gauge then? Because the people who built the tramways used the same jigs and tools that they used for building wagons. which used that wheel spacing.

Okay! Why did the wagons use that odd wheel spacing? Because the first long distance roads in Europe were built by Imperial Rome for the benefit of their legions. Those roads have been used ever since. And the ruts? The initial ruts, which everyone else had to match for fear of destroying their wagons, were originally made by Roman war chariots. Since the chariots were made by or for Imperial Rome, they were all made with similar wheel spacing.

Thus, we have the answer to the original question. The US Standard Railroad Gauge of 4 feet 8.5 inches is derived from the original Mil Spec for Imperial Rome's army war chariots. Mil Specs, like bureaucracies, tend to exist forever.

So, next time you read a Mil Spec and wonder what horse's ass came up with it, you may be exactly right. Because, the Imperial Roman war chariots were designed for maneuverability, as narrow as possible, just wide enough to accommodate the rear ends of two war horses.

(Forwarded by: Kevin Theobald (theobald@capsl.udel.edu).)

Here is an amusing addition from a NASA guy, Howard Winsett:

There is an interesting extension to the story about railroad gauges and horses' behinds. When we see a Space Shuttle sitting on its launch pad, there are two big booster rockets attached to the sides of the main tank. These are solid rocket boosters, or SRBs. Thiokol makes the SRBs at their factory at Utah. The engineers who designed the SRBs might have preferred to make them a bit fatter, but the SRBs had to be shipped by train from the factory to the launch site.

The railroad line from the factory happens to run through a tunnel in the mountains. The SRBs had to fit through that tunnel. The tunnel is slightly wider than the railroad track, and the railroad track is about as wide as two horses' behinds.

So, a major design feature of what is arguably the world's most advanced transportation system was determined over two thousand years ago by the width of a horse's ass.

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On Replacing Fuses with Bullets

You have repeatedly been warned: "Do not replace a fuse unless you have thoroughly checked all other components.... The new fuse may just blow the second time around."

Not necessarily. I have seen cases where the second time around, some other component pops off and the fuse survives!

(From: Keith Morgan (morgankk@boat.bt.com).)

Was a .22 caliber bullet the other component Sam mentioned: (this is an article spotted by Gary Davis in the Arkansas Democrat Gazette 25 July 1996, and reported in the UK Private Eye magazine)

"I thank God every hour that we weren't on that bridge when Thurston shot his nuts off, cos we'd both be pushing up the daisies by now," Billy Ray Wallis told reporters from his hospital bed in the Baptist Medical Center, Woodruff County. "When you leave, can you check if anyone got the frogs from the truck? I'd hate anything to happen to them."

Wodruff County deputy Dovey Snyder later gave a more coherent account of that evening's events. "It seems that Thurston Poole, 33, and Billy Ray Wallis, 38, were returning to Des Arc after a frog-gigging trip, when the fuse for the headlights on Poole's pick-up truck burned out. They didn't have a spare, so Wallis took a .22 caliber bullet from his pistol and found that it fitted perfectly into the fuse box next to the steering wheel column. The headlights started working again, and they resumed their journey, with Poole at the wheel.

"Apparently, it never occurred to them that, if the headlight wiring was faulty, then the bullet would soon overheat. They'd gone about twenty miles and were about to cross White River bridge when it got hot enough to discharge itself, striking Poole in the right testicle and partially severing his scrotum. As a result, the vehicle swerved off the road and drove through the front window of a hamburger bar. Poole (who sustained further abrasions from broken glass, and burns from fried onions) kept shouting at diners 'mind my frogs', while Wallis (who sustained a broken clavicle) attempted to steal a chip-fryer in the confusion. I tell you, I've been a state trooper for ten years, but this is the dumbest thing I've ever come across. I can't believe that those two would admit how the accident happened. And all they keep asking about are their damn frogs."

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Corporate Down-Sizing Affects Everyone Everywhere

North Pole Memo:

Subject: Famous Reindeer Terminated

The recent announcement that Donner and Blitzen have elected to take the early reindeer retirement package has triggered a good deal of concern about whether they will be replaced, and about other restructuring decisions at the North Pole.

Streamlining is due to the North Pole's loss of dominance of the season's gift distribution business. Home shopping channels and mail order catalogues have diminished Santa's market share. He could not sit idly by and permit further erosion of the profit picture.

The reindeer down-sizing was made possible through the purchase of a late model Japanese sled for the CEO's annual trip. Improved productivity from Dasher and Dancer, who summered at the Harvard Business School, is anticipated.

Reduction in reindeer will also lessen airborne environmental emissions for which the North Pole has received unfavorable press.

I am pleased to inform you that Rudolph's role will not be disturbed. Tradition still counts for something at the North Pole. Management denies, in the strongest possible language, the earlier leak that Rudolph's nose got that way, not from the cold, but from substance abuse. Calling Rudolph "a lush who was into the sauce and never did pull his share of the load" was an unfortunate comment, made by one of Santa's helpers and taken out of context at a time of year when he is known to be under executive stress.

As a further restructuring, today's global challenges require the North Pole to continue to look for better, more competitive steps. Effective immediately, the following economic measures are to take place in the "Twelve Days of Christmas" subsidiary:

The partridge will be retained, but the pear tree never turned out to be the cash crop forecasted. It will be replaced by a plastic hanging plant, providing considerable savings in maintenance;

The two turtle doves represent a redundancy that is simply not cost effective. In addition, their romance during working hours could not be condoned. The positions are therefore eliminated;

The three French hens will remain intact. After all, everyone loves the French;

The four calling birds were replaced by an automated voice mail system, with a call waiting option. An analysis is underway to determine who the birds have been calling, how often and how long they talked;

The five gold rings have been put on hold by the Board of Directors. Maintaining a portfolio based on one commodity could have negative implications for institutional investors. Diversification into other precious metals as well as a mix of T-Bills and high technology stocks appear to be in order;

The six geese-a-laying constitutes a luxury which can no longer be afforded. It has long been felt that the production rate of one egg per goose per day is an example of the decline in productivity. Three geese will be let go, and an upgrading in the selection procedure by personnel will assure management that from now on every goose it gets will be a good one;

The seven swans-a-swimming is obviously a number chosen in better times. The function is primarily decorative. Mechanical swans are on order. The current swans will be retrained to learn some new strokes and therefore enhance their outplacement;

As you know, the eight maids-a-milking concept has been under heavy scrutiny by the EEOC. A male/female balance in the workforce is being sought. The more militant maids consider this a dead-end job with no upward mobility. Automation of the process may permit the maids to try a-mending, a-mentoring or a-mulching;

Nine ladies dancing has always been an odd number. This function will be phased out as these individuals grow older and can no longer do the steps;

Ten Lords-a-leaping is overkill. The high cost of Lords plus the expense of international air travel prompted the Compensation Committee to suggest replacing this group with ten out-of-work congressmen. While leaping ability may be somewhat sacrificed, the savings are significant because we expect an oversupply of unemployed congressmen this year;

Eleven pipers piping and twelve drummers drumming is a simple case of the band getting too big. A substitution with a string quartet, a cutback on new music and no uniforms will produce savings which will drop right down to the bottom line;

We can expect a substantial reduction in assorted people, fowl, animals and other expenses. Though incomplete, studies indicate that stretching deliveries over twelve days is inefficient. If we can drop ship in one day, service levels will be improved.

Regarding the lawsuit filed by the attorney's association seeking expansion to include the legal profession ("thirteen lawyers-a-suing") action is pending.

Lastly, it is not beyond consideration that deeper cuts may be necessary in the future to stay competitive. Should that happen, the Board will request management to scrutinize the Snow White Division to see if seven dwarfs is the right number.

The executives at the North Pole wish you and yours a Merry Christmas and a productive New Year.

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Are You a Real Engineer?

(From: Mark Sokos (msokos1@umbc.edu).)

A comment was recently made about the lack of humor on this newsgroup. So, I did an excite search on "electronics humor", and, nothing. Zip. Zero. Nada. (Well, I only checked the first page of listings). So, I did remember snagging this off of the net. It's not quite electronics humor, but it is engineering humor, which I guess is as close as we're going to get.

And yes, it's off topic, so go ahead and flame me.

PS: I'm not going to admit (at least not publically) how many of these I said yes to.

(Author: Jose Herrero (jose@borg.harvard.edu).)

You may be an engineer...

- If Dilbert is your hero.
- If you stare at an orange juice container because it says CONCENTRATE.
- If you want an 8X CDROM for Christmas.
- If you can name 6 Star Trek episodes.
- If the only jokes you receive are through e-mail.
- If your wrist watch has more computing power than a 486DX2-50.
- If your idea of good interpersonal communication means getting the decimal point in the right place.
- If you look forward to Christmas only to put together the kids' toys.
- If you introduce your wife as "mylady@home.wife".
- If your spouse sends you an e-mail instead of calling you to dinner.

- If you can quote scenes from any Monty Python movie.
- If you use a CAD package to design your son's Pine Wood Derby car.
- If you have used coat hangers and duct tape for something other than hanging coats and taping ducts.
- If, at Christmas, it goes without saying that you will be the one to find the burnt-out bulb in the string.
- If you window shop at Radio Shack.
- If your ideal evening consists of fast-forwarding through the latest Sci-Fi movie looking for technical inaccuracies.
- If you have "Dilbert" comics displayed anywhere in your work area.
- If you carry on a one-hour debate over the expected results of a test that actually takes five minutes to run.
- If you are convinced you can build a phaser out of your garage door opener and your camera's flash attachment.
- If you don't even know where the cover to your personal computer is.
- If you have modified your can-opener to be microprocessor driven.
- If you know the direction the water swirls when you flush.
- If you own "Official Star Trek" anything.
- If you have ever taken the back off your TV just to see what's inside.
- If a team of you and your co-workers have set out to modify the antenna on the radio in your work area for better reception.
- If you ever burned down the gymnasium with your Science Fair project.
- If you are currently gathering the components to build your own nuclear reactor.
- If you own one or more white short-sleeve dress shirts.
- If you have never backed-up your hard drive.
- If you are aware that computers are actually only good for playing games, but are afraid to say it out loud.
- If you truly believe aliens are living among us.
- If you have ever saved the power cord from a broken appliance.

- If you have ever purchased an electronic appliance "as-is".
- If you see a good design and still have to change it.
- If the sales people at Circuit City can't answer any of your questions.
- If you still own a slide rule and you know how to work it.
- If the thought that a CD could refer to finance or music never enters your mind.
- If you own a set of itty-bitty screw drivers, but you don't remember where they are.
- If you rotate your screen savers more frequently than your automobile tires.
- If you have a functioning home copier machine, but every toaster you own turns bread into charcoal.
- If you have more toys than your kids.
- If you need a checklist to turn on the TV.
- If you have introduced your kids by the wrong name.
- If you have a habit of destroying things in order to see how they work.
- If your I.Q. number is bigger than your weight.
- If the microphone or visual aids at a meeting don't work and you rush up to the front to fix it.
- If you can remember 7 computer passwords but not your anniversary.
- If you have memorized the program schedule for the Discovery Channel and have seen most of the shows already.
- If you have ever owned a calculator with no equal key and know what RPN stands for.
- If your father sat 2 inches in front of your family's first color TV with a magnifying lens to see how they made the colors, and you grew up thinking that was normal.
- If you know how to take the cover off of your computer, and what size screw driver to use.
- If you can type 70 words a minute but can't read your own handwriting.
- If people groan at the party when you pick out the music.
- If you can't remember where you parked your car for the 3rd time this week.
- If you did the sound system for your senior prom.

- If your checkbook always balances.
- If your wristwatch has more buttons than a telephone.
- If you have more friends on the Internet than in real life.
- If you thought the real heroes of "Apollo 13" were the Mission Controllers.
- If you think that when people around you yawn, it's because they didn't get enough sleep.
- If you spend more on your home computer than your car.
- If you know what http:/ stands for.
- If you've ever tried to repair a $5.00 radio.
- If you have a neatly sorted collection of old bolts and nuts in your garage.
- If your three year old son asks why the sky is blue and you try to explain atmospheric absorption theory.
- If your lap-top computer costs more than your car.
- If your 4 basic food groups are: 1. Caffeine 2. Fat 3. Sugar 4. Chocolate.

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Hardware, Software, Management Humor

(From: Dan Kuechle (dan_kuechle@i-tech.com).)

A hardware engineer, a software engineer, and an engineering manager were skiing over the weekend. Upon leaving the resort the brakes failed on their car. They went screaming down the mountain until they drove into a snow bank. At this point they didn't know what to do. They still had half the mountain to descend, and no brakes. The engineering manager said "I will head up a task force to brainstorm the problem, and then come up with a schedule to implement the outcome." The hardware engineer said "I can fix these brakes! I will jack up the car, remove the wheels, and fix them with my Swiss army knife." The software engineer's only comments were "I think we ought to push the car back up the mountain, try it again, and see if it fails the same way"

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Why Engineers Don't Write Recipe Books

(From: Redd Emmett R (err557f@cnas.smsu.edu).)

Here's one that a friend of mine sent me, I found it pretty funny.

Why Engineers Don't Write Recipe Books

Chocolate Chip Cookies:

Ingredients:

1. 532.35 cm3 gluten
2. 4.9 cm3 NaHCO3
3. 4.9 cm3 refined halite
4. 236.6 cm3 partially hydrogenated tallow triglyceride
5. 177.45 cm3 crystalline C12H22O11
6. 177.45 cm3 unrefined C12H22O11
7. 4.9 cm3 methyl ether of protocatechuic aldehyde
8. Two calcium carbonate-encapsulated avian albumen-coated protein
9. 473.2 cm3 theobroma cacao
10. 236.6 cm3 de-encapsulated legume meats (sieve size #10)

To a 2-L jacketed round reactor vessel (reactor #1) with an overall heat transfer coefficient of about 100 Btu/F-ft2-hr, add ingredients one, two and three with constant agitation. In a second 2-L reactor vessel with a radial flow impeller operating at 100 rpm, add ingredients four, five, six, and seven until the mixture is homogeneous. To reactor #2, add ingredient eight, followed by three equal volumes of the homogeneous mixture in reactor #1. Additionally, add ingredient nine and ten slowly, with constant agitation. Care must be taken at this point in the reaction to control any temperature rise that may be the result of an exothermic reaction.

Using a screw extrude attached to a #4 nodulizer, place the mixture piece-meal on a 316SS sheet (300 x 600 mm). Heat in a 460K oven for a period of time that is in agreement with Frank & Johnston's first order rate expression (see JACOS, 21, 55), or until golden brown. Once the reaction is complete, place the sheet on a 25C heat-transfer table, allowing the product to come to equilibrium.

Someone's note: Cookie sheet thickness is unspecified :-).

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How Data Really Travels

(Author: Anonymous).

If a packet hits a pocket on a socket on a port, And the bus is interrupted as a very last resort, And the address of the memory makes your floppy disk abort Then the socket packet pocket has an error to report.

If your cursor finds a menu item followed by a dash, And the double-clicking icon puts your window in the thrash, and your data is corrupted 'cause the index doesn't hash, The your situation's hopeless, and your system's gonna crash!

You can't say this? What a shame, Sir! We'll find you another game, Sir...

If the label on the cable on the table at your house, Says the network is connected to the button on your mouse, But your packets want to tunnel on another protocol, That's repeatedly rejected by the printer down the hall,

And your screen is all distorted by the side effects of Gauss So your icons in the window are as wavy as a souse, Then you may as well reboot and then you go out with a bang, Cause as sure as I'm a poet, the sucker's gonna hang!

When the copy of your floppy's on the disk, And the microcode instructions cause unnecessary risk, Then you have to flash your memory and you'll want to RAM your ROM. Quickly turn off the computer and be sure to tell your Mom!

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Is Hell Endothermic or Exothermic?

(From: Christopher Donham (donham@axon.engr.sgi.com).)

A thermodynamics professor had written a take home exam for his graduate students. It had one question:

"Is hell exothermic or endothermic? Support your answer with a proof."

Most of the students wrote proofs of their beliefs using Boyle's Law or some variant. One student, however wrote the following:

"First, we postulate that if souls exist, then they must have some mass.

If they do, then a mole of souls can also have a mass. So, at what rate are souls moving into hell and at what rate are souls leaving? I think that we can safely assume that once a soul gets to hell, it will not leave. Therefore, no souls are leaving.

As for souls entering hell, lets look at the different religions that exist in the world today. Some of these religions state that if you are not a member of their religion, you will go to hell. Since, there are more than one of these religions and people do not belong to more than one religion, we can project that all people and all souls go to hell.

With birth and death rates as they are, we can expect the number of souls in hell to increase exponentially.

Now, we look at the rate of change in volume in hell. Boyle's Law states that in order for the temperature and pressure in hell to stay the same, the ratio of the mass of souls and volume needs to stay constant.

So, if hell is expanding at a slower rate than the rate at which souls enter hell, then the temperature and pressure in hell will increase until all hell breaks loose.

Of course, if hell is expanding at a rate faster than the increase of souls in hell, than the temperature and pressure will drop until hell freezes over."

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English is Such a Crazy Language

(From: Ravi Pillutla (ravi@repairfaq.org).)

Let's face it: English is a crazy language. There is no egg in eggplant or ham in hamburger; neither apple nor pine in pineapple.

English muffins were not invented in England or french fries in France. Sweetmeats are candies, while sweetbreads, which aren't sweet, are meat.

We take English for granted. But if we explore its paradoxes, we find that quicksand can work slowly, boxing rings are square, and a guinea pig is neither from Guinea nor is it a pig. And why is it that writers write, but fingers don't fing, grocers don't groce, and hammers don't ham? If the plural of tooth is teeth, why isn't the plural of booth beeth? One goose, 2 geese. So, one moose, 2 meese? One index, two indices? Is cheese the plural of choose?

If teachers taught, why didn't preachers praught? If a vegetarian eats vegetables, what does a humanitarian eat?

In what language do people recite at a play, and play at a recital? Ship by truck and send cargo by ship? Have noses that run and feet that smell? Park on driveways and drive on parkways?

How can a slim chance and a fat chance be the same, while a wise man and a wise guy are opposites? How can the weather be hot as h*ll one day and cold as h*ll another?

When a house burns up, it burns down. You fill in a form by filling it out and an alarm clock goes off by going on.

When the stars are out, they are visible, but when the lights are out, they are invisible. And why, when I wind up my watch, I start it, but when I wind up this essay, I end it?

Now I know why I flunked my English. It's not my fault -- the silly language doesn't quite know whether it's coming or going.

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You Wouldn't Believe These on Amazing Stories

- Police in Wichita, Kansas, arrested a 22-year-old man at an airport hotel after he tried to pass two (counterfeit) $16 bills.
- A man in Johannesberg, South Africa, shot his 49-year-old friend in the face, seriously wounding him, while the two practiced shooting beer cans off each other's head.
- A company trying to continue its five-year perfect safety record showed its workers a film aimed at encouraging the use of safety goggles on the job. According to Industrial Machinery News, the film's depiction of gory industrial accidents was so graphic that twenty-five workers suffered minor injuries in their rush to leave the screening room. Thirteen others fainted, and one man required seven stitches after he cut his head

falling off a chair while watching the film.

- The Chico, California, City Council enacted a ban on nuclear weapons, setting a $500 fine for anyone detonating one within city limits.
- A bus carrying five passengers was hit by a car in St. Louis, but by the time police arrived on the scene, fourteen pedestrians had boarded the bus and had begun to complain of whiplash injuries and back pain.
- Swedish business consultant Ulf af Trolle labored 13 years on a book about Swedish economic solutions. He took the 250-page manuscript to be copied, only to have it reduced to 50,000 strips of paper in seconds when a worker confused the copier with the shredder.
- A convict broke out of jail in Washington D.C., then a few days later accompanied his girl friend to her trial for robbery. At lunch, he went out for a sandwich. She needed to see him, and thus had him paged. Police officers recognized his name and arrested him as he returned to the courthouse in a car he had stolen over the lunch hour.
- Police in Radnor, Pennsylvania, interrogated a suspect by placing a metal colander on his head and connecting it with wires to a photocopy machine. The message "He's lying." was placed in the copier, and police pressed the copy button each time they thought the suspect wasn't telling the truth. Believing the "Lie Detector" was working, the suspect confessed.
- When two service station attendants in Ionia, Michigan, refused to hand over the cash to an intoxicated robber, the man threatened to call the police. They still refused, so the robber called the police and was arrested.
- A Los Angeles man who later said he was "tired of walking," stole a steamroller and led police on a 5 mph chase until an officer stepped aboard and brought the vehicle to a stop.

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Some 'Facts' About Electricity

(From: Jussi Kaasinen (Jussi.Kaasinen@hut.fi).)

Read this but be careful: you might not get any sleep tonight because of these shocking facts...

Perhaps the greatest Electrical Pioneer of them all was Thomas Edison, who was a brilliant inventor despite the fact that he had little formal education and lived in New Jersey. Edison's first major invention in 1877, was the phonograph, which could soon be found in thousands of American homes, where it basically sat until 1923, when the record was invented. But Edison's greatest achievement came in 1879, when he invented the electric company. Edison's design was a brilliant adaptation of the simple electrical circuit: the electric company sends electricity through a wire to a customer, then immediately gets the electricity back through another wire, then (this is the brilliant part) sends it right back to the customer again.

This means that an electric company can sell a customer the same batch of electricity thousands of times a day and never get caught, since very few customers take the time to examine their electricity closely. In fact the last year any new electricity was generated in the United States was 1937; the electric companies have been merely re-selling it ever since, which is why they have so much free time to apply for rate increases.

-- Dave Barry, "What is Electricity?"

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Funny Ways to Get Rid of Telemarketers

(Most from: SLEEZY (sleezy@usa.net).)

I look forward to telemarketers because I have great fun at their expense:

1. Act hard of hearing and make them repeat things.

2. When asked a questions, answer another one (Them: "Sir, would you be interested in buying our crap?" Me: "Why yes, I would like ice cream.").

3. Act extremely stupid and ask off the wall questions ("So... How long does distance have to be before it's considered long distance?").

4. I hand off the phone to my 13 month old.

5. Start off talking to them but at some point quit talking. After they ask if your still there and seem like they're going to hang up, start talking and get them going again. Repeat as necessary.

6. Act REALLY excited. (WHAT? I'm preapproved for my OWN CREDIT LINE? Off PHone: Oh honey, come quick!!! This nice man says I have excellent credit. OH HAPPY DAY!!!!!) This gets some really strange reactions.

7. Let them go through their entire pitch then at the end say: "Oh, I'm sorry, I thought you were someone else.".

8. Let them go through their entire pitch, then at the end say: "Did you know you have spinach in your teeth?".

9. Sound like a psycho-killer.

10. Tell them you have a bad connection but really are interested. Then speak VERY loudly.

11. Say "I'm sorry, you caught me right in the middle of (favorite sexual act here).

12. If it's a person of the opposite sex, start hitting on them.

13. Every once in a while, bark.

14. Start arguing with yourself.

(The following one suggested by: Courtney Eckhardt (cme@mit.edu).)

15. Wait for an opportune moment and say something like: "I'm sorry, I'm really very interested in whatever you are selling, but you see, I just declared personal bankruptcy.....".

So use your imagination. Add to this list.

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The Farmhouse (A Lawyer Joke)

(From: Jim Lagerkvist (jlager@tir.com).)

A rabbi, a hindu, and a lawyer are in a car. they run out of gas, and are forced to stop at a farmers house. The farmer says that there are only 2 extra beds, and one person will have to sleep in the barn. The hindu says, "I'm humble, I will sleep in the barn," so he goes out to the barn. In a few minutes, the farmer hears a knock on the door. It's the hindu and he says, "There is a cow in the barn. It's against my beliefs to sleep with a cow." So the rabbi says, "I'm humble, I will sleep in the barn." A few minutes later, the farmer hears another knock on the door and its' the rabbi. He says that it is against his beliefs to sleep where there is a pig and there is a pig in the barn. So the lawyer is forced to sleep in the barn.

A few minutes later, there is a knock on the door. It's the pig and the cow.

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The Parrot

(From: Dave A. Wreski (dawreski@nic.com).)

A magician was working on a cruise ship in the Caribbean. The audience would be different each week, so the magician allowed himself to do the same tricks over and over again.

There was only one problem: The captain's parrot saw the shows each week and began to understand how the magician did every trick. Once he understood he started shouting in the middle of the show:

"Look, it's not the same hat"

"Look, he is hiding the flowers under the table"

"Hey, why are all the cards the Ace of Spades?"

The magician was furious but couldn't do anything; it was, after all, the captain's parrot.

One day the ship had an accident and sank. The magician found himself on a piece of wood in the middle of the ocean with the parrot, of course.

They stared at each other with hate, but did not utter a word. This went on for a day and another and another.

After a week the parrot said: "OK, I give up. Where's the boat?"

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How High Do You Jump (Discharging a TV)?

(From: Bert Christensen).

A tech that worked for me many years ago was holding on to a chassis and leaning forward to see something on the other side. He was always rather careless and had hooked up the HV lead in a sloppy >manner. His forehead came in contact with the 30kv. He jumped up into the air, turned around twice, said, "I almost f___ING lled myself, >walked out into the customer waiting area and cried. Ten minutes later he was in working on the same set.

We later drew a scale on a leg of the bench. One inch represented how high you jumped with 1 kV and 25 inches for 25 kV, etc. It was remarkably accurate.

(From: Vic Tosca (tosca@warwick.net).)

That's a KICKER!! I've got the same thing here, but I have it scaled to .808 in/kV. I found that's the accurate formula for the average weight bench tech, including glasses and pocket protector. We also put a bell on the ceiling- anyone that hits it with his head because of a shock gets a day off!

It's located right under the emergency repair tool kit, which consists of a rabbit's foot, a magic wand, a crystal ball, and a hammer. We had to get rid of the hand grenade...insurance laws, y'know. THAT was a *great* tool for tough dogs and irate customers!

Clients love it.

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New and Improved Hell

(From: Dave A. Wreski (dawreski@nic.com).)

Author unknown:

An engineer dies and reports to the pearly gates. St. Peter checks his dossier and says, "Ah, you're an engineer -- you're in the wrong place."

So the engineer reports to the gates of hell and is let in. Pretty soon, the engineer gets dissatisfied with the level of comfort in hell, and starts designing and building improvements. After a while, they've got air conditioning and flush toilets and escalators, and the engineer is a pretty popular guy.

One day God calls Satan on the telephone and says with a sneer, "So, how's it going down there in hell?"

Satan replies, "Hey, things are going great. We've got air conditioning and flush toilets and escalators, and there's no telling what this engineer is going to come up with next."

God replies, "What??? You've got an engineer? That's a mistake - he should never have gotten down there; send him up here."

Satan says, "No way. I like having an engineer on the staff, and I'm keeping him."

God says, "Send him back up here or I will sue."

Satan laughs uproariously and answers, "Yeah, right. And just where are YOU going to get a lawyer?"

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Don't Lose Those Unpacking Instructions!

A SCSI drive shipped from Bubba's in Louisiana with THIS article in the packaging. No kidding!!!

ACTUAL UNPACKING INSTRUCTIONS

IMPORTANT! READ THIS BEFORE USING YOUR NEW DEVICE!

Congratulations! You have purchased an extremely fine device that would give you thousands of years of trouble-free service, except that you undoubtedly will destroy it via some typical bonehead consumer maneuver.

Which is why we ask you to:

PLEASE, FOR GOD'S SAKE, READ THIS OWNERS MANUAL CAREFULLY BEFORE YOU UNPACK THE DEVICE. YOU ALREADY UNPACKED IT, DIDN'T YOU? YOU UNPACKED IT AND PLUGGED IT IN AND TURNED IT ON AND FIDDLED WITH THE CONTROLS, AND NOW YOUR CHILD, THE SAME CHILD WHO ONCE SHOVED A POLISH SAUSAGE INTO YOUR VIDEOCASSETTE RECORDER AND SET IT ON "FAST FORWARD", THIS CHILD IS ALSO FIDDLING WITH THE CONTROLS, RIGHT? WE MIGHT AS WELL JUST BREAK THESE DEVICES RIGHT AT THE FACTORY BEFORE WE SHIP THEM OUT, YOU KNOW THAT?!?

We're sorry. We just get a little crazy sometimes because we're always getting back "defective" merchandise where it turns out that the consumer inadvertently bathed the device in acid for six days. So, in writing these instructions, we naturally tend to assume that your skull is filled with dead insects, but we mean nothing by it. OK? Now let's talk about:

1. UNPACKING THE DEVICE

The device is encased in foam to protect it from the Shipping People, who like nothing more than to jab spears into outgoing boxes.

PLEASE INSPECT THE CONTENTS CAREFULLY FOR GASHES OR IDA MAE BARKER'S ENGAGEMENT RING, WHICH SHE LOST LAST WEEK, AND SHE THINKS MAYBE IT WAS LOST WHILE SHE WAS PACKING DEVICES.

Ida Mae really wants that ring back, because it is her only proof of engagement, and her fiancee, Stuart, is now seriously considering backing out on the whole thing, in as much as he had consumed most of a bottle of Jim Beam in Quality Control when he decided to pop the question. It is not without irony that Ida Mae's last name is "Barker", if you catch our drift. WARNING: DO NOT EVER, AS LONG AS YOU LIVE, THROW AWAY THE BOX OR ANY OF THE PIECES OF STYROFOAM, EVEN THE LITTLE ONES SHAPED LIKE PEANUTS.

If you attempt to return the device to the store, and you are missing one single peanut, the store personnel will laugh in the chilling manner exhibited by Joseph Stalin just after he enslaved Eastern Europe.

Besides the device, the box should contain:

- Eight little rectangular snippets of paper that say "WARNING".
- A little plastic packet containing four 5/17 inch pilfer grommets and two club-ended 6/93 inch boxcar prawns.

YOU WILL NEED TO SUPPLY: a matrix wrench and 60,000 feet of tram cable.

IF ANYTHING IS DAMAGED OR MISSING: YOU IMMEDIATELY should turn to your spouse and say "Margaret, you know why this country can't make a car that can get all the way through the drive-through at Burger King without a major transmission overhaul? Because nobody cares, that's why."

WARNING: This is assuming your spouse's name is Margaret. And not Pete.

2. PLUGGING IN THE DEVICE

The plug on this device represents the latest thinking of the electrical industry's Plug Mutation Group, which, in a continuing effort to prevent consumers from causing hazardous electrical current to flow through their appliances, developed the Three-Pronged Plug, then the Plug Where One Prong Is Bigger Than The Other. Your device is equipped with the revolutionary new Plug Whose Prongs Consist Of Six Small Religious Figurines Made Of Chocolate.

DO NOT TRY TO PLUG IT IN!

Lay it gently on the floor near an outlet, out of direct sunlight, and water it weekly with a damp handkerchief.

WARNING: WHEN YOU ARE LAYING THE PLUG ON THE FLOOR, DO NOT HOLD A SHARP OBJECT IN YOUR OTHER HAND AND TRIP OVER THE CORD AND POKE YOUR EYE OUT, AS THIS COULD VOID THE WARRANTY.

3. OPERATION OF THE DEVICE

WARNING: WE MANUFACTURE ONLY THE ATTRACTIVE DESIGNER CASE. THE ACTUAL WORKING CENTRAL PARTS OF THE DEVICE ARE MANUFACTURED IN JAPAN. THE INSTRUCTIONS WERE TRANSLATED BY MRS. SHIRLEY PELTWATER OF ACCOUNTS RECEIVABLE, WHO HAS NEVER ACTUALLY BEEN TO JAPAN BUT DOES HAVE MOST OF "SHOGUN" ON TAPE.

INSTRUCTIONS: For results that can be the finest, it is our advising that: NEVER to hold these buttons two times!! Except the battery. Next taking the (something) earth section may cause a large occurrance! However. If this is not a trouble, such rotation is a very maintenance action, as a kindly (something) virepoint from Drawing B.

4. WARRANTY

Be it hereby known that this device, together with but not excluding all those certain parts thereunto, shall be warranted against all defects, failures and malfunctions as shall occur between now and Thursday afternoon, shortly before 2, during which time the Manufacturer will, at no charge to the Owner, send the device to our Service People, who will emerge from their caves and engage in rituals designed to cleanse it of evil spirits. This warranty does not cover the attractive designer case.

WARNING: IT MAY BE A VIOLATION OF SOME LAW THAT MRS. SHIRLEY PELTWATER HAS "SHOGUN" ON TAPE.

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An Engineer in Paradise

(From Glenn E Wilkop (Glenn_E_Wilkop@email.whirlpool.com).)

This one comes from our beloved Mr. Tibbs... Enjoy!

A rather inhibited engineer finally splurged on a luxury cruise to the Caribbean. It was the "craziest" thing he had ever done in his life. Just as he was beginning to enjoy himself, a hurricane roared on the huge ship, capsizing it like a child's toy. Somehow the engineer, desperately hanging on to a life preserver, managed to wash ashore on a secluded island. Outside of beautiful scenery, a spring-fed pool, bananas and coconuts, there was little else. He lost all hope and for hours on end, sat under the same palm tree.

One day, after several months had passed, a gorgeous woman in a small rowboat appeared. "I'm from the other side of the island," she said. "Were you on the cruise ship, too?" "Yes, I was", he answered, "But where did you get that rowboat?" "Well, I whittled the oars from gum tree branches, wove the reinforced gunnel from palm branches, and made the keel and stern from a Eucalyptus tree." "But what did you use for tools?" asked the man. "There was an unusual strata of alluvial rock exposed on the south side of the island. I discovered that if I fired it to a particular temperature in my kiln, it melted into forgeable ductile iron. Anyhow, that's how I got the tools. But enough of that," she said, "where have you been living all this time? I don't see any shelter." "To be honest, I have just been sleeping on the beach," he said. "Would you like to come to my place?" the woman asked. The engineer nodded dumbly.

She expertly rowed them around to her side of the island, and tied up the boat with a handsome strand of hand-woven hemp topped with a neat back splice. They walked up a winding stone walk she had laid around a palm tree. There stood an exquisite bungalow painted in blue and white. "It's not much but I call it home."Inside she said, "sit down, please. Would you like to have a drink?" "No, thanks," said the man. "One more coconut juice and I will throw up."

"It won't be coconut juice," the woman replied. I have a crude still out back so we can have authentic Pina Coladas." Trying to hid his amazement, the man accepted the drink and they sat down on her couch to talk. After they had exchanged stories, the woman asked, "Tell me, have you always had a beard?" "No," the man replied. " I was clean shaven all my life till I ended up on this island." "Well, if you'd like to shave, there's a razor upstairs in the bathroom." The man, no longer questioning anything, went upstairs to the bathroom and shaved with an intricate bone-and-shell device that was honed razor sharp. Next he showered, not even attempting to guess how she managed to get warm water into the bathroom. Then he went back downstairs. "You look great," said the woman. "I think I will go up and slip into something more comfortable." As she did, the man continued to sip his Pina Colada. After a short time, the woman, smelling of gardenias. returned revealing a gown fashioned out of pounded palm fronds. "Tell me," she asked, "We've both been out here for a very long time with no companionship. You know what I mean. Have you been lonely...is there anything you really miss? Something that all men and women need? Something that would be really nice right now?" "Yes there is!" the man replied, shucking off his shyness. "There is something I've wanted to do for so long but on this island it was well...impossible." "Well, it is not impossible any more" the woman said. The man, practically panting in excitement, said breathlessly, "You mean you actually figured out some way we can check our e-mail here?"

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Hot Water and Ice Makers

(From: Chris Hagwood (hagwood@pobox.com).)

My neighbor just bought a new fridge. He said he was gonna put in an icemaker line, so I stopped by to see how he was getting along. He said he was almost done, but had some trouble early on:

He had called his cousin, who told him to tap into the HOT water line, since "hot water freezes faster--that's a fact" he tells me. So I bit my tongue and waited for him to finish telling me what went wrong. "Did it melt the plastic line?", I thought. No, it seems that he forgot that the same water that was going into his icemaker was going to the "cold water through the door". He would get one glass of cold water, then a glass of HOT! So he had to redo everything on a cold line.

Geez Louis! What people will believe.... "hot water freezes faster"! Insane.

Editor's note: The "Hot water freezes faster" thread, like "NiCds and the memory effect" and "PCs versus Macs" threads are typically never ending. There are simply too many variables to consider in an Internet discussion.

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Horsepower Ratings and AC Line Magnets

"How can an electric motor generate 5HP from a 120VAC, 15A wall outlet that puts out only 2.4 HP?"

(From: John M. Feiereisen (feierejm@utrc.utc.com).)

Maybe they were using Ecoblow(tm) power line magnets. Ordinary electricity molecules clump up and do not efficiently energize electrical equipment. The powerful magnetic field of the Ecoblow breaks up these clumps and aligns the electricity molecules through a process known as gullibility-induced victimization, thereby resulting in more efficient scam - oops - operation.

Using an Ecoblow, you can squeeze almost 35 HP out of an ordinary 120 V, 15 A circuit!

A local bakery installed an Ecoblow 3 on the power cord to their industrial size mixer. Heck, the thing spins so fast now, they don't even have use the oven to bake their bread. (Good thing, too, since they burn their bread with it ever since they installed the Ecoflow(tm) gas line magnet.)

I've got an Ecoblow 3 on the power cord to my 128K Mac and now it's about twice as fast as a Sun Ultra 2! An amazing side effect is that I'm now able run codes in 128KB of memory when they used to take a minimum of 64 MB!

I'm currently in the process of coupling an electric motor to an electrical generator. An Ecoblow 3 on the output of the generator will allow me to power the electric motor *and* produce enough electricity to power my house!

Ecoblow - buy one now, because somebody's got to take your money.

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All About AC Batteries

From a sci.electronics.misc (or related) newsgroup posting:

"This AC Battery thing is all conspiracy - a US Government cover-up. However, now we have the "Net" and soon the truth will be out about Elvis, Roswell, lost socks and AC 9V batteries."

(From: Bob Myers (myers@fc.hp.com).)

Sigh.

I can't believe what a young, gullible crowd we have here. You guys will swallow ANYTHING.

Any true Old Hand at electronics would know that the AC output from 9V batteries is simply a holdover from the days of portable tube radios. The AC was used to run the filaments, and also served to drive the DC-to-DC converter that was used to obtain the 100-200V of plate voltage from the 9V DC output. (Yes, they tried the obvious route of simply making 200 VDC batteries - still with the necessary AC output, mind you! - but some tragic accidents at a few K-marts (which were ultimately traced to a simple packaging defect) ended THAT standard really quickly, let me tell you.

Today, of course, it's rare to find a product which actually makes USE of the AC output from these batteries, with the exception of some earlier portable CD players which derived the base for the multiple-phase oversampling input oscillation-compensation stage backup clock from it. (And boy, weren't THOSE designs fun, huh?) But once a standard is established, it's hard to get rid of it. Especially with all those production lines already tooled up. Sure, they might save a little in not having to add the cavorite in at the anode insertion process, but it's NOT worth completely rebuilding the line, trust me.

Sure glad I could clear that up for you.

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CDs in the Microwave

In response to the following exchange:

"Yes, my microwave-damaged CD's are difficult to repair too. :)"

"What are micro wave damaged CD's?"

(From: DaViD Boulet/Don Harley (dharley@bellatlantic.net).)

The trick is to use a very high-quality line-conditioner for the microwave. I try to microwave my CD's late at night when the electricity is "cleanest" to get the best results. Also, I've found that the newer microwaves with LED time-displays seem to add some euphonic properties to the sound...more relaxed treble, smoother string sound and more liquid midrange. What would be great is if I could get a microwave oven with a detachable power cord so I could use a good-quality MIT power cable. Now *that* would be neat.

I'm hoping that some audiophile company picks up on this and gives a tube-based microwave. Too bad Audio Alchemy went out of business. I heard that they had plans to release an audiophile-designed (tube?) microwave oven before they went under. Any ideas if Camelot might pick up on this? The important thing is that they keep the price under the $1000 to make it affordable to the "normal" starving audiophile.

"Ahh, have you tried STEREO m'waves yet? You have to buy 2 CDs, but the sound is well worth it. Make sure that both microwaves are the same brand so that you can use just 1 remote..."

(From: DaViD Boulet/Don Harley (dharley@bellatlantic.net).)

I like your suggestion except for one thing...I don't believe that remotes should be part of a high-end microwave set-up. In my opinion...one should get up to change the minutes/defrost setting. My experience has shown that, in general, companies who offer remotes with their microwaves seem to compromise in sound-quality. Then again, this effect is not resultant from the remote itself. It just seems to stem from a "philosophy" of consumer-gadgetry that many "receiver" style microwave ovens reflect. My favorite (and best sounding) microwave is plain black...with a simple "on-off" switch and no tone controls.

(From: Pat Crean (pat@crean.com).)

Mine sounded FANTASTIC until the turntable stopped - I'm going to make sure my next microwave has a built-in carousel for uninterrupted listening pleasure!

(From: Ian Stirling 000033C19ADC.NO_UCE@mauve.demon.co.uk).)

Hmm, anyone thought about making a plasma speaker, using a modulated microwave?

(From: Armand (mondo@voicenet.com).)

I tried shaking my MV rapidly and nothing happened-- although my macaroni and cheese did resemble plasma. ;}

(From: Dave).

I doubt that with the grade of microwave-wire you're using...you'd possibly be able to hear the improvement. Why invest hundreds of dollars in a high-end microwave set-up (including disc treatments like the marinating solvent...which I heard at my friend's house and it *really* makes a noticeable difference...especially in the bass--much more dynamic and full) only to shove that signal through a cheap pair of interconnects? IMO, you should have *just* as much money invested in your microwave cables as you spend on the rest of microwave-system.

(From: Derrick Hopkins (dhopkins@infi.net).)

Oh please. If you're going to go with Microwaved CD's(instead of the vastly superior Oven cooked LP's) it doesn't really matter kind of interconnect you use. A micro waved atom is a microwaved atom..period. Even if it's garbled a little, the average person can hear a difference.

When you get past all of the audiophile/gourmet snobbery, you'll realize that a $99 Walmart microwave sounds just as good as a $7000 McIntosh microwave.

Consumer Reports did a huge feature on this back in March '92. A Kmart microwave placed ahead of Carver, Sony, Westinghouse, and Adcom. The only model to beat it was Denon and that's only because it was THX/Redenbokker certified.

(From: DaViD Boulet/Don Harley (dharley@bellatlantic.net).)

First of all...we *all* know that when consumer reports rates microwaves...sound quality is the last thing on their mind. If I recall, they didn't even feel that gold-plated-audiophile microwaves offered any sonic improvement! Consumer reports is only interested in specs and features...

Secondly, your assertion that a 10 year old conventional oven-baked LP can sound *better* than a microwaved CD won't be true much longer. Once we get the next-generation of DVD-based Microwaves with 24-beep/96-calories and multi-panel sound, the debate between analog-ovens and digital microwaves will be over once and for all.

(From: Guillermo Gonzalez (gonzalez@netrox.net).)

Yeah, but my problem remains, that the copper sulfate used in the green marker that I use on my CD's, well, it causes some serious arcing in the microwave...

Alas, what is an audiophile to do?

(From: L. E. Sixma (lesixma@introweb.nl).)

Reheat the lot in a gas-oven for 24 hours at a temperature of 215 degrees Centigrade could do the trick. This is a classic analogue trick. Still you got to be shure that the cookies are taken out in time or else they will be sounding awful. Cassette-spaghetti takes less cooking time and in this case 100 degrees will do for audiophile ear-food.

(From: Nicholas Bodley (nbodley@tiac.net).)

Just a tad off color, but curious. Reminds me of the apparently true story about the red-tailed hawks that would periodically let out a long stream above high-voltage transmission lines and cause arcs that tripped circuit breakers and shut down the lines. This was a significant problem for a while, until they found out how to make the hawks move elsewhere (I've forgotten how they did it). Apparently, the hawks weren't hurt...

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The Barking Dog

(From: Jack Kraft (jackjk@iwaynet.net).)

It is common practice in England to ring a telephone by signaling extra voltage across one side of the two wire circuit and ground (earth in England). When the subscriber answers the phone, it switches to the two wire circuit for conversation. This method allows two parties on the same line to be signaled without disturbing each other.

Anyway, an elderly lady with several pets called to say that her telephone failed to ring when her friends called and on the few occasions when it did ring her dog always barked first just before the ring. Pat proceeded to the scene, curious to see this psychic dog.

He climbed the nearby pole, hooked his test set to the lady's line, and dialed the number. The phone didn't ring. He tried again. The dog barked loudly, followed by a ringing telephone. Climbing down the pole the amazed Pat found:

1. The dog was tied to the telephone systems ground post via a metal chain and collar.
2. The dog was receiving 90 volts of signaling current.
3. After several such jolts, the dog would start barking and urinating on the ground.
4. The wet ground now completed the circuit and the phone would ring.

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On the Effects of Magnetic Water Softeners

(From: several authors, unknown, for obvious reasons).

> "Testing magnetic softeners can be very dangerous. Should you accidentally over-magnetize the water and unknowingly drink the same, your stomach could burst if you come too near a large ferrous object."
>
> "This happened to a friend of mine. With the philosophy "if one is good, two is better", he put two magnetic water softeners on the same line. Being warm from doing the job, he took a large drink, than

walked by a steel support post in his basement. He was in the hospital for over a month while they did reconstructive surgery on his guts...

Oddly enough, until the magnets were removed, all his faucets constantly oriented themselves toward the north. It was spooky..."

"This really explains a lot for me!

I installed one of these when we first moved into our house 4 years ago. Ever since then we wake up each morning facing north for no apparent reason. If my wife and I sleep facing the same direction (head to toe) we wake up on opposite sides of the bed. If we sleep in opposite directions we wake up clinging to each other in the middle of the bed. Our dishes and clothes always manage to align with north after several days in the drawers too. My 10 month old daughter just started to crawl and she only crawls towards north. We have shale in the ground here and a well. Shale contains lots of iron. We must be magnetizing the iron molecules in the water. The grass that I water always seems to bend north no matter which way I mow. Several floppy disks and video tapes which I stored near an humidifier were mysteriously erased. I seem to bump into large steel objects a lot. Some times I have a hard time getting out of the car, and I never seem to be able to get a compass to work correctly."

In response to the question: "Why are magnetic water softeners so expensive":

"That's probably because you're pricing it as though they were ORDINARY magnets, which of course are fairly inexpensive. But, as anyone will tell you, ordinary magnets do not have any water-conditioning capabilities.

I believe the magnets used in these water conditioners are quantum-mechanic super-heterodyne field effect tachyon-modulated (QMSHFETM) magnets, which of course are more expensive. The manufacturer uses a proprietary process which converts ordinary magnets into the QMSHFETM type, and the process ain't cheap. (This same process, I believe, is what is used to make the 'blue water' that goes into those Laundry CD's and other devices which replace laundry detergent. Hence, these devices are also much more expensive than one would expect for a piece of plastic filled with blue dye.)"

"Of course the price is higher than the materials; the question is, what are the potential benefits worth to you?

After we started using it, our water became so soft we have to add salt to it to get the soap off our skin; my polyps shrank; and my children started getting better grades at school. If Monsieur Henri Paul had passed his wine through a magnetic conditioner, all this would never have happened. So anyway, I recommend it highly at any price.

In addition, I have been watering my flowers with the magnetized water. You've never seen such roses...they're the size of satellite dishes. (I mean those new DSS ones, not the old large ones. Maybe if I planted old roses...) Curiously, the roses all point north. I guess that's because they're magnetized. This makes them useless as satellite dishes, because the geosynchronous satellites are all in the southern sky."

"Yeah, but have you tried putting the conditioned water on dollar bills? Several weeks after getting mine, I left a couple of one dollar bills in my pants in the wash. Boy was I surprised when I took the pants out of the dryer to find two *TEN* dollar bills in the pocket.

> Since then, I've laundered over 70 one dollar bills, netting me a $630 profit, which was almost enough to pay for the magnet. I'm seriously saving up for another one, figuring my dryer will then spit out $100 bills, saving me lots of time!"

(From: Andy Wing).

A magnetic water softener limerick:

> "The MWT pundits won't yield
> Despite no 'hard' evidence to wield
> , of course
> will flog the dead horse
> And insists that it works in the field!

Sorry folks, couldn't resist, puns intended. :-)

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Suggestions for Repairing Scratched CDs

(From: Christopher Bedwell (Bedwell@southwest.com.au).)

Try connecting the laser on your CD player to a flux capacitor. That should generate the 1.21 Giga Watts needed to repair the proton electrical photon surface. Hopefully with enought plutonium you can glow in the dark too!!!

Or you could just rub it in a MacDonalds burger! that certainly has enough chemical content residue to melt and re-bond anything.

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Warnings about Sucking up Radio Waves

(From: Pat Crean (pat@crean.com).)

You have to be very careful when using devices with good sensitivity.

Remember, the transmitters are pumping a certain amount of power into the VHF/UHF bands with the expectation that there are receiving devices available to absorb it. If too many people use highly sensitive receivers, the excess energy not being absorbed will accumulate until we have an explosion in the affected band that will rival Krakatoa in its effects.

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Engineers versus Business Executives

(From: Marcio Domene (mdomene@unisys.com.br).)

Engineers and scientists will never make as much money as business executives.

Now a rigorous mathematical proof that explains why this is true:

- Postulate 1: KNOWLEDGE is POWER
- Postulate 2: TIME is MONEY

```
As every engineer knows:      WORK
                            --------- = POWER
                              TIME

Since KNOWLEDGE = POWER, and TIME = MONEY, we have:   WORK
                                                    --------- = KNOWLEDGE
                                                      MONEY

Solving for money, we get:        WORK
                              ------------- = MONEY
                                KNOWLEDGE
```

Thus, as KNOWLEDGE approaches zero, MONEY approaches infinity, regardless of the WORK done!

Conclusions: The less you know, the more money you Make.

Note: It has been speculated that the reason why Bill Gates dropped out of Havard's math program was because he stumbled upon this proof as an undergraduated, and dedicated the rest of his carrer to the pursuit of ignorance.

(From: John Woodgate (jmw@jmwa.demon.co.uk).)

But there is a third postulate, at least equally well-known as those:

- Postulate 3: MONEY is POWER

But WORK/TIME = MONEY only if you are paid by the hour: monthly staff do not get overtime pay.

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Keeping Electricity Working

(From: Dave VanHorn" (uce@ftc.gov).)

Warning: Do not read while drinking!

This is even funnier if you follow Alt.religion.scientology, but all by itself, it's a hoot.

HUMOR - KEEPING ELECTRICITY WORKING

The loyalist officers in 4th dimensional hiding captured the following post from the alt.religion.electricity newsgroup in an alternate universe. Any resemblance to Earth people living or dead is purely accidental and is due to God playing dice with the various universes.

-- The Pilot

KEEPING ELECTRICITY WORKING - A 21st Century Retrospective

By David MissCambridge, Keeper of the Current

Issue authority granted by the first Church of Edison

As KofC of the CofE, it is with humble pride and pleasure that I announce the upcoming hundredth anniversary of one of our most basic policies, Keeping Electricity Working, issued by our glorious founder on Jan 17, 1898.

It is this policy above all others which has preserved the technology of electricity for us and future generations.

It was here that TOM first identified the evil world conspiracy of financiers, plagiarists, and space aliens that was attempting to pervert his discoveries and deny electricity to mankind.

Consider, for example, the evil Tesla who proposed that the divine current should ALTERNATE! A stupid and ridiculous idea. How would it achieve any useful work if the current simply zig zagged back and forth in the wires? He would have undermined the entire structure of DIRECT CURRENT which moves DIRECTLY to its target and achieves LIGHTNING FAST 100 PERCENT STANDARD RESULTS.

But TAE, by virtue of his superior genius, saw that it wasn't just the yappings of Tesla and Westinghouse, for the same attacks and unworkable ideas were showing up all over the world.

Of course we know that the characteristics of a suppressive person would be to deny the truth of the CofE and seek to deny it financing by undercutting its prices. But it was only TAE himself who could spot the true source of all these SPs, the true suppressive influence behind them.

We now know that it was the Venusians, led by their evil telepathic ruler, XeMoonie, who inspired these diabolical attacks. But by means of our tin foil protective hats and an enlightened legal system, we have driven his influences off of Earth and will keep mankind free of his dreadful doings.

Now remember the key points,

1. Stamp out any experimentation or variation of our workable tech.

2. Buy a fresh foil hat from your local CofE every year

3. Report any squirrel wire twisters to the police immediately.

Remember that only certified CofE graduates may work on anything connected with electricity. We know that the courses are expensive, but the results are proven.

For Electricity is dangerous and anyone who applys squirrel practices to twist wires on their own could be electrocuted or have their house burned down. Your entire neighborhood is at risk if you ignore them. Keeping our homes safe is everybody's job.

And we have a wonderful new TECH BREAKTHROUGH to announce.

By careful study of TAE's research notes, we have discovered that the size of the wire might be increased to carry more current.

Our new double sized copper conductors will be available next year at only $100 dollars a yard. Not only will this bring about obvious savings, but it will allow the average apartment house to support more lighting fixtures.

With this breakthrough, we think that it will even be possible to place lights in stairwells. Just imagine it, your iceman will no longer have to stumble around in the dark with a heavy and potentially dangerous cube of ice for your icebox.

We are working now on a project to carve TAE's writings onto iron plates and bury these in secret vaults all over the world. This will ensure that future civilizations will benefit from his wisdom and knowledge. Send your contributions in now.

Building a better future,

-- Davy

(End of interdimensionally captured transmission)

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Transistors, Anyone?

I don't think the following questions are quite addressed but anyhow....

"Would you please tell me what transistors do and how they do so? What is the difference between PNP and NPN transistors? What is the concept of using a transistor as a switch? Thanks a lot."

(From: Gareth Alun Evans (gareth@cemetery.demon.co.uk).)

A transistor is rather like the human alimentary canal, after the typical USA diet of burgers and chips; - it constipates, as do semiconductor diodes with no appled bias - the available holes get filled in and nothing can move.

The base current is like a small application of laxative; some of the constipation passes through, until the effect of the laxative wears off. The total throughput depends upon the Mobility. By applying a continuous feed of laxative, then a continuous current passes through. Applying too much laxative results in saturation - i.e., there is a limit to the maximum throughput, depending on the external circuit; in this case, the maximum rate at which you can feed in the burgers at one end. (If you are a customer of MacDonalds, here in Chippenham, Wiltshire, UK then this rate is very low - I have been there twice, and both times, the service was *APPALLING*.)

The difference between PNP and NPN is the direction. In the old days, PNP was used, whereby one injected from the rear end, using a sort of huge syringe - hence PNP - "Put-in Near Poo". More recently NPN is more common, where the laxative is entered via a carrier of some sort, usually chocolate and so we have NPN - "Now Pleasant Nutrient".

Despite the adverse effects, the USA diet of burgers and chips carries on, and recourse has to be made once again to the chocolate. Now the ratio of the carriers of the constipation, the burgers and chips, is much higher than that of the chocolate. Thus they are referred to as the Majority Carriers and the Minority Carriers. If you indulge too much, you find that the vendor will provide you with a paper bag, known as an Excess Carrier.

More recently, there are problems with impurities and you find that the opposite effect occurs. You have no time to reach home before diarrhea takes over. You have no option but to stop the car and nip over a gate into a field. Hence the Field Effect Transistor. This time you have to inject something to STOP the flow. Now, assuming that there was a certain control over events; nothing happened until the Gate was encountered, you then became the Source of flow, and the field itself acted as the Drain. What was originally dirt, became grass, was consumed by the Cow, you ate it as a burger, and it has now returned to the topsoil, an effect known in the trade as Surface Recombination. (Incidentally, did you know that Diarrhea is hereditary? Apparently it runs in the jeans.)

Some of the impurities accumulate in your rear end, and no matter how valiantly you try, you cannot rid yourself of them. Hence In-de-Bum is known as a Try-Valiant Impurity. In the same way, Arsenic, well known for its ill-effects and accumulation in the body tissues is known as a Pent-Up-Valiant Impurity.

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Bill Gates' New House

(Forwarded by: Bob Parker (bobpar@ozemail.com.au).)

While the Gateses are moving in from their temporary quarters nearby, final construction of their new house is not expected to be completed until the end of the year. Now if I were a contractor with a sense of humor...

Bill: "There are a few issues we need to discuss."

Contractor: "Ah, you have our basic support option. Calls are free for the first 90 days and $75 a call thereafter. Okay?"

Bill: "Uh, yeah... the first issue is the living room. We think it's a little smaller than we anticipated."

Contractor: "Yeah. Some compromises were made to have it out by the release date."

Bill: "We won't be able to fit all our furniture in there."

Contractor: "Well, you have two options. You can purchase a new, larger living room; or you can use a Stacker."

Bill: "Stacker?"

Contractor: "Yeah, it allows you to fit twice as much furniture into the room. By stacking it, of course, you put the entertainment center on the couch... the chairs on the table... etc. You leave an empty spot, so when you want to use some furniture you can unstack what you need and then put it back when you're done."

Bill: "Uh... I dunno... issue two. The second issue is the light fixtures. The bulbs we brought with us from our old home won't fit. The threads run the wrong way."

Contractor: "Oh! Thats easy. Those bulbs aren't plug and play. You'll have to upgrade to the new bulbs."

Bill: "And the electrical outlets? The holes are round, not rectangular. How do I fix that?"

Contractor: "Just uninstall and reinstall the electrical system."

Bill: "You're kidding!?"

Contractor: "Nope. Its the only way."

Bill: " Well... I have one last problem. Sometimes, when I have guests over, someone will flush the toilet and it won't stop. The water pressure drops so low that the showers don't work."

Contractor: "That's a resource leakage problem. One fixture is failing to terminate and is hogging the resources preventing access from other fixtures."

Bill: "And how do I fix that?"

Contractor: "Well, after each flush, you all need to exit the house, turn off the water at the street, turn it back on, reenter the house and then you can get back to work."

Bill: "That's the last straw. What kind of product are you selling me?"

Contractor: "Hey, if you don't like it... nobody made you buy it."

Bill: "And when will this be fixed?"

Contractor: "Oh, in your next house -- which will be ready to release sometime near the end of next year. Actually it was due out this year, but we've had some delays..."

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The Philogiston Theory of Electronics

(Original author's name not available or he didn't want credit.)

(Forwarded by: Atesli (atesli@aol.com).)

A sheet of paper crossed my desk the other day and as I read it, realization of a Basic Truth came to me. So simple! So obvious we couldn't see it! John Kuivinen, Chairman of the Palomar Repeater Committee, (an amateur radio group), I think has discovered what makes integrated circuits work. He says that smoke (yes, you read smoke) is the thing that makes ICs work because every time you let the smoke out of it, the IC stops working. I was flabbergasted!!! Why of course he's right!!!

Smoke makes all things electrical work. Remember the last time the smoke escaped from your Lucas voltage regulator? Didn't it stop working?

I sat and smiled like an idiot as more of the truth dawned. It's the wiring harness that carries smoke from one device to another in your machine and when the harness springs a leak, it lets the smoke out all at once, and then nothing works. Can't you see now why motors have to be large to handle all that smoke, and don't they have smoke all over the inside when they quit working? Think about it!

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Microsoft TV Dinners

(Forwarded from: Nicholas Bodley (nbodley@tiac.net).)

Instructions for Microsoft's New TV Dinner Product:

You must first remove the plastic cover. By doing so you agree to accept and honor Microsoft's rights to all TV dinners. You may not give anyone else a bite of your dinner (which would constitute an infringement of Microsoft's rights). You may, however, let others smell and look at your dinner and are encouraged to tell them how good it is.

If you have a PC microwave oven, insert the dinner into the oven. Set the oven using these keystrokes: <\mstv.dinn.//08.5min@50%heat//. Then enter: If you have a Mac oven, insert the dinner and press start. The oven will set itself and cook the dinner.

If you have a Unix oven, insert the dinner, enter the ingredients of the dinner (found on the package label), the weight of the dinner, and the desired level of cooking and press start. The oven will calculate the time and heat and cook the dinner exactly to specifications. Be forewarned that Microsoft dinners may crash, in which case your oven must be restarted.

This is a simple procedure. Remove the dinner from the oven and enter Many users have reported that the dinner tray is far too big, larger than the dinner itself, having many useless compartments, most of which are empty. These are for future menu items. If the tray is too large to fit in your oven you will need to upgrade your equipment.

Dinners are only available from registered outlets, and only the chicken variety is currently produced. If you want another variety, call Microsoft Help and they will explain that you really don't want another variety. Microsoft Chicken is all you really need. Microsoft has disclosed plans to discontinue all smaller versions of their chicken dinners. Future releases will only be in the larger family size. Excess chicken may be stored for future use, but must be saved only in Microsoft approved packaging.

Microsoft promises a dessert with every dinner after '98. However, that version has yet to be released. Users have permission to get thrilled in advance.

Microsoft dinners may be incompatible with other dinners in the freezer, causing your freezer to self-defrost. This is a feature, not a bug. Your freezer probably should have been defrosted anyway.

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Is Windows a Virus or a Bug?

(From: John Borchard (jb@dendritics.com).)

Is Windows a Virus? No, Windows is not a virus. Here's what viruses do:

1. They replicate quickly - okay, Windows does that.
2. Viruses use up valuable system resources, slowing down the system as they do so - okay, Windows does that.
3. Viruses will, from time to time, trash your hard disk - okay, Windows does that too.
4. Viruses are usually carried, unknown to the user, along with valuable programs and systems. Sigh... Windows does that, too.
5. Viruses will occasionally make the user suspect their system is too slow (see 2) and the user will buy new hardware. Yup, that's with Windows, too.

Until now it seems Windows is a virus... But there are fundamental differences:

Viruses are well supported by their authors, are running on most systems, their program code is fast, compact and efficient and they tend to become more sophisticated as they mature.

So Windows is not a virus.

It's a bug.

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Did They Really Say That?

(Forwarded by: Barry Werner (werner@repairfaq.org).)

Caveat emptor! Read on...

Recently reported in the Massachusetts Bar Association Lawyers Journal:

The following are questions actually asked of witnesses by attorneys during trials and, in certain cases, the responses given by insightful witnesses:

1. "Now doctor, isn't it true that when a person dies in his sleep, he doesn't know about it until the next morning?"
2. "The youngest son, the twenty-year old, how old is he?"
3. "Were you present when your picture was taken?"
4. "Were you alone or by yourself?"
5. "Was it you or your younger brother who was killed in the war?"
6. "Did he kill you?"
7. "How far apart were the vehicles at the time of the collision?"
8. "You were there until the time you left, is that true?"
9. "How many times have you committed suicide?"
10. Q: "So the date of conception (of the baby) was August 8th?"
    A: "Yes."
    Q: "And what were you doing at that time?"
11. Q: "She had three children, right?"
    A: "Yes."
    Q: "How many were boys?"
    A: "None."
    Q: "Were there any girls?"
12. Q: "You say the stairs went down to the basement?"
    A: "Yes."
    Q: "And these stairs, did they go up also?"
13. Q: "Mr. Slatery, you went on a rather elaborate honeymoon, didn't you?"
    A: "I went to Europe, Sir."
    Q: "And you took your new wife?"
14. Q: "How was your first marriage terminated?"
    A: "By death."
    Q: "And by who's death was it terminated?"
15. Q: "Can you describe the individual?"
    A: "He was about medium height and had a beard."
    Q: "Was this a male, or a female?"
16. Q: "Is your appearance here this morning pursuant to a deposition notice
    which sent to your attorney?"
    A: "No, this is how I dress when I go to work."

17. Q: "Doctor, how many autopsies have you performed on dead people?"
    A: "All my autopsies are performed on dead people."

18. Q: "All your responses must be oral, OK? What school did you go to?"
    A: "Oral."

19. Q: "Do you recall the time that you examined the body?"
    A: "The autopsy started around 8:30 p.m.."
    Q: "And Mr. Dennington was dead at the time?"
    A: "No, he was sitting on the table wondering why I was doing an autopsy."

20. Q: "You were not shot in the fracas?"
    A: "No, I was shot midway between the fracas and the navel."

21. Q: "Are you qualified to give a urine sample?"
    A: "I have been since early childhood."

22. Q: "Doctor, before you performed the autopsy, did you check for a pulse?"
    A: "No."
    Q: "Did you check for blood pressure?"
    A: "No."
    Q: "Did you check for breathing?"
    A: "No."
    Q: "So, then it is possible that the patient was alive when you began the autopsy?"
    A: "No."
    Q: "How can you be so sure, Doctor?"
    A: "Because his brain was sitting on my desk in a jar."
    Q: "But could the patient have still been alive nevertheless?"
    A: "It is possible that he could have been alive and practicing law somewhere."

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Battery Humor

(From: bobv@pacifier.com).

You did hear about the Electrical Engineer that was arrested for battery. They put him in a dry cell :).

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What Happens When Engineers Think Too Much About Christmas

(Forwarded by: Steve Seaman (sseaman@fundy.net).)

It's an oldie, but a goodie.

1. No known species of reindeer can fly. But there are 300,000 species of living organisms yet to be classified, and while most of these are insects and germs, this does not completely rule out flying reindeer, which only Santa has seen.

2. There are 2 billion children (under 18) in the world. But since Santa doesn't appear to handle Muslim, Hindu, Buddhist, and Jewish children, that reduces the work load to 15% of the total - 378 million or so. At an average rate of 3.5 children per household, that's 91.8 million homes.

   One presumes there's at least one good child in each.

3. Santa has 31 hours of Christmas to work with thanks to time zones and the rotation of the earth, assuming he travels east to west. This works out to 822.6 visits per second. This is to say that for each Christian household with good children, Santa has 1/1000th of a second to park, hop out of the sleigh, jump down the chimney, fill the stockings, distribute the remaining gifts under the tree, eat the snacks, get back up the a chimney, get back in the sleigh, and move on to the next house. Assuming that each of these 91.8 million homes are distributed evenly (which we know to be false but for the sake of these calculations we will accept) we are now talking about .78 miles per household, a total trip of 75 1/2 million miles, not counting bathroom stops. This means that Santa's sleigh is traveling at 650 miles per second, 3000 times the speed of sound. For comparison, the fastest man made vehicle, the Ulysses space probe moves at a poky 27.4 MPS; the average reindeer runs at 15 MPH.

4. The sleighs payload adds another interesting element. Assuming that each child gets nothing more than a medium sized LEGO set (2 pounds), the sleigh is carrying 321,300 tons not counting Santa, who is inexorably described as overweight. On land, confessional reindeer can pull no more than 300 pounds. Even granting that "flying reindeer" (see point one) could pull TEN TIMES the usual amount, we can not do the job with 8 or even 9, we need 214,000 reindeer. This increases the weight, not even counting the sleigh, to 353,430 tons. Again for comparison this is 4 times the weight of the Queen Elizabeth 2.

5. 353,000 tons traveling at 650 miles per second creates enormous air resistance. This will heat the reindeer in the same manner as a spacecraft re-entering the earth+s atmosphere. The lead pair of reindeer will absorb 14.2 QUINTILLION joules of energy. Per second. Each. In short, they will burst into flame almost instantaneously, exposing the next pair of reindeer, and creating deafening sonic booms in their wake. The entire team will be vaporized within 4.26 thousands of a second. Santa, meanwhile, will be subjected to centrifugal forces 17,500.06 times the force of gravity. A 300 pound Santa would be pinned to the back of his sleigh by 4,315,015 pounds of force.

6. Conclusion: There was a Santa, but he's dead now.

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Old Digital Engineers

(From: John Woodgate (jmw@jmwa.demon.co.uk).)

Old digital engineers (well, there will be some, one day) never die, they only lose their most significant bits.

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That Darn Oops Button

Haven't you always wanted a button labeled 'oops' on your keyboard for those occasions where 1 microsecond after posting something to sci.electronics.repair (or a more juicy newsgroups), you realized how stupid it was?

Maybe the 'Oops' button would create a market for those no-longer-needed 'printer buffers'??? :-) Darn, that great an idea shouldn't be in a publicly accessible document. Oops!

(From: Mr Fixit (mrfixit@cyberhighway.net).)

I believe I could retire in style if I can design a ad-on computer button labeled 'Oops'. It would be wired to a small, but high powered electronic box that would go in-line at the modem connection.

Once in place, we usenet users would have a means of dealing with that dreaded situation when we push the 'post' button at the same instant we realize that we shouldn't have pushed it. A quick slap on the 'oops' button would instantly send a high powered jolt down the phone line where it would catch up to the inadvertently sent message and blow it to smitherines, like a Patriot missile intercepting a Scud.

I know I would make regular use of it, as well as Sam, Joe and countless others on this NG alone. And just think of how many NG's there are with their own regretful posters!

Of course, I would have to SPAM all of the NG's to get the word out and start my $millions rolling in. But, knowing me I would probably have second thoughts about being a SPAMMER the instant I push the 'post' button. My knee-jerk reaction would undoubtably be to slap the new prototype 'oops' button on my computer and blast my own SPAM before it could be delivered. The end result being that I would be the only one on usenet with this powerful technology-turned personal toy.

Never mind that this would be grossly unfair to everyone else, the cold reality would be that I just blasted away my comfortable retirement.

Retirement.....that reminds me...I've got toilets, sinks, tubs, floors, walls, windows, doors, etc., etc., to fix. I don't have time to be inventing toys!

So, in lieu of all that, we'll all just have to accept human nature for what it is (occasionally unreliable) and offer Sam a knowing grin, and get on with what we're here for.

Now, what was it we are here for?

Where's that darned 'oops' button now when I need it? Umm, never mind.

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Atomic Charge

(Forwarded from: Brad Albing (albing@ct.picker.com).)

Two atoms are sitting in a bar:

> Atom 1 (in a whisper): I think I've lost an electron.
> Atom 2: Are you sure?
> Atom 1: I'm positive.

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Transformer Design - Tomato Launcher

This is actually part of a long thread on sci.electronics.design (much of it between Chuck Parsons and Winfield Hill) but I got tired of extracting and formatting all the relevant stuff!

(From: Chuck Parsons (Chuck@CatenaryScientific.com).)

Well there is nothing I like better than finding the right intuitive model fo something. Intuition is so fast if you can keep out the bad intuition. Many thanks for helping me lay another block in my EE foundation I hope others benefited as well.

While mulling this over last night I tried to come up with a circuit that explored both converters. I came up with a hybrid design that uses both converters in a single transformer. First though I needed a reason for building it, this is what I came up with. I don't claim that the design is particularly good I was just trying to bring some of the issues in to play. I invite anyone who cares to to disparage or (better) improve the designs.

Our story begins many years ago (at least for some of us) when all of us in the sci.electronics.design gang happened to be about 16. Old enough to drive, but young enough that the police might still take us too our parents instead of jail.

Those jerks in alt.pdf_not_gif.big_binaries.wannabies.geese. are getting their due at the hands of our car mounted linear induction motor tomato launcher. It launches 1kg tomatoes. 1 kg tomatoes are rather large, but we have gardening expertise here in sci.electronics and have no trouble procuring our superior ammunition. I have grown 1.1kg tomatoes, and last summer was hours away from picking 4 even larger ones when those &%#@* alt.pdf_not_gif.big_binaries.wannabies GEESE got them.

Careful, but messy, testing has determined that 30 meter per second (108 kph or 67 mph) launch speeds are possible without PPF (premature projectile fragmentation) requiring another trip to the car wash. Naturally we want to come as close to this as possible without exceeding it. The energy of a 1kg projectile traveling at 30 mps is 450 Joules. Our launcher has an impressive 45% efficiency (of course we designed it!) so a launch requires 1000 Joules of energy. We store this energy in 220,000 uF of capacitance at 100 Volts. the caps are discharged all the way to 30 volts during firing, so only 1100 Joules of energy storage is needed to deliver 1000 Joules. Testing has also shown that for small variations in the linear motor input voltage the variation in projectile speed is reasonably linearly related to the voltage variation.

Generation 1 used a simple 20 watt 100 kHz PWM flyback design to generate the 100 volts from the car battery. The ferrite needs to store 200 uJ on each pulse. A ferrite capable of storing 400uJ was chosen to avoid saturation at high input voltages. This design worked great. The 100 volts was accurate assuring reproducible launches whether or not we had the car revving for get away or had the battery just about dead after a long day of field trials. I sketch it here:

```
                           +----------|>|----------+-------+-----o 100 V
Vin 10-15 volts o-----+ ||(                        |       |
                       )||(                       _|_      |
                       )||(                 .22 F ---      |
                       )||(                        |       |
                   +--+ ||(                       _|_      |
       30 V        |       +--+                    -       |
       MOSFET .|---+         _|_                           |
              ||<--.          -                            |
          +---'|---+                                       |
          |       _|_                                      |
          |        -                                       |
          |     +----------------------------------+       |
          +-----| PWM Controller: 0-80% duty cycle |-------+
                +----------------------------------+
```

The inductance of the primary and the avalanche capability of the Mosfet have served to protect the circuit from those nasty 50 Volt transients in the car's ignition system.

Unfortunately after a few successful raids the alters took advantage of the 50 second recharge time to close and return fire from close range.

Generation 2 then using the same ferrite modified the design to use forward conversion allowing an average 200 watts of power transfer and a much quicker 5 second reload time, which is about how long it took Win to pass up those tomatoes from the back seat through the sun roof anyway.

```
                               +---+    +----|>|-------+-------+-----o 100 V
Vin 10-15 volts o---------+ ||(   _|_   |              |       |
                           )||(    -    |             _|_      |
                           )||(         |       .22 F ---      |
                           )||(         |              |       |
                +----+----+ ||(         |             _|_      |
    30 V        |    |         +--------+              -       |
    MOSFET .|---+   _|_                                        |
           ||<--.   --- Snubber                                |
       +---'|---+    |                                         |
       |       _|_  _|_                                        |
       |        -    -                                         |
       |     +------------------------------------------+      |
       +-----| Fixed 100 kHz Controller: 80% duty cycle |------+
```

```
               +------------------------------------------+
```

We had to add a snubber because now the magnetization flux is just being dumped into the mosfet at the end of every cycle. Since we are using the same transformer and frequency as well as maximum duty cycle this energy amounts to just the 20 watts of the flyback converter.

This produced a glorious victory over the alters, plastering them at close range as they closed with their basket of 100 gram wormy tomatoes.

However, there were problems. The Generation 1 circuit could be left on continuously and preloaded allowing instant reaction to sneak attacks when getting in the car in the morning. Leaving the Generation 2 circuit on all night killed the battery, despite nearly 90% efficiency at full load (and full output voltage).

The efficiency at low loads, or low output voltages is poor. Continuous firing is possible until the transformer overheats. At full load _and_ output voltage, the transformer heat load is not bad, but during the output rampup currents are only limited by the leakage inductance (much lower than the full winding inductance), winding resistance and MOSFET on resistance. To minimize the charging time we of course minimized all of these, leading to 100 amp peak currents. Furthermore changes in the input voltage lead to problems in figuring range and aiming accurately. Indeed several second shots while racing away at low gear and high RPMs lead to high battery charging voltages and embarrassing PPF (premature projectile fragmentation).

Generation 3 is to combine the best features of both designs. (The turns on the secondary are reduced 10% to ensure the flyback is the only active energy transfer at full load. This isn't always enough reduction to ensure the output voltage never exceeds 100 volts, but it is a compromise between overcharging at high input voltages and slow charging at low input voltages.)

```
                             +--+--|>|--------+--------+-----+--o Vout: 100 V
  Vin 10-15 volts o-----+ ||(   |             |        |     |
                         )||(   +--|<|--+--+  |       _|_    |
                         )||(           | _|_ | .22 F ---    |
                         )||(   +--|<|--+  =  |        |     |
                     +--+ ||(   |             |       _|_    |
         30 V        |       +--+--|>|--------+        -     |
         MOSFET .|---+                                       |
                ||<--.                                       |
            +---'|---+                                       |
            |       _|_                                      |
            |        -                                       |
            |  +------------------------------------------+  |
            +--| 100 kHz PWM Controller: 0-80% duty cycle |--+
               +------------------------------------------+
```

In this design the snubber disappears because the magnetization energy is captured for use in the output flyback. At low output voltage the design works primarily as forward conversion but at some point the output voltage equals the input voltage multiplied by the turns ratio and the design transfers over to pure flyback. We can once again leave the circuit running continuously. We can get off 10 shots in 50 seconds before the transformer and mosfets overheat, though the output voltage will then be 90 instead of 100 leading to reduced range. The flyback just has to top off the capacitors so if we can 15 seconds instead of 5 (but not 50) between shots we can assure a steady output voltage. The biggest problem is that variation in the input voltage leads to variations in the amount of time spent in flyback versus forward conversion. A second problem is that the flyback, moving charge all the way from ground to 100 volts at the end of the top-off is rather slow. Basically we would like to extend the period of time in forward conversion but we have to adjust the winding turns so that at maximum input voltage the forward conversion output voltage is less than the desired Vout. We can increase the amount of work done in forward conversion as follows, simultaneously greatly improving the charge delivery of the flyback, by giving it a slower rampdown.

```
                            +--+--|>|------+--------+-------+--o Vout 1: 100 V
 Vin 10-15 volts o-----+ ||(   |           |        |       |
                        )||(   +--|<|--+   |       _|_      |
                        )||(          _|_  | .22 F ---      |
                        )||(           -   |        |       |
                    +--+ ||(               |       _|_      |
        30 V        |       +--+--|>|------+        -       |
        MOSFET .|---+          |                            |
               ||<--.          +--o Vout 2: 80 V            |
           +---'|---+         _|_                           |
           |       _|_        --- 2,000 uF, low ESR         |
           |        -         _|_                           |
           |                   -                            |
           |  +------------------------------------------+  |
           +--| 100 kHz PWM Controller: 0-80% duty cycle |--+
              +------------------------------------------+
```

A miracle has happened, with our generation 4 design even in August we don't have enough tomatoes. Maybe we should modify it for zucchini ;-).

Much more - search via Google Groups (formerly Deja.com/Dejanews) for: "sci.electronics.design", and "Re: Transformer design equations - tomato launcher", or maybe just "cherry tomatoes" or "zucchini" for the subject line! :-)

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Leave It To The Physicists

(From: Chuck Parsons (Chuck@CatenaryScientific.com).)

A biologist, a engineer and a physicist are assigned to monitor a building. After watching for a whole day two people are observed going in and three people come out:

> Biologist: "They must be breeding."
> Engineer: "There must have been am measurement error."
> Physicist: "Now if one more person goes in the building will be empty."

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Vc Versus Vs

(From: Jim Klein (kdpoptics@kdpoptics.com).)

The speed of light is greater than the speed of sound. That's why some people seem very bright until you hear them speak.

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Selling It

(Forwarded by: Chris Cobb" (cobb@ct.picker.com).)

- Illiterate? Write today for free help.
- Auto Repair Service. Free pick-up and delivery. Try us once, you'll never go anywhere again.
- Our experienced Mom will care for your child. Fenced yard, meals, and smacks included.
- Dog for sale: eats anything and is fond of children.
- Man wanted to work in dynamite factory. Must be willing to travel.
- Stock up and save. Limit: one.
- Semi-Annual after-Christmas Sale.

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Parts Replacement

So many repair questions take the form:

"Where can I get the microprocessor or flyback or CRT or mainboard or 'most expensive part' because I think THAT must be the problem".

(From: David J. Pittella (ddc_pitt@ix.netcom.com).)

I frequently read or overhear discussions about the repair of products that are controlled by a microprocessor or microcontroller and wonder why technicians are always trying to replace these, typically prior to any testing or troubleshooting?

I wonder if they will ever believe that these devices are typically very reliable and that the lack of a proper voltage, or a failed or dirty sensor or switch be the real fault?

New troubleshooting technique:

1. Replace ALL the biggest chips FIRST, the more pins the better.

2. If step #1 doesn't resolve the problem, see if there is service literature available?

3. If there is no service literature, see if the something called the MAIN BOARD! Just replace anything that could be a MAIN BOARD - that should fix the problem!

4. If steps (1) to (3) don't cure the problem, advise the customer that "parts are no longer available" or "the cost of repair exceeds the cost of replacement".

WARNING: DO NOT attempt to use a voltmeter to make simple voltage tests, or an ohmmeter to possibly check the continuity of the on/off switch!! :-)

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But Does it do Windows?

From a sci.electronics newsgroup posting:

> "Free Theory and Plans. Levitation craft. Hover silently above trees. Lands anywhere. Unlimited ceiling. Lifts over 250 lbs. Requires no fuel. Operates on Inverted-Gravity Chamber (IGC). Perpetual motion machine. Consists of mass circulation upward through IGC and downward outside chamber. Generates electrical power. Utilizes less power than it generates. Based on field theory, rather than old-fashion particle theory."

From: George X. Kambic (kambic@ct.picker.com).)

Damn! I wish people would tell me when the laws of physics change.

[...deleted to save stomach contents.....]"

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You Know You're from Silicon Valley When...

(From: Filip Fuma (filfuma@csi.com).)

- You make $120,000 a year, but can't find a place to live.
- You see nothing but expensive cars because of .
- Your commute time is 45 minutes and you live 8 miles from work.
- You stop asking how much things cost and start asking: "How long will it take?"
- Two-thirds of the people you know are from Boston, Austin, Raleigh-Durham or New York, but you are living in PST.
- You know vast and subtle differences between Thai, Vietnamese, Chinese, Japanese, Cantonese, and Korean food.
- Your home computer contains mostly hardware/software that isn't on the consumer market yet.
- You go to "The City" on weekends but don't live there because you like your car.
- You think that "I'm going to Fry's Electronics" is an acceptable excuse to leave the office for a while. And your boss does too.
- You /lost/never had/don't know how to set the alarm clock. You'll just get to work when you get there.
- You go to an industrial-heavy-metal bar and see two guys get into a fight over what flavor of UNIX is better.
- You own more than 10 articles of clothing that have hardware and/or software companies printed on them. (Bonus for embroidered stuff.)
- You know where Woz Way, Resistor Ave, and Floppy Drive are located.
- You know where Woz is.
- You know Hwy 280 North runs west, and Hwy 680 North runs East.
- Even though Microsoft employs quite a few programmers in the Bay Area, they only work on Powerpoint, and the company is still the embodiment of Satan. (Even if their stock IS worth more than yours.)
- You see a billboard that says "FGPA2ASIC" and aren't fazed.
- When you need the updated Diamond Monster 3D drivers, you just walk across the street.
- You have more bandwidth in your apartment or condo than most major universities.
- You have to hire security to keep the panhandlers off your terrace. (Oakland/Berkeley).
- None of the people you work with are bible thumpers.
- You scan yard sales for back issues of "Dr. Dobbs."

- Your favorite computer reseller speaks only Cantonese.
- Your workplace vending machines dispense "100% natural twig-bars" right next to Jolt cola and Instant Espresso mix.
- No one brings radios into work - they just use RealAudio and listen to the dj.com, rebelradio.com, or other out-of-state stations.
- You don't understand how the carpool lanes work because you normally don't commute during those hours.
- You meet a friend for lunch and the first topic is where they are working now.
- You go to the movies and EVERYBODY claps along with the SciFi theme music.
- You entice prospective employees to join your company by bragging about the speed of your internet connection.
- You've replaced your box of floppies with a box of Zip disks, but that's just until you get your box of Jaz disks.
- You have completely forgotten how to write longhand.

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Lawyer One-Liners

Sorry (well not really) for any lawyers reading this. :-)

(Forwarded by: Jim Lagerkvist (jlager@tir.com).)

> Q: What do you call a lawyer with an I.Q. of 50?
> A: Your honor.
>
> Q: What do you call a lawyer whose gone bad?
> A: Senator.
>
> Q: What's the difference between a lawyer and a trampoline?
> A: You take off your shoes to jump on a trampoline!
>
> Q: What do you call 5000 dead lawyers at the bottom of the ocean?
> A: A good start!
>
> Q: How can you tell when a lawyer is lying?
> A: His lips are moving.
>
> Q: What's the difference between a dead dog and a dead lawyer in the road?
> A: There are skid marks in front of the dog.

Q: How many lawyers does it take to roof a house?
A: Depends on how thin you slice them.

Q: Why won't sharks attack lawyers?
A: Professional courtesy.

Q: What do you have when a lawyer is buried up to his neck in sand?
A: Not enough sand.

Q: When lawyers die, why are they buried in a hole 24 feet deep?
A: Because down deep, they are all nice guys!!!!

Q: How do you get a lawyer out of a tree?
A: Cut the rope.

Q: How do you stop a lawyer from drowning?
A: Shoot him before he hits the water.

Q: What is the definition of a shame (as in "that's a shame")?
A: When a bus load of lawyers goes off a cliff.

Q: What is the definition of a "crying shame"?
A: There was an empty seat.

Q: How many lawyers does it take to stop a moving bus?
A: Never enough.

Q: Have you heard about the lawyers word processor?
A: No matter what font you select, everything comes out in fine print.

Q: What's the difference between a porcupine and two lawyers in a Porsche?
A: With a porcupine, the pricks are on the outside!

Q: What do you buy a friend graduating from Law School?
A: A lobotomy.

Q: What's the difference between a catfish and a lawyer?
A: One's a bottom-crawling scum sucker and the other's just a fish.

Q: Hear about the terrorist that hijacked a 747 full of lawyers?
A: He threatened to release one every hour if his demands weren't met.

Q: What does a lawyer and a sperm have in common?
A: Both have about a one in 3 million chance of becoming a human being.

Q: Why is it that many lawyers have broken noses?
A: From chasing parked ambulances.

Q: Where can you find a good lawyer?
A: In the cemetery

Q: What do lawyers use as contraceptives?
A: Their personalities.

Q: What's the difference between a lawyer and a herd of buffalo?
A: The lawyer charges more.

Q: What's the difference between a lawyer and a vampire?
A: A vampire only sucks blood at night.

Q: What is brown and black and looks good on a lawyer?
A: A doberman.

Q: What is the difference between a lawyer and a rooster?
A: When a rooster wakes up in the morning, its primal urge is to cluck defiance.

Q: How many law professors does it take to change a light bulb?
A: Hell, you need 250 just to lobby for the research grant.

Q: Why did the post office recall the new lawyer stamps?
A: Because people could not tell which side to spit on.

Q: Did you hear about the new sushi bar that caters exclusively to lawyers?
A: It's called, Sosumi.

Q: Did you hear about the lawyer from Texas who was so big when he died that
they couldn't find a coffin big enough to hold the body? A: They gave him an enema and buried him in a shoe box.

Q: Santa Claus, the tooth fairy, an honest lawyer, and an old drunk are walking down the street together when they simultaneously spot a hundred dollar bill. Who gets it?
A: The old drunk, of course, the other three are mythological creatures.

Q: What is the ideal weight of a lawyer?
A: About three pounds, including the urn.

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Garage Tools

(Forwarded by: blinkys@execpc.com).

HAMMER: Originally employed as a weapon of war, the hammer nowadays is used as a kind of divining rod to locate expensive car parts not far from the object we are trying to hit.

MECHANIC'S KNIFE: Used to open and slice through the contents of cardboard cartons delivered to your front door; works particularly well on boxes containing convertible tops or tonneau covers.

ELECTRIC HAND DRILL: Normally used for spinning steel Pop rivets in their holes until you die of old age, but it also works great for drilling rollbar mounting holes in the floor of a sports car just above the brake line that goes to the rear axle.

HACKSAW: One of a family of cutting tools built on the Ouija board principle. It transforms human energy into a crooked, unpredictable motion, and the more you attempt to influence its course, the more dismal your future becomes.

VISE-GRIPS: Used to round off bolt heads. If nothing else is available, they can also be used to transfer intense welding heat to the palm of your hand.

OXY-ACETYLENE TORCH: Used almost entirely for lighting those stale garage cigarettes you keep hidden in the back of the Whitworth socket drawer (what wife would think to look in there?) because you can never remember to buy lighter fluid for the Zippo lighter you got from the PX at Fort Campbell.

ZIPPO LIGHTER: See oxy-acetylene torch.

WHITWORTH SOCKETS: Once used for working on older British cars and motorcycles, they are now used mainly for hiding six-month-old Salems from the sort of person who would throw them away for no good reason.

DRILL PRESS: A tall upright machine useful for suddenly snatching flat metal bar stock out of your hands so that it smacks you in the chest and flings your beer across the room, splattering it against the Rolling Stones poster over the bench grinder.

WIRE WHEEL: Cleans rust off old bolts and then throws them somewhere under the workbench with the speed of light. Also removes fingerprint whorls and hard-earned guitar callouses in about the time it takes you to say, "Django Reinhardt."

HYDRAULIC FLOOR JACK: Used for lowering a Mustang to the ground after you have installed a set of Ford Motorsports lowered road springs, trapping the jack handle firmly under the front air dam.

EIGHT-FOOT LONG DOUGLAS FIR 2x4: Used for levering a car upward off a hydraulic jack.

TWEEZERS: A tool for removing wood splinters.

PHONE: Tool for calling your neighbor Chris to see if he has another hydraulic floor jack.

SNAP-ON GASKET SCRAPER: Theoretically useful as a sandwich tool for spreading mayonnaise; used mainly for getting dog-doo off your boot.

E-Z OUT BOLT AND STUD EXTRACTOR: A tool that snaps off in bolt holes and is ten times harder than any known drill bit.

TIMING LIGHT: A stroboscopic instrument for illuminating grease buildup on crankshaft pulleys.

TWO-TON HYDRAULIC ENGINE HOIST: A handy tool for testing the tensile strength of ground straps and hydraulic clutch lines you may have forgotten to disconnect.

CRAFTSMAN 1/2 x 16-INCH SCREWDRIVER: A large motor mount prying tool that inexplicably has an accurately machined screwdriver tip on the end without the handle.

BATTERY ELECTROLYTE TESTER: A handy tool for transferring sulfuric acid from car battery to the inside of your toolbox after determining that your battery is dead as a door nail, just as you thought.

AVIATION METAL SNIPS: See hacksaw.

TROUBLE LIGHT: The mechanic's own tanning booth. Sometimes called a drop light, it is a good source of vitamin D, "the sunshine vitamin," which is not otherwise found under cars at night. Health benefits aside, its main purpose is to consume 40-watt light bulbs at about the same rate that 105mm howitzer shells might be used during, say, the first few hours of the Battle of the Bulge. More often dark than light, its name is somewhat misleading.

PHILLIPS SCREWDRIVER: Normally used to stab the lids of old-style paper-and-tin oil cans and splash oil on your shirt; can also be used, as the name implies, to round off Phillips screw heads.

AIR COMPRESSOR: A machine that takes energy produced in a coal-burning power plant 200 miles away and transforms it into compressed air that travels by hose to a Chicago Pneumatic impact wrench that grips rusty suspension bolts last tightened 40 years ago by someone in Abingdon, Oxfordshire, and rounds them off.

JESUS CLIP: "Jesus" every time you drop one of these.

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Tesla Coil Caps

Actually, the warnings about PCBs (and I don't mean Printed Circuit Boards) are real!

So you are looking for BIG capacitors...... :-)

(From: Bill Coderre (bc@apple.com).)

Just watch out for PCB-laden oil-filled caps.... Those are usually the ones you find at the junk yard or the surplus place for REAL cheap, big grey cans with lightning protectors on top, usually labeled something like "1 uF @ 100 kV." They're extra cheap if they're already leaking!

Just remember, if you come across a pile of drum caps in an abandoned lot in an industrial section of town - even if the sign on top says "FREE! FREE!" - they are not good for you. Just Say No to PCBs.

I personally wish that Norm Abrams, host of the New Yankee Workshop, would run a show for electronics experimenters, something like the New Geek Workshop:

"Today we're going to be making a tesla coil from champagne bottles, a spark coil from a 53 DeSoto, and this hand-knurled lightning rod. It'll look great next to my Louis XIV-style marquetry and scrollwork Orgone Cabinet!. But first, let's talk about Safety Glasses...."

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Customer Translations

(From: Dan (tvman@newwave.net).)

I once had a customer who insisted on "helping" me fix his TV. I politely told him that he had done enough damage to it already."

How about the customer who brought his TV in and said that "it worked fine until" he worked on it. (At least he was honest.)

(From: Michelle Hunt (michell5@ix.netcom.com).)

I had one of those the other day... This guy brought in a little Magnavox 19" and the conversation went something like this:

Him: "I don't know what happened, it just suddenly quit working."

Me: "Was that before or after you dropped it?"

Him: "How did you know I dropped it?"

Me: "It was easy... the cabinet usually isn't broken into pieces like this".

(From: Chris Mann).

How about customer translations such as:

"I think it's got a shorted fuse" - "I don't have a clue as to what's wrong but I know some electronic words so don't rip me off".

"I think it's just a bad connection" - "I know something major happened. I just don't want to think that something major happened."

"I think something's loose inside" - "My child uses it for his piggy bank".

"It fell off the shelf".

"It just stopped working" - "I spilled my drink and it went inside"

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Advertising to Dummies

(I was going to use the 'for' word but then a certain publisher's lawyers would come complaining.)

(From: Charley S. McCue (csmccue@midusa.net).)

I once spent 15 minutes trying to convince a customer they had not bought a $20 satellite dish from TV Guide (back when C band was the only option).

(From: Gary Woods (gwoods@wrgb.com).)

That's the ad that I still think is the high-water mark of advertising to stupid people:

"You're not paying cable fees, because this is not a satellite antenna. It uses proven RF technology to pick signals RIGHT OUT OF THE AIR!"

People still bought them thinking they'd get cable or something. We had a copy on the door of the tech shop for a while.

Reminds me of the fellow who offered on a bulk emailer site one million email addresses for only ten dollars. "Generated by sophisticated random number technology", they are all guaranteed undeliverable! People actually sent him orders!

P.T. Barnum was right!

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The Hazards of Multimeters

(From: Ed Price (edprice@pacbell.net).)

Let me add my own tale of knowledge gained through stupid experimentation. In 1961, right after I built my Knight Kit VTVM, I was measuring the voltage and resistance of everything I could find. I eventually found an old "Press" style flashbulb, about an inch in diameter. I started out on a high Ohms range, and worked my way down to the 1x range. The lessons I learned involved design of experiments, resistance testing, chemical reaction of magnesium, optical transfer of energy and emergency room procedure. Did you know that those old bulbs had a plastic outer layer which could very effectively fuse to charred skin?

Dirty Harry Callahan was right; "...when properly used, you can REMOVE the fingerprints."

Next time (if somebody asks politely), I'll tell you how I got radiation burns from a pencil.

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The Surgeons' Choice

(Forwarded by Fil Fuma (filfuma@csi.com).)

5 surgeons are taking a coffee break:

The first surgeon says: "Accountants are the best to operate on because when you open them up, everything inside is numbered."

The second surgeon says: "Nah, librarians are the best. Everything inside them is in alphabetical order."

The third responds: "Try electricians, man! Everything inside THEM is color coded."

The fourth intercedes: "I like engineers...they always understand when you have a few parts left over at the end."

To which the fifth surgeon, who has been quietly listening to the conversation, says: "You're all wrong. Lawyers are the easiest. There's no guts, no heart, no spine and their head and butt are interchangeable."

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VCR Only Works Upside-Down

(From: Clifton T. Sharp Jr. (agent150@ml.org).)

Maybe you should reverse the wires to the vertical yoke windings of the TV as well. :-)

I'll never forget the old 21" round picture tubes and the giant yokes that went on them; the yokes had quick-disconnect spade terminals which connected to the chassis through individual wires. When I had a customer with a sense of humor, or when I worked on my brother's TV, I would first reverse the horizontal winding wires and "work on some adjustments" while waiting for the reaction. They'd say "the picture is backwards, look at the text," and I'd hold my mirror up from behind the set and say, "Looks just fine to me, I can read it." I'd let them remind me about the mirror image or coax me out from behind the set, then I'd shut the set off and instead of fixing the horizontal windings, reverse the vertical. Turning on the set always got "Now it's upside-down!" at which I would rise and lean over the set from the back, chin above forehead, and say "Looks okay to me."

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Abbott and Costello Meet Windows 95

(Forwarded by: Barry Werner (werner@repairfaq.org).)

Costello: Hey, Abbott!

Abbot: Yes, Lou?

Costello: I just got my first computer.

Abbot: That's great Lou. What did you get?

Costello: A Pentium II-266, with 40 Megs of RAM, a 2.1 Gig hard drive, and a 24X CD-ROM.

Abbot: That's terrific, Lou

Costello: But I don't know what any of it means!!

Abbot: You will in time.

Costello: That's exactly why I am here to see you.

Abbot: Oh?

Costello: I heard that you are a real computer expert.

Abbot: Well, I don't know-

Costello: Yes-sir-ee. You know your stuff. And you're going to train me.

Abbot: Really?

Costello: Uh huh. And I am here for my first lesson.

Abbot: OK Lou. What do want to know? Costello: I am having no problem turning it on, but I heard that you should be very careful how you turn it off.

Abbot: That's true.

Costello: So, here I am working on my new computer and I want to turn it off. What do I do?

Abbot: Well, first you press the Start button, and then-

Costello: No, I told you, I want to turn it off.

Abbot: I know, you press the Start button-

Costello: Wait a second. I want to turn it off. Off. I know how to start it. So tell me what to do.

Abbot: I did.

Costello: When?

Abbot: When I told you to press the Start button.

Costello: Why should I press the Start button?

Abbot: To shut off the computer.

Costello: I press Start to stop.

Abbot: Well Start doesn't actually stop the computer.

Costello: I knew it! So what do I press.

Abbot: Start

Costello: Start what?

Abbot: Start button.

Costello: Start button to do what?

Abbot: Shut down.

Costello: You don't have to get rude!

Abbot: No, no, no! That's not what I meant.

Costello: Then say what you mean.

Abbot: To shut down the computer, press-

Costello: Don't say, "Start!"

Abbot: Then what do you want me to say?

Costello: Look, if I want to turn off the computer, I am willing to press the Stop button, the End button and Cease and Desist button, but no one in their right mind presses the Start to Stop.

Abbot: But that's what you do.

Costello: And you probably Go at Stop signs, and Stop at green lights.

Abbot: Don't be ridiculous.

Costello: I am being ridiculous? Well. I think it's about time we started this conversion. Abbot: What are you talking about?

Costello: I am starting this conversation right now. Good-bye.

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A Pound of Electrons, Please!

(From: Clifton T. Sharp Jr. (agent150@spambusters.ml.org).)

Once on a very very bored day, I and a friend decided to compute how long it would take for a black-and-white TV to shoot a pound of electrons at the screen. If you ever get so bored that you want to duplicate this entirely silly exercise:

1. Take the rest mass of an electron.
2. Convert from nanopicofemtoattograms (whatever) to pounds.
3. Invert to find quantity of electrons in a pound.
4. Determine average beam current of the TV.
5. Convert amps to coulombs per second.
6. Divide quantity in (3) by quantity in (5) to determine number of seconds. Convert to megacenturies.
7. Tell your friends.
8. Do what your friends tell you and get a life.

(Anyone who doesn't see how entirely silly this is and posts corrections to the lousy data should be bolted by aliens to a spaceship and towed through the galaxy until struck by a pound of cosmic rays.)

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In Defense of Fuse Eating Equipment

(From: Frank McNally (emcnally@mail.otenet.gr).)

There is absolutely nothing wrong with a TV that eats fuses , most of them do it at some time , What is wrong is that a non technical person should try checking his fuses in a TV that eats fuses . When it has eaten one it is quite likely that it will want to eat another ! and another ! until its appetite has been quenched.

Just how hard did the TV eat the Fuse - was it just a small nibble or the fully grown. "I haven't eaten a fuse for god knows how many years." Bite that left the fuse black and charred.? I have seen Philips TVs that have eaten fuses down to the Glass tube that surrounds them leaving only metal caps in the fuse holder. If the fuse doesn't look burnt, like the TV toasted it before it ate it, the possibility is that the fuse died of old age and thermal shock before it parted company with its end-caps.

A fuse that, like the one that lost its jacket as well as its cool, and must have been eaten alive, before it even had time to think about whether it should holiday in a warm sunny or a cold wintry climate, has definitely wetted the appetite of even the most expensive piece of equipment.

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The Ultimate Toaster

(Frowarded by: Jeff Granito (jmg@repairfaq.org).)

Once upon a time, in a kingdom not far from here, a king summoned two of his advisors for a test. He showed them both a shiny metal box with two slots in the top, a control knob, and a lever. "What do you think this is?"

One advisor, an electrical engineer, answered first. "It is a toaster," he said.

The king asked, "How would you design an embedded computer for it?"

The advisor: "Using a four-bit microcontroller, I would write a simple program that reads the darkness knob and quantifies its position to one of 16 shades of darkness, from snow white to coal black. The program would use that darkness level as the index to a 16-element table of initial timer values. Then it would turn on the heating elements and start the timer with the initial value selected from the table. At the end of the time delay, it would turn off the heat and pop up the toast. Come back next week, and I'll show you a working prototype."

The second advisor, a software developer, immediately recognized the danger of such short-sighted thinking. He said, "Toasters don't just turn bread into toast, they are also used to warm frozen waffles. What you see before you is really a breakfast food cooker. As the subjects of your kingdom become more sophisticated, they will demand more capabilities. They will need a breakfast food cooker that can also cook sausage, fry bacon, and make scrambled eggs. A toaster that only makes toast will soon be obsolete. If we don't look to the future, we will have to completely redesign the toaster in just a few years."

"With this in mind, we can formulate a more intelligent solution to the problem. First, create a class of breakfast foods. Specialize this class into subclasses: grains, pork, and poultry. The specialization process should be repeated with grains divided into toast, muffins, pancakes, and waffles; pork divided into sausage, links, and bacon; and poultry divided into scrambled eggs, hard-boiled eggs, poached eggs, fried eggs, and various omelet classes."

"The ham and cheese omelet class is worth special attention because it must inherit characteristics from the pork, dairy, and poultry classes. Thus, we see that the problem cannot be properly solved without multiple inheritance. At run time, the program must create the proper object and send a message to the object that says, 'Cook yourself.' The semantics of this message depend, of course, on the kind of object, so they have a different meaning to a piece of toast than to scrambled eggs."

"Reviewing the process so far, we see that the analysis phase has revealed that the primary requirement is to cook any kind of breakfast food. In the design phase, we have discovered some derived requirements. Specifically, we need an object-oriented language with multiple inheritance. Of course, users don't want the eggs to get cold while the bacon is frying, so concurrent processing is required, too."

"We must not forget the user interface. The lever that lowers the food lacks versatility, and the darkness knob is confusing. Users won't buy the product unless it has a user-friendly, graphical interface. When the breakfast cooker is plugged in, users should see a cowboy boot on the screen. Users click on it, and the message 'Booting UNIX v.8.3' appears on the screen. (UNIX 8.3 should be out by the time the product gets to the market.) Users can pull down a menu and click on the foods they want to cook."

"Having made the wise decision of specifying the software first in the design phase, all that remains is to pick an adequate hardware platform for the implementation phase. An Intel Pentium with 48MB of memory, a 1.2GB hard disk, and a SVGA monitor should be sufficient. If you select a multitasking, object oriented language that supports multiple inheritance and has a built-in GUI, writing the program will be a snap."

The king wisely had the software developer beheaded, and they all lived happily ever after.

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Ten Commandments of Electrical Safety

Navy style, at least. :-)

(From: Gordon S. Hlavenka (nospam@crashelex.com).)

```
I    Beware of the lightning that lurketh in seemingly uncharged capacitors,
     lest it cause thee to bounce upon thy buttocks in an unseamanlike manner
     and cause thy hair to stand on end, thereby exceeding regulation length.


II   Cause thou the switch that supplieth large quantities of juice to be
     opened and thusly tagged, that thy days may be long in this earthly vale.


III  Prove to thyself that all circuits that radiateth and upon which thou
     worketh are grounded and thusly tagged, lest they lift thee to radio
     frequency potential and causeth thee to radiate with the angels.


IV   Tarry thou not amongst those fools that engage in intentional shocks, for
     they are not long of this world and are surely unbelievers.


V    Take care thou useth the proper method when thou taketh the measure of
     high voltage so that thou dost not incinerate both thee and thy test
     meter.  For verily, though thou has no NSN and can be easily surveyed,
     the test meter has one, and as a consequence, bringeth much woe unto thy
     supply officer.


VI   Take care thou tamperest not with interlocks and safety devices, for this
     incurreth the wrath of thy department head and bringeth the fury of thy
     commanding officer on thy head.


VII  Work thou not on energized equipment without proper procedures, for if
     thou dost so, thy shipmates will surely be buying beers for thy widow and
     consoling her in certain ways not generally acceptable to thee.


VIII Verily, verily, I say unto thee, never service equipment alone, for
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     electrical cooking is a slow process, and thou might sizzle in thy own
     fat upon a hot circuit for hours on end before thy maker sees fit to end
     thy misery and drag thee into his fold.


IX   Trifle thee not with radioactive tubes and substances lest thou commence
     to glow in the dark like a lightning bug and thy wife be frustrated and
     have no further use for thee except for thy wages.


X    Commit thou to memory all the words of the prophets which are written
     down in the 300th chapter of thy Bible which is the "Naval Ships'
     Technical Manual", and giveth out with the straight dope and consoleth
     thee when thou hast suffered a ream job by thy division LPO.
```

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Information Transfer - NOT

(If you are actually an engineer, substitute "Engineering" for "Information Technology", below. :)

(From: Martin (wavefront@bigfoot.com).)

A hot-air balloonist realises he is lost, and so reduces height to ask directions from a man on the ground.

"Excuse me, can you tell me where I am?"

"Yes," says the man below, "You're in a hot-air balloon, hovering about 30 feet above the ground."

"You must work in Information Technology" says the balloonist.

"I do," replies the man."How did you know?"

"Well," says the balloonist "everything you have told me is technically correct, but its no use to anyone."

The man below is now getting pissed off.

"You must work in business as a manager," he says.

"I do," replies the balloonist, "but how did you know?"

"Well," says the man, "You don't know where you are, or where you're going, but you expect me to be able to help. You're in the same position you were before we met, but now it's my fault."

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If Cars were like PCs

(Forwarded by: Cye Landy (clandy@columbus.rr.com).)

At a recent computer expo (COMDEX), Bill Gates reportedly compared the computer industry with the auto industry and stated: "If GM had kept up with technology like the computer industry has, we would all be driving $25 cars that got 1000 miles to the gallon."

In response to Bill's comments, General Motors issued a press release stating: If GM had developed technology like Microsoft, we would all be driving cars with the following characteristics:

1. For no reason whatsoever your car would crash twice a day.
2. Every time they repainted the lines on the road you would have to buy a new car.
3. Occasionally your car would die on the freeway for no reason, and you would just accept this, restart and drive on.
4. Occasionally, executing a maneuver such as a left turn, would cause your car to shut down and refuse to restart, in which case you would have to re-install the engine.
5. Only one person at a time could use the car, unless you bought "Car95" or "CarNT". But, then you would have to buy more seats.
6. Macintosh would make a car that was powered by the Sun, was reliable, 5 times as fast, and twice as easy to drive, but would only run on 5% of the roads.
7. The oil, water temperature and alternator warning lights would be replaced by a single "general car default" warning light.
8. New seats would force everyone to have the same size butt.
9. The airbag system would say "Are you sure?" before going off.
10. Occasionally for no reason whatsoever, your car would lock you out and refuse to let you in until you simultaneously lifted the door handle, turned the key, and grabbed hold of the radio antenna.
11. GM would require all car buyers to also purchase a deluxe set of Rand McNally road maps (now a GM subsidiary), even though they neither need them nor want them. Attempting to delete this option would immediately cause the car's performance to diminish by 50 percent or more. Moreover, GM would become a target for investigation by the Justice Dept.
12. Every time GM introduced a new model car buyers would have to learn how to drive all over again because none of the controls would operate in the same manner as the old car.
13. You'd press the "start" button to shut off the engine.

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Why Windows is so Huge, Slow, and Buggy

(Forwarded by: Cye Landy (clandy@columbus.rr.com).)

```
(FOR YOUR EYES ONLY)


/*   Windows '98 source code.
   TOP SECRET Microsoft(c) Code


      Project: Chicago(tm)
 Projected release-date: Summer 1998
*/


    #include "win31.h"
    #include "win95.h"
    #include "evenmore.h"
    #include "oldstuff.h"
    #include "billrulz.h"
    #define INSTALL = HARD


    char make_prog_look_big[1600000];


    void main()
    {
        while(!CRASHED)
       {
            display_copyright_message();
            display_bill_rules_message();
            do_nothing_loop();
            if (first_time_installation)
            {
               make_50_megabyte_swapfile();
               do_nothing_loop();
               totally_screw_up_HPFS_file_system();
                search_and_destroy_the_rest_of_OS/2();
               hang_system();
            }
            write_something(anything);
            display_copyright_message();
            do_nothing_loop();
            do_some_stuff();
            if (still_not_crashed)
```

```
            {
                display_copyright_message();
                do_nothing_loop();
                basically_run_windows_3.1();
                do_nothing_loop();
                do_nothing_loop();
            }
        }


        if (detect_cache())
            disable_cache();


        if (fast_cpu())
        {
            set_wait_states(lots);
            set_mouse(speed, very_slow);
            set_mouse(action, jumpy);
            set_mouse(reaction, sometimes);
        }


        /* printf("Welcome to Windows 3.11"); */
       /* printf("Welcome to Windows 95"); */
       printf("Welcome to Windows 98");
       if (system_ok())
             crash(to_dos_prompt);
       else
            system_memory = open("a:\swp0001.swp", O_CREATE);


        while(something)
       {
            sleep(5);
            get_user_input();
            sleep(5);
            act_on_user_input();
            sleep(5);
       }
       create_general_protection_fault();


   }    crash_no_warning_message
```

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How NOT to Repair a TV

(From: Wes Hilterbrand (replayelectronics@usa.net).)

Here's a humorous (hopefully) little story I wanted to share with everyone.

This is about the people on this earth, and my area especially, that think they can repair stuff without having any clue as to what they are doing. I'm sure most of you know the type.

It happened that a good ol' boy, we'll call him Bubba, had bought a TV, a pretty nice Sanyo DS25030 stereo 25", at a pawn shop I do repairs for. Bubba shortly brought the set back, saying that it quit working. After some questioning, Bubba admitted to connecting the set to 220V(don't ask me how - maybe he thought his reception would be twice as good). The set was in rough condition (more about this follows) and he was told that it may be scrap, but wanted it looked at anyway. The following is my guess as to how the set died - the sequence of events is based on the most obvious things that I found when I looked inside the set. The situations are fictitious - the result of these fictitious situations, however, is sitting on my shop floor.

After Bubba finds out that TVs don't particularly like being fed 220 volts (he was clued in by the loud belch immediately following the feeding), he decides that he can fix whatever ails it. Now he knows that 'lektric'ty is bad for you, so he does unplug the set (Safety first, you know!). Now, instead of finding a 1/4" nut driver or even a socket and ratchet, he uses an angle grinder to cut open the back of the TV. He finds C006, a 470uF 200V electrolytic (that beer-can lookin' thang), blown open. So being the resourceful fellow he is, he wraps approx. 12" of bare 24AWG solid wire around the terminals of the capacitor (about 10 turns) and uses Scotch tape to hold it in place, since he thinks that this part is kinda unnecessary anyway. He plugs the set back in (to 110V this time - he did learn a little), and the main 4A line fuse opens. Again, being the astute repairman, he wraps the fuse with a foil gum wrapper (works ev'ry time!). After plugging the set back in, resistor R001 opens (Why don't this dang thang work?). There are no outward signs that the resistor is open, so Bubba gets discouraged (dang cheap crap TV). He decides he's gonna take it back and claim it's a junk TV. It's a good thing he does, because it probably saves the trailer, outhouse, and dog-lot from burning down.

Well, I picked the TV up yesterday at the pawn shop. The shop owner told me that I didn't need to try to fix it; he was giving it to me. In his exact words, "Anyone stupid enough to open a TV with a grinder is too stupid to own a television anyway." :-)

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Cheat Sheet for Stock Market Reporters

(From: Stan Tamulevich stantam@itis.com).)

- Helium was up, feathers were down. Paper was stationary.
- Fluorescent tubing was dimmed in light trading.
- Knives were up sharply.
- Cows steered into a bull market.
- Pencils lost a few points.
- Hiking equipment was trailing.
- Elevators rose, while escalators continued their slow decline.
- Weights were up in heavy trading.
- Light switches were off.

- Mining equipment hit rock bottom.
- Diapers remained unchanged.
- Shipping lines stayed at an even keel.
- The market for raisins dried up.
- Coca Cola fizzled.
- Caterpillar stock inched up a bit.
- Sun peaked at midday.
- Balloon prices were inflated.
- Scott Tissue touched a new bottom.
- Batteries exploded in an attempt to recharge the market.

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Some Mice are Just Plain Stupid

(Forwarded by: Andre (A.J.De-Guerin@herts.ac.uk).) Some tech was doing a post mortem on a blown TV chassis (fuse kept blowing.) Examined further, found a dead mouse with its teeth firmly embedded in the mains lead to the switch. Its tail was shorting to ground, hence instantly smoked fuses. Tech extracted mouse, set worked OK.

Mouse demonstrated its own stupidity by:

1. Managing to get into a TV without using proper tools (i.e. its teeth).
2. Doing this while set was energized.
3. Chewing the mains HOT lead when it could have munched any of 22 other cables happily without getting fried.
4. Not taking proper electrical safety precautions.
5. Not using established repair techniques (e.g. using own body as a test probe with no series resistor).
6. Forgetting to use an isolation transformer.

Here's what a smart mouse would have done...

1. Waited until set was switched off
2. Chewed half through flyback HV lead in several places
3. Then wait for the action...

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Worst Techs Ever - Take Your Pick

(From: Bill Rosen (brosen@iglou.com).)

By far the worst "tech" I even saw was when I was in the military some thirty something years ago. He would "troubleshoot" boxes that popped circuit breakers (or blew fuses) by holding in the circuit breaker (or putting in a larger fuse) until something smoked and then marking it for "depot" repair. He was great at repairing items that used tubes. He just replaced every tube. It fixed the problem 95 percent of the time. He got transferred at last and I think someone finally got w1 (From: Vince, AA9TL (hamvak@mindspring.com).)

Made him a COOK??? This kinda guy would probably try everything in the pot until he found something that WOULDN'T kill you

(From: Brad Thompson (Brad_Thompson@pop.valley.net).)

During a hitch at Sears as a TV tech, I noted an absence of Phillips screwdrivers. When I borrowed one from the senior tech, he informed me that I should get my own and stash them away where "Bob", another tech, (his real name) couldn't find them.

Apparently, when "Bob" needed a scratch awl or a flat-bladed screwdriver, he'd simply find a Phillips and spend a few minutes at the bench grinder....

"Bob" also once installed a new refrigerator and an icemaker at a customer's house, using only one of two possible screws to fasten the icemaker's "vampire tap" to the cold water line. When the customer returned a few hours later, he found six inches of water in the basement - "Bob's" handiwork had failed.

I wonder what "Bob" does for work today.... He's probably an HMO exec. :-)

(From: Alan Peterman (alp@jps.net).)

For reasons I could never fathom, our AVIONICS shop hired this fellow right out of avionics school. He darn near had to shown which end of the soldering iron to hold.

He once used silicon GLUE, instead of silicon GREASE to pack an aileron servo. That was a fun test flight - I happened to be on it, and when I engaged the autopilot, it promptly blew the circuit breakers - luckily the clutches did their job so we could hand fly the plane.

Then there was the time he wired the lights in a new radio for 12 volts, and put it into a 24 volt plane. Ah well..

Of course we had one mechanic in the power plane shop who often came in somewhat hung over - he forgot to safety wire an oil drain plug on a heart surgeon's plane. Luckily, the plane was a twin so when the plug came off in flight, the doctor was able to land the plane. The shop bought and installed a new engine for him - $18,000 if I remember right.

If you knew the general level of aviation repairmen, you'd be way less happy when flying..

(From: Tobi Scags (tartan54@hotspam.com).)

Just as well he was a heart surgeon, then. He could restart his own when that engine went bang! :)

(From: BillK2 (billk2@aol.com).)

When I started in an engine overhaul shop, airplane yet, all seven of the clamshell balancing machines were down hard. Seems like this fellow replaced the 1/4 amp fuse with a 25 amp fuse in all the controllers. Servos make terrible fuses. A couple of years later I left. Six months after that I got a call from the fellow to see if I had his multimeter. He didn't use it much.

(From: Alan Peterman (alp@jps.net).)

Sounds like the same guy I wrote about. :-)

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Blue Screen on Emerson TV

From a posting on sci.electronics.repair:

> "Can someone explain why my Emerson model VT1975 TV all of a sudden has a blue screen pop up after a few minutes of running?"

(From: Robert Blackshaw (blackshaw@erols.com).)

Is it running Windows 95?

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Airplane Maintenance

WARNING: Don't read if you fly a lot. :-)

(From: Chris (news@zabadak.globalnet.co.uk).)

Here are some apparently actual maintenance complaints submitted by US Air Force pilots and the replies from the maintenance crews. \223Squawks\224 are problem listings that pilots generally leave for maintenance crews.

- Problem: Left inside main tire almost needs replacement.
  Signed Off: Almost replaced left inside main tire.

- Problem: Test flight OK, except autoland very rough.
  Signed Off: Autoland not installed on this aircraft.

- Problem #1: Number 2 propeller seeping prop fluid.
  Signed Off: Number 2 propeller seepage normal.
  Problem #2: Propellers 1, 3, and 4 lack normal seepage.

- Problem: The autopilot doesn't.
  Signed Off: It does now.

- Problem: Something loose in cockpit.
  Signed Off: Something tightened in cockpit.

- Problem: Evidence of hydraulic leak on right main landing gear.
  Signed Off: Evidence removed.

- Problem: Number 3 engine missing.
  Signed Off: Engine found on right wing after brief search.

- Problem: DME volume unbelievably loud.
  Signed Off: Volume set to more believable level.

- Problem: Dead bugs on windshield.
  Signed Off: Live bugs on order.

- Problem: Autopilot in altitude hold mode produces a 200 foot per minute descent.
  Signed Off: Cannot reproduce problem on ground.

- Problem: Friction locks cause throttle levers to stick.
  Signed Off: That's what they're there for.

- Problem: IFF inoperative.
  Signed Off: IFF inoperative in OFF mode.

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You Might Be An Engineer If...

(Forwarded by: Marvin Moss (mmoss@mindspring.com).)

- The only jokes you receive are through email.

- At Christmas, it goes without saying that you will be the one to find the burnt-out bulb in the string of Christmas lights.

- Buying flowers for your girl friend or spending the money to upgrade your RAM is a moral dilemma.

- Everyone else on the Alaskan Cruise is on deck peering at the scenery, and you are still on a personal tour of the engine room.

- In college, you thought Spring Break was metal fatigue failure.

- The Sales People at Circuit City can't answer any of your questions.

- You are always late to meetings.

You are at an air show and know how fast the sky divers are falling.

- You are next in line on death row in a French Prison and you find that the guillotine is not working properly, so you offer to fix it.
- You bought your wife a new CD ROM for her birthday.
- You forget to get a haircut (for 6 months!).
- You can quote scenes from any Monty Python movie.
- You can type 70 words per minute but can't read your own handwriting.
- You can't write unless the paper has both horizontal and vertical lines.
- You comment to your wife that her straight hair is nice and parallel.
- You go on the rides at Disneyland and sit backwards in the chairs to see how they do the special effects.
- You have Dilbert comics displayed anywhere in your work area.
- You have ever saved the power cord from a broken appliance.
- You have more friends on the internet than in real life.
- You have never backed up your hard drive.
- You have never bought any new underwear or socks for yourself since you got married.
- You have used coat hangars and duct tape for something other than hanging coats and taping ducts.
- You know what http:// stands for.
- You look forward to Christmas only to put together the kids' toys.
- You own one or more white short-sleeve dress shirts.
- You see a good design and still have to change it.
- You spent more on your calculator than you did on your wedding ring.
- You still own a slide rule and you know how to use it .
- You think a pocket protector is a fashion accessory .
- You think that when people around you yawn, it's because they didn't get enough sleep.
- You wear black socks with tennis shoes (or vice versa).
- You window shop at Radio Shack.

- You're in the back seat of your car, she's looking wistfully at the moon, and you're trying to locate a geosynchronous satellite.

- Your checkbook always balances.

- Your laptop computer costs more than your car.

- Your wife hasn't the foggiest idea of what you do at work.

- Your wrist watch has more computing power than a 300 MHz pentium.

- You've already calculated how much you make per second.

- You've ever tried to repair a $5 radio.

- Your four basic food groups are: (1) Caffeine, (2) Fat, (3) Sugar, (4) Chocolate.

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The Dark Sucker Theory and the Truth About Light Bulbs

(Forwarded by: Martin Griffith wavefront@bigfoot.com).)

For years, it has been believed that electric bulbs emit light, but recent information has proved otherwise. Electric bulbs don't emit light; they suck dark. Thus, we call these bulbs Dark Suckers.

The Dark Sucker Theory and the existence of dark suckers prove that dark has mass and is heavier than light.

First, the basis of the Dark Sucker Theory is that electric bulbs suck dark. For example, take the Dark Sucker in the room you are in. There is much less dark right next to it than there is elsewhere. The larger the Dark Sucker, the greater its capacity to suck dark. Dark Suckers in the parking lot have a much greater capacity to suck dark than the ones in this room. So with all things, Dark Suckers don't last forever. Once they are full of dark, they can no longer suck - just like a vacuum cleaner does if you forget to change the bag. This is proven by the dark spot on a full Dark Sucker. Then the Dark Sucker quits working.

A candle is a primitive Dark Sucker. A new candle has a white wick. You can see that after the first use, the wick turns black, representing all the dark that has been sucked into it. If you put a pencil next to the wick of an operating candle, it will turn black. This is because it got in the way of the dark flowing into the candle. One of the disadvantages of these primitive Dark Suckers is their limited range.

There are also portable Dark Suckers. In these, the bulbs can't handle all the dark by themselves and must be aided by a Dark Storage Unit. When the Dark Storage Unit is full, it must be either emptied or replaced before the portable Dark Sucker can operate again.

Dark has mass. When dark goes into a Dark Sucker, friction from the mass generates heat. Thus, it is not wise to touch an operating Dark Sucker.

Candles present a special problem as the mass must travel into a solid wick instead of through clear glass. This generates a great amount of heat and therefore it's not wise to touch an operating candle.

Also, dark is heavier than light. If you were to swim just below the surface of the lake, you would see a lot of light. If you were to slowly swim deeper and deeper, you would notice it getting darker and darker. When you get really deep, you would be in total darkness. This is because the heavier dark sinks to the bottom of the lake and the lighter light floats at the top. The is why it is called light.

Finally, we must prove that dark is faster than light. If you were to stand in a lit room in front of a closed, dark closet, and slowly opened the closet door, you would see the light slowly enter the closet. But since dark is so fast, you would not be able to see the dark leave the closet.

So next time you see an electric bulb, remember: It's really a Dark Sucker!

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The Microsoft Phone

(Forwarded by: Brian Karas (brian@karas.com).)

I heard that the current version only allows you to TALK, and the speaker functionality to HEAR the other party is planned for Phone2000.

Also, the 7,9,5,6,3,4,2,0 and * keys do not work, but Microsoft has a special support phone number: 888-888-8888.

The phone is currently available to beta testers, but you can only call other people with the same build of phone that you have, and each call is limited to 7 seconds, including the time while the phone is ringing.

There is a similar product that works with Linux, the sound quality rivals that of $5,000 audio systems, the range of the cordless model is 20 miles, and it stores the entire phone directory locally. However, you need to hardcode the number you are calling into the phone's microcode (in assembler), then recompile it's kernel.

IBM will have their own version shortly, it's just the Microsoft phone in a grey case, but they've also disables the # key, to distinguish it from the Microsoft version.

(From: David Richards (dr@ripco.com).)

Then there's the OpenBSD phone, which works just like the Linux phone except it eliminates the 42 assorted buffer overflows and 'rootshell' holes (which allow anybody to bill international calls to your phone) and is specifically designed to link against a MD5 triple-DES PGP encryption module that you can only download from a server in Argentina. :-)

Oh, and instead of recompiling your kernel, a runtime LKM holds the number to be dialed...

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Miscellaneous Error Messages and Other One-Liners

- Vampire Error: (A)vert, (R)eflect, (I)mpale. :-]
- My other vehicle is a Galaxy Class Starship. =()
- Do wizards use spell checkers?
- He's dead Jim. You get the tricorder, I'll get his wallet. :)
- REALITY.SYS Corrupted: Re-boot universe? (Y/N).
- Drive not ready: (A)bort (R)etry (F)ix with a hammer.
- Radioactive cats have 18 half-lives.
- I am Ohm of Borg. Conductance is futile. (HeHe)
- "I am Homer of Borg, prepare to be ... Mmmmmm. Doughnuts."
- I've heard about the Fountain of Youth, now how about a fountain of SMART?
- Nature abhors second order differential equations.
- One man's magic is another man's engineering. Supernatural is a null word.
- Never underestimate the power of human stupidity. -Robert A. Heinlein
- Wanted: Heisenberg - reason uncertain.. :)
- Do not adjust you mind, it is reality that is malfunctioning.
- We have a DEFENSE department that has a first strike capability?
- Wanted: Schrodinger's Cat - Dead or Alive.
- Think 'honk' if you're a telepath.
- Seen on T-shirts at NASA: WILL BUILD SPACE STATION FOR FOOD.
- We've replaced the Dilithium with new Folger's Crystals.
- SYSTEM ERROR: press F13 to continue.
- SLEEP.COM *** Process interrupted. Kill intruder (Y/N)?
- SMARTDRV installed. It's your data that's stupid.
- Part-time musicians are semiconductors.
- McBorgs - Over one billion assimilated!
- Diagonally parked in a parallel universe.
- Does the name Pavlov ring a bell?
- DOS never says EXCELLENT command or filename.
- Strike any user when ready.
- Critical Error. (S)hout, s(M)ash, or (B)uy a Mac.
- A penny saved is a congressional oversight.
- Error. Keyboard not found. Press any key to continue...
- Keyboard: Device used to enter errors into the computer.
- A seminar on Time Travel will be held two weeks ago
- If it can't possibly go wrong then it will..
- Nothing can go wrofff001010 bus error: core dumped
- For sale: One Russian space station. Needs minor repairs.. 8-)
- For sale: Politicians brain. Never used.
- For sale: Minor planetoid. First person to land there gets ownership...

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Guaranteed to Start a Flame War

How about...

- Self discharge of car batteries left sitting on concrete floor.
- Magnetic water treatment.
- Free energy, cold fusion.
- Power factor correction and fooling the power meter.
- Traffic light remote controls, radar detectors and jammers.
- How to build a stun gun (or star wars laser saber).
- Do we need TCE's RealStuff[tm] solder to do the CTC169 tuner fix?
- Business practices and strange customers in the repair business.
- Lamenting about the quality of $99 Walmart VCRs and TVs.

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How to Cure a Parrot with a Bad Attitude

(Forwarded by: Redgie (RodzSkolar@aol.com).)

David received a parrot for his birthday. The parrot was fully grown with a bad attitude and worse vocabulary. Every other word was an expletive. Those that weren't expletives, were to say the least, rude.

David tried hard to change the bird's attitude and was constantly saying polite words, playing soft music, anything he could think of to try and set a good example...

Nothing worked. He yelled at the bird and the bird yelled back. He shook the bird and the bird just got more angry and more rude. Finally, in a moment of desperation, David put the parrot in the freezer.

For a few moments he heard the bird squawk and kick and scream - then suddenly, there was quiet. Not a sound for half a minute.

David was frightened that he might have hurt the bird and quickly opened the freezer door. The parrot calmly stepped out onto David's extended arm and said, "I believe I may have offended you with my rude language and actions. I will endeavor at once to correct my behavior. I really am truly sorry and beg your forgiveness."

David was astonished at the bird's change in attitude and was about to ask what had made such a dramatic change when the parrot continued,

"May I ask what the chicken did?".

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One Frustrated Frog

(Forwarded by: Larry Steckler (Lartronics@aol.com)

A guy is taking a walk and sees a frog on the side of the road. As he comes closer, the frog starts to talk. 'Kiss me and I will turn into a princess.' The guy picks the frog up and puts it in his pocket.

The frog starts shouting, 'Hey! Didn't you hear me? I'm a Princess. Just kiss me and I will be yours.' The guy takes the frog out of his pocket and smiles at it and puts it back.

The frog is really frustrated. 'I don't get it. Why won't you kiss me? I will turn into a beautiful princess and do anything you ask.'

The guy says, 'Look, I'm a computer geek. I don't have time for girls. But a talking frog is cool!'

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A Little Project

(From: Ralph & Diane Barone (barone@mdi.ca).)

Someone wrote:

> "I need to convert 300,000 Volts DC to 240 VAC, 60 Hz. 80 mA is available from a 300 kV DC source which equals 24 kW. This means 100 Amps capability from the 240 volt 60 Hz output of >some type of converter.
>
> Does anyone have recommendations or schematic diagrams that would provide a conversion for high voltage/low current TO low voltage/ high current as stated above?
>
> Thanks!"

No problem. We have one almost like that where I work (ratings are only slightly different). However, here is the description:

We use SCRs because we are connected to an existing AC power supply and we can let the external supply commutate the SCRs. If you don't have an external AC supply, you will need to use power MOSFETS, IGBTs or GTOs. In our application, each SCR is in an arrangement of 360 devices connected in series parallel (180 series/2 parallel) with the requisite firing pulse isolation transformers (720), RC snubbers (2,160), voltage breakover firing circuits (4,320) and dI/dt limiting series reactors (1,980). Firing pulses come from a custom GE control system which occupies three 3' wide cabinets. From the transformers, we go into our 230 kV AC bus. We have filters on the AC bus to remove the harmonics created by the conversion process. These filters consist of air core (but oil cooled) reactors and a whole wack of capacitors. These filters occupy approx 300 square meters of space in the switchyard.

After the 230 kV bus, we step the power down to 25 kV, then we have another transformer that goes 25 kV to 240 V with a grounded center tap.

If you would like photocopies of our design drawings, please send me five (5) empty 4 drawer filing cabinets and $10,000 to cover copying and shipping. :)

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The Ultimate Engineering Test

What we REALLY need here is a test that checks to see if you're competent to deal with REAL-WORLD design issues. I will humbly (yeah, right) now offer a few example questions to get us started:

(Test questions from: Bob Myers (myers@fc.hp.com). Answers from: Sarlock T. (sarlock@twcny.rr.com).)

- Q1. Your management has handed you a set of design specifications which violate all known laws of physics, including several from the "Star Trek" universe. What should you do?

  A1. Lights, lots of blinky lights and special effects, incorporate lasers if need be, and sound you need lots of sound (every time you push a button it beeps) and the power supply has got to hum like it's sucking down 5,000 amps.

- Q2. Supplier A offers components which are technically superior and available at half the cost of supplier B's, but supplier B gives you better T-shirts. Whose party do you try to crash at Comdex?

  A2. Both of them, because the one with the more expensive parts and T-shirts will have better liquor, and the ones with the cheaper parts might have free samples, maybe some cheap liquor to get you started ;)

- Q3. Through basically clumsy application of a test probe and an unfortunate error regarding which terminal was the 400V supply, you have destroyed a prototype representing 300 man-months of effort and an R&D budget equal to that of some developing nations. Who should you blame this on, and how?

  A3. The same people who are conspiring to sell the public short life light bulbs.

- Q4. List, in descending order of generated volume, the top 5 components in terms of producing the most smoke when incorrectly connected.

  A4. Oil Filled Capacitors, oil filled transformers, transformers, electrolytic caps, and hmmm, maybe really big carbon resistors?

- Q5. Give at least three examples of politically-incorrect color-code mnemonics.

  A5. Err... yoiks, I guess I flunk the test, I only know one..

- Q6. How many "Dilbert" calendar pages are required to fully cover the walls of the average R&D engineer's cubicle?

  A6. Unknown, I've never met an 'average' engineer. :)

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Battery Powered Human

So, how many AA batteries would it take to power a standard adult human for one day?

(From: Ben Gebeau (bengebeau@hotmail.com).)

A Manganese/Alkaline AA cell it rated at about 2.4 AH. If we assume 1.5 volts average this gives approximately 3.6 watt hours (slightly optimistic). Since there are 3,600 seconds in an hour this is equivalent to 12,960 Joules.

A human consumes about 2,000 calories/day. A dietician calorie is equal to 1,000 engineering calories. A calorie is equal to 4.2 Joules. Therefore this is equivalent to 2,000 * 1,000 * 4.2 = 8.4 * 10E6 Joules per day.

Dividing one by the other you will need about 648 AA cells to power a human for one day.

This assumes that the power from the AA cell will go through the same inefficiencies as the chemical processes in a human. (A human runs at about 20% efficiency chemical energy to mechanical energy). If we can circumvent this inefficiency we would only need 20% of this number of cells - say 130 cells.

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Cooking Versus Engineering

(From: ANHCNS (anhcns@aol.com).)

In my month+ of unemployment, I've been keeping busy around the house between the occasional interviews or lead followup. One of the things that has been filling my time is cooking.

I'm not a pro-chef, but I believe it is the result of a 'Transferrable Skill' of Electronics.

Let's compare...

```
      Baking cookies                 Assembling a circuit
  --------------------------------------------------------------------
     First get a recipe              First get a schematic
     then round up ingredients       then round up components
     Mix ingredients                 Bend and cut leads, etch PCB, etc.
     Bake                            Solder
     Enjoy                           Enjoy!
```

(From: Sam)

The true engineer will insist on NIH - Not Invented Here - and do their own design. Likewise, the true chef will create his/her own recipe for each batch of cookies!

(From: Robert Hancock (hancockr@home.com).)

Not to mention that in both activities, you can tell you screwed up by all the smoke and the bad smell. :-)

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Sometimes it DOES take a Rocket Scientist

(Source unknown, forwarded by Jeff Gronito (jmg@repairfaq.org).)

Scientists at NASA have developed a gun built specifically to launch dead chickens at the windshields of airliners, military jets and the space shuttle, all traveling at maximum velocity. The idea is to simulate the frequent incidents of collisions with airborne fowl to test the strength of the windshields. British engineers heard about the gun and were eager to test it on the windshields of their new high speed trains. Arrangements were made. But when the gun was fired, the engineers stood shocked as the chicken hurtled out of the barrel, crashed into the shatterproof shield, smashed it to smithereens, crashed through the control console, snapped the engineer's backrest in two and embedded itself in the back wall of the cabin. Horrified Britons sent NASA the disastrous results of the experiment, along with the designs of the windshield, and begged the U.S. scientists for suggestions. NASA's response was just one sentence, "Thaw the chicken."

(From: David Cary (d.cary@ieee.org).)

The The Rooster Booster Page and Urban Legends Reference Page have more facts and links on this exciting topic.

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The Ultimate in New and Improved Speaker Cable!

(From Steve Roberts (osteven@akrobiz.com).)

We here at Infinite Audio have a announcement of our new product line, speaker cables for the wickedly rich.

First of all, our new **Dark Optical Speaker Cable:** Tired of shot noise and 1/F noise interfering with your quiet passages? Our new dark cable relies on the fact that the speed of darkness is indeed faster then the speed of light. Our cable converts your amp output to light, thus when there is no audio, there is dark, to quickly sweep away light noise, long before it can start. $1995 a foot, polishing and termination extra.

Second is our new **Blumlein Series Speaker Cable:** We use a second mirror cable to add capacitance in parallel with the existing cable, then just when you need it for those splendid tweeter blowing highs or that extra megawatt of base, our patented superswitch RCA Tee connector/switch takes the stored energy in your cable and uses it to its maximum by converting from series to parallel. Superswitch's patented tin plating makes the switching decisions far faster then any solid state device could. By using our short pulse energy techniques, you will actually be able to see your tweeter diaphragms move, and move faster. 2300$ a foot, exclusive licensing and secrecy agreement required. Inquire today about our boosted storage version for class D PWM amps!

Finally, **Cryocord**, our revolutionary new cable for home theater installs. Cryocord consists of a 99.9% pure copper core zip cord plated with 14 karat gold then dipped with a layer of of our patented mercury superconductor material. This core is then wrapped with 20 turns of our super low leakage kraft paper insulator and shoved down a long piece of large diameter glass tubing which is ringed by a another silver plated glass tube with a vacuum in it, thus preventing loss of your precious audio signal by the dreaded permittivity and resistivity of dry air. Copious quantities of liquid nitrogen from a 16 meter long 3 meter diameter tank on a semi truck are then pumped through the cable, insuring that your amps see a zero ohm, zero parasitic cable straight to your speakers. Each speaker has its own glasswork, thus greatly reducing crosstalk. Note: If you need to move a speaker, please schedule a visit from Horatio, our friendly glassblower two to three months before you need to move the speaker. Pricing available on request, please bring you current rating in Whos Who and Your listing in Standard and Poor's along with some stock certificates with intact coupons before ordering. Remember with our Dewer covered cables, you can brag about being hollow state through your system!

Seriously, $7K for a chunk of pink pre-soldered ribbon cable with cheap shrink and Far East RCA plugs! Man, am I in the wrong business!!!!! They didn't even bother to make every other strand a ground to reduce crosstalk. ;-) And, they forgot the silver solder for better conductivity.

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The Technology of Startrek

Some of my observations, in no particular order:

1. Life and death are a binary process - with one quick low cost test using the Tricorder, the Doc will know if the patient will survive and if not, down to the microsecond when death will occur, unless (1) there is a stasis chamber handy or (2) some alien technology is available.

2. It is generally possible to duck the 24th century hand weapon. I recommend a 1930's vintage submachine gun if you have a choice.

3. Starship weapons couldn't hit the broad side of a barn and targeting servo systems are totally useless.

4. Diagnostics are guaranteed to determine everything there is about the ship's systems. The remedy will always involve improving the efficiency of something.

5. Computer backups aren't used any more frequently in the 24th century than our own.

6. The concept of the 'copy' and 'cp' command was lost sometime after the breakup of Microsoft.

7. Somehow, it is possible to send an entire person (real or holographic) through an alien comm link or wormhole that won't even pass a short audio fragment intact.

8. The Holodeck safety systems can somehow be disabled by the holographic characters. Somehow, this is the first thing to happen in a crisis.

9. The Transporter acts as a high resolution 3-D fax XOR a matter transfer device depending the script's needs.

10. The Enterprise crew will fail to attack a knowingly hostile alien ship at point-blank range that everyone in the audience knows should be vaporized instantly if the rest of the plot would be nullified by its destruction (e.g., the Borg sphere in "First Contact").

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If God were an Engineer

I (Sam) must note that I firmly believe in Darwinian evolution as the basis for all life on Earth. However, much of the structure of DNA might just be consistent with creationism if God were an engineer:

Considering the tight (but not unusual) schedule of 6 days for the "Earth Project", any resourceful engineer must do whatever it takes. Note that even for God, I do suspect that the 6 day goal was just a bit optimistic and with the usual delays, it probably did in fact stretch to 3 or 4 billion years in schedule overruns as is typical in these cases.

Any seasoned engineer, having outgrown the NIH (Not Invented Here) syndrome will always attempt to reuse whatever can be reused. Programmers take their old programs and rework them; computer designers base new products on those that have come before. Why should Life be any different? When assigned to create, say, a Better Bug, one should always start with a success story like the cockroach and just make minor modifications (another thing all Engineers know is to change as little possible between revisions). Shorten a leg, lengthen a mouth part, tinker with their mating call, etc., based on all the considerable stack of problem report forms collected over a few billion years.

In the case of Man, being quite complex after all, even if not quite as complex as everyone thought a little while ago, any approach that saves time would be beneficial. So the overworked Engineer would download the best features (in their opinion, lacking realistic input from the Marketing Department or Management, "No chance, adding 2 additional arms would blow the project schedule and budget!") of mice and monkeys and just add the necessary DNA to combine them as quickly as possible. Note that during this process, its not surprising at all that some unfortunate defects (bugs?) have crept into the DNA. And, what about all that junk DNA? Any software programmer knows that when writing a new program, it is expedient to include all the subroutines ever likely to be used - computer memory is cheap but trying to figure out exactly what will be needed ahead of time takes too much time. However, much of that code never actually gets used and ends up in this case as what our greatest minds have declared to be filler. (But, some small amount could also be comment statements!) So, it's not unexpected that Man has only about twice as many genes as a fruit fly. However, if an ear of corn really does have about the same number of genes as Man, some cost reduction should certainly be possible (for the corn at least).

The dinosaurs were one of those Marketing experiments that wasn't entirely successful and the product line had to be cut in conjunction with a down-sizing. Same for wooly mammoths. These had both been pushed over the considerable objections of the Engineering Department unworkable and inefficient and it was thus quite amazing they lasted as long as they did. Insects, on the other hand, have been one of the best collections of critters providing a steady return over the eons.......

So, if God were an engineer, one could almost believe in creationism. :)

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The Truth About Electric Circuits

(Forwarded: Tom MacIntyre (tmacinty@ns.sympatico.ca).)

Quote from Dave Barry:

> "Electricity originates inside clouds. There, it forms into lightning, which is attracted to the Earth by golfers. After entering the ground, the electricity hardens into coal, which, when dug up by power companies and burned in big ovens called 'generators,' turns back into electricity, where it is transformed by TV sets into commercials for beer, which passes through the consumers and back into the ground, thus completing what is known as a 'circuit.'"

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More Takes on Comprehending Engineers

(Forwarded by: Dave Carpenter (voicebox@dnai.com).)

1. Three engineering students were gathered together discussing God. One said, "God is a mechanical engineer. Just look at all the joints." Another said, "No, God is an electrical engineer. The nervous systems has many thousands of electrical connections." The last said, "Actually, God is a civil engineer. Who else would run a sewage pipeline through a recreation area?"

2. A priest, a lawyer and an engineer are about to be guillotined. The priest puts his head on the block, they pull the rope and nothing happens. He declares that he's been saved by divine intervention, so he's let go.

   The lawyer is put on the block, and again the rope doesn't release the blade. He claims he can't be executed twice for the same crime and he is set free too.

   They grab the engineer and shove his head into the guillotine. As he looks up at the release mechanism, he says, "Wait a minute, I see your problem..."

3. There once was an engineer who had an exceptional gift for fixing all things mechanical. After serving his company loyally for over 30 years, he happily retired. Several years later the company contacted him regarding a seemingly impossible problem they were having with one of their multi-million dollar machines. They had tried everything and everyone else to get the machine fixed, but to no avail. In desperation, they called on the retired engineer who had solved so many of their problems in the past. The engineer reluctantly took the challenge.

   He spent a day studying the huge machine. At the end of the day, he marked a small "x" in chalk on a particular component of the machine and proudly stated, "This is where your problem is". The part was replaced and the machine worked perfectly again. The company received a bill for $50,000 from the engineer for his service. They demanded an itemized accounting of his charges. The engineer responded briefly:

    - One chalk mark: $1.

    - Knowing where to put it: $49,999.

   It was paid in full and the engineer retired again in peace.

   (A common variation on this one is that the "X" marked where to smack the machine with a big hammer. --- Sam)

4. The Top 10 Things Engineering School Didn't Teach

   #10. There are at least 10 types of capacitors.
   #9. Theory tells you how a circuit works, not why it does not work.
   #8. Not everything works according to the specs in the data book.
   #7. Anything practical you learn will be obsolete before you use it, except the complex math, which you will never use.
   #6. Always try to fix the hardware with software.
   #5. Engineering is like having an 8 a.m. class and a late afternoon lab every day for the rest of your life.
   #4. Overtime pay? What overtime pay?
   #3. Managers, not engineers, rule the world.
   #2. If you like junk food, caffeine and all-nighters, go into software.
   #1. Dilbert is a documentary.

5. What is the difference between Mechanical Engineers and Civil Engineers? Mechanical Engineers build weapons, Civil Engineers build targets.

6. Engineers think that equations approximate the real world.
   Scientists think that the real world approximates equations.
   Mathematicians are unable to make the connection...

7. A pastor, a doctor and an engineer were waiting one morning for a particularly slow group of golfers. The engineer fumed, "What's with these guys? We must have been waiting for 15 minutes!" The doctor chimed in, "I don't know, but I've never seen such ineptitude!" The pastor said, "Hey, here comes the greens keeper. Let's have a word with him."

   "Hi George. Say, what's with that group ahead of us? They're rather slow, aren't they?"

   The greens keeper replied, "Oh, yes, that's a group of blind fire fighters. They lost their sight saving our clubhouse from a fire last year, so we always let them play for free anytime." The group was silent for a moment.

   The pastor said, "That's so sad. I think I will say a special prayer for them tonight."

   The doctor said, "Good idea. And I'm going to contact my ophthalmologist buddy and see if there's anything he can do for them."

   The engineer said, "Why can't these guys play at night?"

8. In the high school gym, all the girls in the class were lined up against one wall, and all the boys against the opposite wall.

Then, every ten seconds, they walked toward each other until they were half the previous distance apart.

A mathematician, a physicist, and an engineer were asked, "When will the girls and boys meet?"

The mathematician said, "Never".

The physicist said, "In an infinite amount of time."

The engineer said, "Well... in about two minutes, they'll be close enough for all practical purposes."

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Where weatherman come from

(Originally from a college chemistry text. Forwarded by: Dave Carpenter (voicebox@dnai.com).)

- Bad chemists become mathematicians.
- Bad mathemeticians become physicists.
- Bad physicists become weathermen.

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How to make a perpetual motion machine

(Portions from: Stephen Shaw (xstephenx@apple2.org.za).)

The only known way to make a perpetual motion machine is with a cat and a slice of buttered toast. Buttered toast always lands face down when dropped. A cat always lands on its feet when dropped. Therefore, if you tie a slice of buttered toast face up on the cats back you will have a (hovering) perpetual motion machine as both items try to land on their respective correct positions.

The greatest minds pondering the secrets of the Universe have been unable to explain away the violation of laws of conservation of energy but as "they" say: "If it works, use it!" :)

(From: Duke McMullan, N5GAX (DukeMc@mail.com).)

It's a nice idea, but it doesn't work. Evidently the spin states of the bread/cat dipole are unresolved, so it spins in a superposition of clockwise and counterclockwise. All attempts to collapse its collective wave function to date have extracted no useful energy, have gotten butter all over the experimenter's clothes, and usually deep claw marks resulted in the experimenter's arm and hand.

("What did you do to the cat? It looks half dead." --- Schrodinger's wife.)

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Patient Advice and Consultation

(From: Lance Dyer (d.lance@sk.sympatico.ca).)

Patient's guardian complained of a washed out vision with prominent white lines across the face when awoken. Secondary complaint of bright red face when going to sleep as well as turning green or red when channels rolled over and prominent white lines in the face as well.

Patient history

- First Name - F27700.
- Second Name - CTC169c-5.
- Family - RCA.
- Birthday - 1993 week 34.
- Age - approximately 8 years.

Consent for treatment signed by guardian.

Diagnosis

9:30 am:

Upon initial diagnosis found patient to be suffering from a malfunction at the junction of the E-C of q2906 luminance buffer. Junction was shorted.

Action taken:

9:45 am:

Patient was immediately scheduled for transistor-ectomy to remove the failed component. Solder pads were cauterized with hot iron and excess fluid removed with sterile solder wick gauze. Diseased part was skillfully replace with donor transistor. Pads were recauterized and an antiseptic 60/40 solder was placed over joints for strength and protection.

Patient Status

9:50 am:

Patient awoke from operation with normal vision and all vital signs checked normal and within acceptable parameters.

Patient transferred to intensive care for monitoring:

10:20 am:

Patient went into arrest. Face flashed, shrunk in height and died. Attempt to restart patient with power button failed. Unit unplugged and expletives expressed to the corpse. Removed guts and began examination again.

Found same malfunction at the junction. Applied power to patient to check vital signs and patient was alive with washed out white face and lines. Patient had relapsed. Repeated transistor-ectomy with another donor transistor, checked vital still normal.

5:30 pm:

Left to go golfing for the day. Patient was still stable at this time.

Would like a consultation and second opinions on whether or not this patient has:

1. An incurable disease of an intermittently shorting picture tube causing cancer of the buffer.

2. A virus or leprosy of the luminance buffer that is attacking it at random.

Sorry my HMO or Health Care provider will not pay for consultation fees but your input is greatly appreciated.

Signed: Dr. Lance R.A.T.S (Radio And Television Service)

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Mental Calculation in the Service Shop

(From: Jerry Greenberg (jerryg50@hotmail.com).)

The benefit is to have a good idea of what your answer is going to be.

This is especially true in calculation your customer's reaction when you tell him the bad news, and how much it is going to cost him! You then square that factor, and convert it to the distance that will be required between you and him. Just make sure that you have a very wide service counter between you and him to start with!

The width of the service counter should be at least 1-1/2 his arm length plus 12% of his height. You should be standing at a distance of about 30% more then the sum of his blood pressure + the other mentioned factors. Also, it is important that you are wearing a very good pair of high-grip running shoes, shorts, and a tee-shirt. A good non-slip coating on the bottom of the running shoe soles would also be a good idea. There should be a clear path between you and the opposite direction from him.

Now this is a good logical mental calculation for you.

I think this should sum things up for Y'a!

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The System Administrator

This is the individual (usually a human being but perhaps not always) who runs the computer system or ISP you use. They are all alike. Pimply-faced teenagers or if older than 19, pimply-faced teenager wannabees who have never grown up. They have absolute power over their kingdom, whether it's a unix, linux, VMS, or Win NT system, or server farm. This is something not found in many other professions or even most nation states.

Their domain will be an office or cubical with at least 4 of the fastest computers (not accessible to "users") with the best flat panel LCD monitors currently available. If asked a question, the reply will not be a complete sentence or even in English but some obscure technospeak designed to be impossible to understand. When asked to clarify, the response is likely to be a similar sentence fragment selected to indicate that anyone with intelligence greater than that of a typical carrot should have understood the first time. Very often, the first attempt to fix something will not work but when told this, they will never admit the possibility of having made a mistake but will just try something else that doesn't work. Only after several aborted attempts obviously becoming increasingly annoyed at having to cater to a mere mortal, will the concept of actually testing what was done enter their mind. And then, it will somehow have been the user's fault even if protections and variables in 17 locations which could be accessed only by the Sysadmin had to be changed. That is, if they can take time out from playing Doom to actually respond to questions.....

My apologies to those system administrators who are actually real human beings. :)

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Reward Offered

(From a posting on the USENET newsgroup sci.electronics.repair by Bob Parker (bobpar@ozemail.com.au).)

A reward of 500 microfarads is offered for information leading to the arrest of Hopalong Capacity. This unrectified criminal escaped from a Weston Primary cell, where he had been Clamped in Ions awaiting the Gauss chamber.

He is charged with the induction of an 18 turn Coil named Milli Henry, who was found Choked and robbed of valuable Joules. He is armed with a Carbon Rod and is a Potential killer.

Hopalong Capacity is also charged with driving a DC motor over the Wheatstone bridge and refusing to let the Band Pass. If encountered he may offer Series Resistance.

The Electromotive Force spent the night searching for him in the Magnetic Field where he had gone to Earth. They had no success and believed Capacity returned Ohm via a Short Circuit. He was last seen, riding a Kilocycle with his friend, Eddy Current, who was playing "Ohm on the Range" on his Harmonic.

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Engineering Marketing Hype Translated

(From: nipperchipper (nipperchipper@hotmail.com).)

- NEW: Different color from previous design.
- ALL NEW: Parts not interchangeable with previous design.
- EXCLUSIVE: Imported product.
- UNMATCHED: Almost as good as the competition.
- DESIGNED SIMPLICITY: Manufacturer's cost cut to the bone.
- FOOLPROOF OPERATION: No provision for adjustments.
- ADVANCED DESIGN: Nobody understands it.
- FIELD-TESTED: Manufacturer lacks test equipment.
- HIGH ACCURACY: Unit on which all parts fit.
- DIRECT SALES ONLY: Factory had big argument with distributor.
- YEARS OF DEVELOPMENT: We finally got one that works.
- REVOLUTIONARY: It's different from our competitors.
- BREAKTHROUGH: We finally figured out a way to make it work.
- FUTURISTIC: No other reason why it looks the way it does.
- DISTINCTIVE; A different shape and color than the others.
- MAINTENANCE-FREE: Impossible to fix.
- RE-DESIGNED: Previous faults corrected, we hope....
- HAND-CRAFTED: Assembly machines operated without gloves on.
- PERFORMANCE PROVEN: Will operate through the warranty period.
- MEETS ALL STANDARDS: Ours, not yours.
- ALL SOLID-STATE: Heavy as Hell!
- BROADCAST QUALITY: Gives a picture and produces noise.
- HIGH RELIABILITY: We made it work long enough to ship it.
- SMPTE BUS COMPATABILE; When completed, will be shipped by Greyhound.

- NEW GENERATION: Old design failed, maybe this one will work.
- MIL-SPEC COMPONENTS: We got a good deal at a government auction.
- CUSTOMER SERVICE ACROSS THE COUNTRY: You can return it from most airports.
- UNPRECEDENTED PERFORMANCE: Nothing we ever had before worked THIS way.
- BUILT TO PRECISION TOLERANCES: We finally got it to fit together.
- SATISFACTION GUARANTEED: Manufacturer's, upon cashing your check.
- MICROPROCESSOR CONTROLLED: Does things we can't explain.

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A Guide to Abacus Repair

> "My abacus, the most advanced computing device known to mankind, is damaged. What do I need to repair such a highly sophisticated device ? Please help!"

(From: Jeff Liebermann (jeffl@comix.santa-cruz.ca.us).)

You forgot to specify the maker, model, and exact mode of failure. In most cases, the failure is not mechanical but can be attributed to operator error. However, there are some common problems found in the common abacus:

1. Do you have a worm? This is found by running one of the various worm and virus removal programs. They'll help you spot the holes in the main frame bored by the worm. Remedial action depends upon the type of worm. To avoid further infections, please use an anti-worm cover and scan for worms often.

2. When did you last reboot your abacus? Simply shaking the abacus to remove cached numbers often helps with arithmetic errors.

3. Have you installed all the updates and patches necessary for efficient operation? While many of these patches may look like band-aids, cloths pins, hose clamps, sticky goo, and other temporary contrivances, it's the best that the manufacturers can offer.

4. Are you running an open source abacus? If so, you may be missing some dependency or library required to run the abacus. Please inspect the storage area to insure that everything is properly installed. Consult your librarian for the missing libraries.

5. Utilities often interfere with the operation of the abacus. For example, a bolt on fan, cell phone, and CCFL lamp will suck all the power from the abacus. I suggest unloading all your utilities and accessories and see if that helps.

6. Do you have sufficient cooling? The high performance abacus can have considerable friction between the main frame data paths and the beads. If you overclock the abacus and operate the beads faster than the manufacturer intended, heating will be an issue.

Hopefully, these pointers will help you repair or mitigate your undisclosed abacus problem. This is a good thing because when computers are universally banned as a serious detriment to productivity, the abacus will then be the primary computing system.

(From: Sam.)

Also note that accidentally installing some of the beads upside-down can result in subtle errors in lengthy calculations. If the abacus was recently repaired, this may be the problem. Unfortunately, I do not know how to determine if the beads are orientated correctly. :)

In the future, please include the builder's name and approximate date of construction (within a century or two would be adequate). This is the only way anyone can provide specific repair information.

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-- end v2.09 --

International Power and Standards Conversion

Version 1.12

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

While every effort has been made to assure that the information in this document is accurate and complete, there is no way to guarantee that it will apply to your particular equipment. Depending on the specific design, what works in most cases may result in unacceptable performance, blown fuses or tripped circuit breakers, or overheating and possible fire, damage to the powered equipment or property.

We will not be responsible for improper operation, equipment or collateral damage, or expenses resulting from following the suggestions contained herein.

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Introduction

Scope and Purpose of this Document

The following types of questions arise quite often:

- Question: Will my U.S. made TV and VCR work in Europe?

  Answer: A simple step down transformer to convert from 220 to 110 V will probably permit them to work together (i.e., to play previously recorded tapes) but you will not be able to receive any cable or broadcasts.

- Question: I have a microwave oven but will be moving to France. Would I be better off selling it or getting a power adapter?

  Answer: Due to the high wattage of a microwave oven, converting the power will be costly. Sell it and buy a new one at your destination.

- Question: Should I bring by European appliances back to the U.S.?

  Answer: This depends on the specific appliances. See the remainder of this document!

- Question: Will my Onkyo receiver work in Japan?

  Answer: Not without some modifications - which may not be worth it.

We cannot generally provide an answer based on your exact model equipment and the specific standards in use. There are too many variations to deal with in this sort of document. However, the information contained herein in conjunction with the type and specifications of the equipment you own and the power and standards in use at your destination hsould enable you to make an informed decision. Note that if you plan to be moving between countries with different standards, it may pay to invest in appliances and electronic specifically designed for multisystem operation. However, there are all sorts of definitions of 'multisystem' - not all will handle what you need so the specifications must be checked carefully and even then, marketing departments sometimes get in the way of truth in advertising! Again, the information in this document and the links below should aid in this effort.

Related Information

A great deal of specific country information is available at:

- World Electric Guide

including power, plug configurations, telephones, and TV standards.

This should help you issues involved before you reach your destination!

Panel Components - Guide to Worldwide Plug/Socket Patterns and Power Mains has information and photos.

In addition, we deal with general issues related to adapting entertainment equipment and appliances to different power and the implications of reduced or increased voltage and frequency.

Note: this initial release will concentrate mostly on power issues. Later, we will deal with video, communications, and phones systems. For those, the documents: Notes on Video Conversion, Troubleshooting and Repair of Computer and Video Monitors, Troubleshooting and Repair of Television Sets, and Troubleshooting and Repair of Video Cassette Recorders, and others at this site may contain some of the information you seek on these other topics.

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Types of Conversion

You Mean it is More Than Just the Type of Plug?

It would be nice if all you had to do was match up a plug and socket to make anything in the universe work together. Unfortunately, while this does work for some things - garden hoses, for example :-) - it rarely is as simple as this for electrical power, video, or communications.

Power Conversion

This relates to what comes out of the wall socket. Nearly every country in the world uses an AC voltage between 90 and 240 V at 50 or 60 Hz. There may be some exceptions (like 600 V at 25 Hz powering portions of the New York City subway system or 28 V at 400 Hz on board an F-18 - but this is not something you are likely to need to deal with!) - if you encounter such unusual situations, we will be happy to add them to this document!

The three important considerations are:

- Voltage - the RMS (Root Mean Square - you really don't need to worry about the term) value of the nominal power line voltage. (OK, if you really care, the RMS value of an AC waveform will be equal to that of a DC voltage which will have the same heating effect. It is the squareroot of the mean (average) of the waveform squared. Got that? :-).

- Frequency - the number of cycles per second now expressed in Hz (pronounced like the Hertz car rental company). Almost all power around the world is AC. There are some exceptions but you will be unlikely to encounter them.

- Plugs and sockets - there are several dozen variations (at least) with and without a safety ground depending on your location. If you purchase *the* adapter that they recommend at the travel store, there is good chance it will not fit when you actually get to your destination! However, there are universal plug and socket adapter sets which may have a better track record.

Video Standards Conversion

This relates to the scan rates, color encoding, and audio transmission of the baseband video signals in use in your country.

- Scan rate - how many total scanning lines are used and how many times per second a complete picture is 'painted' on the picture tube screen. (Note that exsiting TV standards use interlaced scanning - a picture is made up of an even field (all the even numbered lines) and an odd field (all the odd numbered lines) and a picture consists of both of these. The most common (pre-HTDV) are 525 lines at 30 Hz (e.g., U.S. NTSC) and 625 lines at 25 Hz (e.g., U.K. PAL). However, there are others.

- Color Encoding - the way the color information is combined with the basic monochrome (black and white) picture signal. These differ between NTSC and PAL and there are several variations for PAL as well. The effect of a TV with the wrong decoding circuitry will be either a black and white picture or possibly color interference effects.

- Audio - the location of the subcarrier frequency for the sound information among other things may differ as well.

Broadcast (and Cable) Standards

- Radio - AM and FM channel locations and spacing.

- Video - VHF and UHF channel assignments, color encoding, audio carrier, etc.

- Telephone - ???

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Voltage Conversion Issues and Common Types of Voltage Converters

How to Get Power for Equipment A to Work with Equipment B

There are a variety of approaches to adapting equipment designed for one power system to another.

- Transformers will always work but may be too heavy or expensive to justify their use.
- Electromechanical approaches go back quite far, are quite efficient, but are heavy, bulky, noisy, not very flexible.
- Solid state converters vary widely in complexity, capabilities, and cost. Some may destroy motors or electronic equipment and this may not be obvious from the product description.

Note that in cases, the proper (or close enough) power may be available already.

- Where 110 VAC is standard, 220 VAC is usually present in the residence since the power originates from a 220-0-220 VAC utility (pole) transformer. In some cases, a suitable outlet will even be present though usually one will have to be added. Whether this is worth the effort and expense for a $30 coffeemaker you picked up in your travels is another matter. :-)

  In industrial or office buildings, 208 VAC will be available (since they use three-phase power but that is another story) and this may be close enough for most applications (though heating appliances won't be quite as zippy as if they were running on the proper 220 VAC and therefore your eggs may take a little longer to cook).

- Where 220 VAC is standard, hotels and other public buildings may provide 110 VAC convenience outlets for foreign visitors. While the frequency will probably still be the standard 50 Hz for these countries, many appliances don't care. See the chapter: "Frequency Issues".
- Many appliances have a voltage selector switch usually near the power cord entrance though some may require changing internal jumpers. See your user manual! This is particularly true of appliances that are typically used overseas like shavers.
- Many types of equipment like laptop computers, camcorders, and computer monitors, use universal switching power supplies that automatically adapt at anything from 100 to 240 V, 50 to 400 Hz (maybe even DC). With these, the nameplate will clearly specify this universal operation. However, you cannot assume this! Applying 240 V to a device that doesn't accept it WILL result in damage or a meltdown.
- Where a power transformer is used as with most audio equipment, there may dual primary windings, possibly with additional taps, to permit the unit to be configured for almost any voltage.

Unfortunately, manufacturers often save a few pennies by using a power transformer in equipment for sale in the U.S. with only a 115 VAC primary. You may be able to determine this by checking the wiring to the primary of the transformer - if each of the line wires goes to a pair of terminals/wires into the transformer, it is likely that the required pair of windings is present and can be rewired in series. If they only go to a single terminal/wire, then this probably can't be done.

True Transformers

This refers to devices that consist solely of a pair (at least) of windings on an iron core. There are no other devices in a transformer beyond possibly a switch, indicator light, thermal protector, and/or a fuse or circuit breaker, and a plug or terminal block for input and socket or terminal block for output.

In the following, we assume that the two voltages are 110 VAC and 220 VAC. Similar comments apply if the ration is not 2:1.

There are several types including:

- Isolated step-up for converting from 110 VAC to 220 VAC.
- Isolated step-down for converting from 220 VAC to 110 VAC.
- Autotransformer step-up for converting from 110 VAC to 220 VAC.
- Autotransformer step-down for converting from 220 VAC to 110 VAC.

Autotransformers are cheaper but do not provide line isolation which may be desirable. In general, a step-up or step-down transformer can be used backwards to effect the opposite conversion - whether this is possible is a construction detail. In addition, a 1:1 isolation transformer can be used as a 1:2 (stepup) or 2:1 (stepdown) autotransformer with a VA rating twice of what it would be when used normally.

The relevant parameters characterizing a tansformer consist of:

- Voltage - The ratio of the number of turns of wire on the output winding(s) and input winding determines the output:input voltage ratio. Electrically, input and output can be interchanged to obtain the opposite conversion. Whether this is supported by the packaging is another story.

- Power/VA capacity: The size of the core and the wire determine the power handling capability. VA is simply the voltage (V) multiplied by the current (A) for the input or output. For a resistive load like a space heater or light bulb, this is the same as true power in watts (W). Due to unavoidable losses in the transformer, the input and output ratings are not quite the same. The transformer must be capable of supplying the required VA of the desired maximum load without exceeding the current rating of the input line.

- Frequency: The relevant values are 50 Hz or 60 Hz. There may be issues of core saturation occurring when attempting to run a transformer designed for 60 Hz on the same input voltage but at 50 Hz. (There is no going the other way.) This isn't an issue if the transformer has been engineered with adequate safety margins but could result in overheating and failure for a 'designed as cheaply as possible. unit. This probably isn't that likely but if the transformer gets excessively hot or has an unusual amount of hum, saturation may be the problem. Running it on slightly reduced input voltage may help but whether this is a viable option depends on many factors and the rest of the equipment may end up being unhappy. See the chapter: Is Frequency Conversion Needed?.

Transformers of adequate capacity can be used with all types of equipment.

However, they are heavy and costly and do not convert frequency. Thus, they may be unsuitable in some situations and there may be cheaper more appropriate alternatives. A *suitable* transformer large enough to power a space heater would weigh about 50 pounds and cost perhaps $200 - much more than the the space heater is worth.

Using a Low Voltage Transformer to Increase or Reduce Line Voltage

Sometimes, it is only necessary to adjust the voltage by 10 or 20 V to be fully compatible. For example, this might be the case when using domestic Japanese gear in the U.S. and vice-versa. Their line voltage is closer to 100 VAC compared to our 115 VAC.

An easy way to change the voltage by 15 V (for example) up or down, is to obtain a transformer with a 110 V primary and around a 15 V secondary. The secondary current rating needs to be at least equal to the load requirements. Wire it up so the secondary is in-phase in series with the AC to the load to boost voltage (as shown below) or out-of-phase to reduce it.

Note: To obtain exactly the correct voltage will require a slightly higher or lower voltage transformer than this simple explanation would indicate since the input voltage will be slightly lower or higher than the transformer's rated input voltage. This is usually not an issue since precise voltage to an appliance or piece of electronic equipment is generally not required.

```
                   +-----------+
                   |           |
     AC In o-------+--+        |
                     o )|| +----+
                       )||(
105 VAC Line   Primary )||( Secondary
                       )||( o
                       )|| +---------o AC Out
     AC In o-------+--+
                   |                          120 VAC to Load
                   +-----------------o AC Out
```

Thyristor Based Converters

These are the low cost devices available at Radio Shack or a travel accessories store that weigh almost nothing and have huge power ratings. They operate by switching the power on to the load at the appropriate time during each cycle of the AC voltage (120 or 100 times a second) resulting in approximately the proper power being delivered to the load.

Thyristor based converters are for converting from 220 VAC to 110 VAC without changing frequency with major restrictions:

- WARNING: These are suitable ONLY for resistive loads like light bulbs, space heaters, and frying pans WITHOUT induction motors, transformers, or electronic controls.

- They are designed to provide approximately the correct *power* conversion factor for resistive loads (and possibly universal motors). The maximum voltage may still be close to that of the input - 220 V. This will instantly (or at least quickly destroy electronics and may destroy induction motors, transformers, and other similar loads rated for 110 VAC only slightly more slowly.

- The output is very spike-y unlike the smooth sinusoid of the normal power line AC. This in itself may result in addition problems including radio frequency interference (RFI) and equipment buzz or hum.

Since all a thyristor (triac) can easily do is turn on - it has to wait until the end of the cycle to turn off - to get the same effective power from a 220 VAC input as a 110 V input will require a higher peak voltage with a duty cycle of much less than 100 percent. Capacitors in the power supply of typical electronic like to charge to the peak - BLAM! The high peak voltage can result in breakdown of underrated insulation and have other undesirable effects on devices like induction motors and transformers. Even equipment for which these are supposedly designed can be destroyed or may represent a safety risk since there can be much higher voltages inside than normal.

Motor Alternators

Before the development of solid state power devices, these represented an efficient, if bulky way of converting both voltage and frequency. A synchronous induction motor is coupled to an alternator (AC generator) on the same shaft. By designing with the appropriate number of poles for each, this could easily, if noisily, perform both voltage and frequency conversion.

Solid State (AC->DC->AC) Converters

These provide efficient conversion of both voltage and frequency in a light weight compact package. The best of these generate an output nearly identical to the power obtained from the wall socket and operate as follows:

- Rectify and filter AC input to provide direct current (DC).

- Chop the DC at a high frequency controlling both polarity and amplitude to synthesize a replica of the desired power (sinusoidal) waveform.

- Use a transformer to step this up to the required voltage
- Provide a filter to remove the high frequencies from the output.

The waveform before smoothing would look similar to the following:

```
    ||                  ||
  ||||||              ||||||
 ||||||||            ||||||||
||||||||||          ||||||||||
||||||||||          ||||||||||
          ||||||||||          ||||||||||
          ||||||||||          ||||||||||
           ||||||||            ||||||||
            ||||||              ||||||
              ||                  ||
```

After smoothing, the result would be very similar to a sinusoid.

This more costly approach enables arbitrary voltage *and* frequency conversion but as we will se later, this is rarely needed. For an idea of how to design such a converter, see the section: Design of High Efficiency Power Inverters.

Cheaper models simply generate a square wave or modified sinewave at the appropriate frequency:

Squarewave:

```
 _________           _________
|         |         |         |
|         |         |         |
|         |         |         |
|         |         |         |
          |         |         |         |
          |         |         |         |
          |         |         |         |
          |_________|         |_________|
```

Modified sinewave:

```
    _____                 _____
   |     |               |     |
   |     |               |     |
   |     |               |     |
___|     |____       ____|     |____
```

```
                          |       |                  |      |
                          |       |                  |      |
                          |       |                  |      |
                          |_______|                  |______|
```

The nice thing about the modified sinewave is that its RMS and peak values match that of the true sinusoid (as well as other advantages in terms of harmonic content). If you don't know what this means, don't worry, Your life doesn't depend on it. One implication, however, is that heating loads and electronic devices which rectify and filter the input power will see the same effective voltage.

For many devices including all resistive loads, either of these approaches is adequate. However, devices with motors and/or transformers will be much happier with smoothed sinusoidal power. Switching power supplies (except universal types) will be underpowered with the simple squarewave inverter and may overheat running near full load.

Design of High Efficiency Power Inverters

Here is a general recipe - season to taste. :) (From: James Meyer (notjimbob@earthlink.net).)

1. Make a DC to DC converter using any one of several standard designs available almost anywhere. Pick a design using switch-mode control and a high frequency transformer. The input voltage you already know. Make the output voltage adjustable over a 0 to 170 volt range by way of a low-level input signal of maybe 0 to 10 volts. The output current will be whatever you want for the 120 volt AC output current. You'll probably want to have a transformer in there to isolate the output from the input, but it will be a small one because the frequency will be very much higher than 60 Hz.

2. Build a signal generator that puts out a 0 to 10 volt signal that looks like a half-wave rectified 60 Hz waveform. Use that to control the DC to DC converter.

3. Then use an H-bridge switch on the output of the 0 to 170 volt converter to get alternate plus and minus output. Use a square wave that changes state at each 0 volt output point of the input signal to drive the H-bridge.

Using this approach, you can step the input voltage up to the peak of the sine wave that you want at the output with a decent converter that can be very efficient and produce little waste heat.

The H-bridge MOSFETs are also only switches so they can be efficient. Plus, you're switching currents at the output voltage level which is a lot smaller than the current at the DC input.

You'll get a sine wave at the output and the whole thing should be simple and fairly cheap. The high frequency switching converter will be the hardest part to get going because of the wide adjustable output voltage range required, but I think it will still be easier than the "brute force" method.

Some Power Converter Companies Here are a few random

companies that offer power converters. I am in no way endorsing their products and have no direct knowledge of their quality or performance. Listed in alphabetical order.

- **Stark Electronic**
- **Voltage Valet**
- **Walkabout Travel Gear**
- **Todd Systems**

What Appliances will be Damaged by Reduced Voltage?

Here is a summary of various appliance types and how they are affected by the severely reduced voltages possible during a brownout:

- **Resistance heating elements/incandescent bulbs/ and similar will not be damaged and will actually last longer. Of course, light and/or heat will be reduced.**
- **Constant horsepower loads like refrigeration compressors will be severely stressed and may burn out.**
- **Shaded pole motors will run slow but will probably not be damaged. Many of these are designed to survive a stalled condition as well.**

  Examples: fans and some blowers, can openers, pencil sharpeners.
- **Capacitor run and other larger induction motors without a starting switch will run slow with reduced torque. However, if they stall, overheating and burnout is possible.**

  Examples: some blowers, dishwashers.

- **Motors with a starting switch may not reach starting winding cutout speed and result in motor damage - burnt out starting winding.**

  Examples: washing machines, cloths dryers, circulator and other larger pumps, large furnace blowers, stationary shop tools.

- **Universal motors will run slow with decreased torque and reduced cooling. There may be a range of speeds over which they will overheat.**

  Examples: vacuum cleaners, electric leaf blowers, many other portable line powered tools

- **Switching power supplies will run hot and may fail.**

  Examples: TVs, some VCRs, computers (PCs and laptops), monitors, and some peripherals,

- **Linear power supplies will probably just not regulate well resulting in hum in audio or hum bars in video.**

  Examples: Stereo receivers, CD players, cassette decks, phones, some fax machines, some printers.

- **Anything with relays may have problems with the relays not operating reliably or cycling.**

  Examples: heating and cooling systems, garage door openers, etc. but most of these will have other components more severely affected.

For appliances with more than one type of device like a microwave oven, all factors must be considered. For this example, the oven will heat at a reduced power level (which is safe) but the cooling fan(s)

will also run more slowly resulting in possible overheating and failure of the magnetron. A convection space heater may overheat for similar reasons.

How Big a Difference in Voltage Before a Converter is Needed

> "I would like to bring a variety of small to medium-sized Japanese electrical products (100V 50/60 Hz) with me when I move back to the U.S. (e.g., lights, rice-cooker, cassette player, VCR...) Individual transformers like those sold in travel shops are quite expensive. Is it possible buy a large number of small stepdown transformers -- or to make them as kits? Any advice would be greatly appreciated."

First, for some of these like the VCR, the 15% difference between 115 VAC and 100 VAC may not matter. The only way to be sure is to check with the manufacturer.

For others like the rice cooker, it too may be ok if it uses a thermostat to control its heating element.

However, the simplest way to reduce 115 to 100 VAC is to buy or construct an autotransformer.

To construct one, you need a stepdown transformer with an output of about 15 V (for this example) and a secondary current rating at least equal to your total current needs. Then, the primary is connected to the line and the secondary is wired anti-phase in series with the loads and the line.

For devices using AC adapters, I would just replace the AC adapters with a US version.

Effects of Improper Voltage on Resistive Loads

- Incandescent light bulbs. Light output will increase or decrease by a greater relative percentage than the voltage change. Life will be impacted dramatically. The life function for an incandescent light bulb is roughly (V/Vo)^^14. This is the actual voltage divided by the nominal voltage raised to the 14th power! A 5 percent increase in voltage will decrease life by about 50%.

With greatly excessive voltage (i.e., running a 110 V light bulb on 220 V), burnout will be nearly instantaneous - the bulb may even explode.

With reduced voltage, the light output will be reduced and life will be extended dramatically as well. However, efficiency decreases faster than voltage so it doesn't make sense to use bulbs on lower voltage unless they are in a hard-to-reach spot as the energy cost dominates. Extending the life of a 25 cent bulb just doesn't save money in the end especially if a higher wattage or additional bulbs must be used to make up the light reduction.

- Space heaters (excluding fans) and heating appliances like rice cookers, deep fryers, toaster, etc. Power is proportional to the square of the voltage. Reduced voltage will result in less heat or longer cycles (if thermostatically controlled). Excessive voltage will result in more heat or shorter cycles. However, there could be fire risk if the appliance is not designed with adequate insulation and safeguards to handle the extra power.

  With greatly excessive voltage, heating devices will blow a fuse or internal thermal protector, the AC fuse or circuit breaker, or burn out.

Effects of Improper Voltage on Constant Power Loads

- Induction motors. These are found in refrigeration equipment (fridges, freezers, air conditioners, dehumidifiers), air compressors, washing machines, dryers, some stationary shop tools, pumps, and many other domestic and industrial applications.

An induction motor is a nearly constant speed drive. Reduce the voltage and it will still try to maintain almost the same speed. Where the load is constant, this means that it will draw greater current to compensate for the reduced voltage (remember: P = constant = V*I). This will result in excessive heating and stress. The equipment may fail to start properly at all or cycle on its thermal/overcurrent protector. Its life may be shortened or it may burn out quickly.

Excess voltage isn't good either since the construction may result in magnetic core saturation which will also result in overheating, added noise (hum), and lower efficiency.

- Regulated switchmode power supplies

  These share many of the characteristics of induction motors in that they will attempt to maintain the same power to the load. Thus, at low line voltage, they will draw additional current and internal parts may be stressed to the point of (possibly catastrophic) failure. Unlike induction motors, this is much more difficult to predict as it is highly design dependent.

  Usually a slight reduction or increase in voltage will not affect the performance or longevity. However, unless specified as a universal input (90 to 240 VAC) or where specific recommendations are available, remaining within a 10 percent window is best. This is especially critical on the low side when running near full load.

  Running a non-universal switching power supply from a squarewave inverter result in overheating and subsequent failure near full load. The reason is that the peak value of the input waveform is about 7/10ths of that from the normal AC line and the current must increase to compensate.

Effects of Improper Voltage on Transformer Loads

While the ideal transformer (the one they may have taught you about in EE101) doesn't care about its actual input voltage, real transformers do. If the voltage increases significantly above what it was designed for, the core may saturate. This means that the magnetic field in the core cannot increase any further and the result is to effectively short circuit the input (above a certain voltage on the waveform). At the very least, this will result in excessive heating and hum or buzz. The transformer may burn out if a fuse doesn't blow first.

How much excess voltage is acceptable is not something that can be determined without testing. Some transformers are designed very conservatively (bigger cores, more copper, etc.) while others just barely get away with running on the nominal line voltage.

Certainly, 2:1 will be too much for almost any transformer. You may get away with a 25% increase without too many problems.

It is possible to test for this by slowing increasing the input voltage while monitoring input current. Up until saturation, it will increase linearly with voltage. As saturationg sets in, a small increase in voltage will result in a large increase in current and increased buzz or hum as well.

Reducing voltage to a transformer is not a problem unless the load will then demand more current - which may result in excessive heating and failure.

Effects of Improper Voltage on Motor Loads

- As noted above, induction motors are constant speed devices so that the current will tend to decrease as voltage is increased and increase as voltage is decreased. There can also be core saturation effects just as with transformers.

- Universal motors - those found in vacuum cleaners, portable shop tools, and so forth - will run with a speed that it related to input voltage (unless feedback regulated). On low voltage, the speed will be lower and your vacuum cleaner won't suck as well. Since it uses bypass air to cool the motor, it may overheat also. On higher than normal voltage, it will run faster adding wear and tear to the bearings. Blowers and flywheels may disintegrate if not designed for the added centrifugal loads.

- Fan motors - these are shaded pole induction type usually and so lossy to begin with that speed will vary with voltage. Again, bad things may happen at too low or too high voltage but they will probably survive modest changes.

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Line Frequency (50/60 Hz) Issues

Is Frequency Conversion Needed?

The question of 50 Hz vs. 60 Hz always comes up in conjunction with international power. However, except for equipment with induction motors (e.g., fans, compressors), or where the line frequency is used for timing (electric or line powered electronic clocks), the line frequency may be irrelevant.

Effects of Improper Frequency

- Clocks/timers run slow or fast. Devices that depend on synchronous motors or count the cycle of the line voltage directly like desk or alarm clocks, clocks in clock radios, appliance timers, anti-burglery timers, and so forth, will run fast or slow by the precise ratio of the correct to actual line frequency. In nearly all cases, this will be either 5/6 or 6/5 based on the ratio of 50 to 60 Hz and vice-versa.

In the case of synchronous motors, there is nothing you can do - the speed is determined by construction and the gear ratios.

Those that are entirely electronic may have a switch or jumper (probably inside) to select the AC frequency - 50 or 60 Hz.

Many devices use an internal quartz crystal for the clock or timer and will not be affected at all. Devices like VCRs may or may not use the power line for timing. Of course, battery operated equipment will always use an internal quartz crystal as there is no connection to the power line.

- Transformer core saturation - excessive heating. Reducing the frequency of the input to a transformer also increases the likelihood of core saturation. Therefore, going from 60 Hz to 50 Hz may be a problem for your stereo (which likely uses a power transformer) if its design is marginal. As with voltage, there is no way to know except by testing unless the nameplate specifically states a frequency spec - 50/60 Hz.

- Induction motor speed and torque. As noted, these are nearly constant speed devices dependent on power line frequency:

  - Going from 50 Hz to 60 Hz: motor will run fast with reduced torque.

  - Going from 60 Hz to 50 Hz: motor will run slow with reduced torque.

- Note that most modern electronic equipment (with the possible exceptions listed above) does not depend on the power line frequency for anything. This includes CD players, cassette decks, servo-drive turntables, TVs (unless there is an on-screen line timed clock), VCRs (ditto), computers, monitors, printers, fax machines, etc.

Equipment that Will Probably not Care About the Line Frequency

The following are generally insensitive to frequency (50/60 Hz):

- **Appiances with only heating elements (e.g., toaster, radient space heater) and incandescent light bulbs.**
- **Devices with universal motors (e.g., vacuum cleaner, electric drill).**
- **Fluorescent lamps using electronic ballasts (including many compact fluorescents).**
- **TVs, VCRs, computers, monitors, universal AC adapters, other devices using switching power supplies. (The a clock may run at an incorrect rate if it depends on the power line frequency.)**

However, note different TV standards will likely result in your TV and VCR working together but not able to receive or record broadcasts or cable.

Some equipment explicitly states the acceptable voltage and frequency range. In the case of a universal power adapter, this may range from 90 to 260 V DC or AC up to 400 Hz - or more.

Equipment that May Work with a Different Line Frequency

The following will probably work when going from 50 Hz power to 60 Hz power and may work going the other way. However, transformer cores designed for 60 Hz may saturate on 50 Hz and run hotter and/or blow internal fuses and cooling fans will run slower - this should be checked to make sure there is no hazard:

- **Audio equipment (e.g., receivers, CD players, tape decks, servo locked turntables). However, since the broadcast channel spacing may differ, tuning may not operate correctly.)**
- **Devices using wall wart AC adapters with actual transformers**

(these are massive as opposed to universal AC adapters which weigh almost nothing) (e.g., calculators, boomboxes, telephones and answering machiens, external modems and CDROM drives, dust busters hand vacs). However, the phone system may not be compatible.)

- Printers, fax machines, and other computer peripherals which use a power transformer in their power supply.

- Microwave ovens (power is related somewhat to frequency, cooling fans and turntables will run slow on 50 Hz).

- Fans and blowers (will run slower on 50 Hz).

- Convection space heaters (shaded pole fan motor will run faster on 60 Hz). If designed for 60 Hz and run off 50 Hz, it will run slower possibly resulting in overheating.

Equipment that May have Problems on Different Line Frequency

The following may have problems:

- Audio equipment using AC motors like some turntables and reel-to-reel tape decks. Speed will be incorrect. Mechancial adapters may be available.

- Clocks and devices with built in clocks or timers. Many of these depend on the power line frequency for timekeeping. They will therefore run at a 5/6 or 6/5 rate when the frequency changes. (This may be desirable - your day could last 20% longer! :-)).

- Electric shavers depending on a resonant linear motor (vibrator). The frequency difference may be enough to kill the resosnance and result in weak or no blade motion. (Remingtons used to use this technique; I do not know what manufacturers still do.)

- Large fixed power devices like refrigeration compressors.

- **Equipment with a combination of resistive heating elements and/or induction motors and/or electronics. One or more subsystems may have performance or overheating problems.**
- **Fluorescent lamps and fixtures using iron ballasts.**

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Recommendations for Specific Equipment

General Considerations

The sections below summarize the major issues with respect to common appliances and consumer electronic equipment. Following these are those which relate specifically to moving overseas or vice-versa.

Television Sets and Video Cassette Recorders

A voltage converter - preferably a true transformer or modified or true sinewave inverter will be needed to adapt the voltage unless the unit has a universal power supply.

Modern TVs do not care about power line frequency at all as they do not have any power transformer. Really old sets may run into core saturation problems but these are mostly dead by now.

Note: the video frame rate is not tied to the power line in any way. Therefore, a U.S. TV with a 60 Hz (actually 59.94 Hz) frame rate will work just fine in a country with 50 Hz power assuming the voltage is correct. However, it will not be compatible with broadcast or cable or likely a VCR purchased in that country - see below.

VCRs may use a small power transformer in the power supply so

changing from 60 Hz to 50 Hz may result in overheating though probably not likely.

However, taking a VCR and TV from the U.S. to a European country, for example, may not be worth it. They will work fine with each-other (as long as the voltage is proper) but the video standards in foreign countries are not compatible with those in the U.S. Therefore, it may be better to buy new equipment overseas unless you are taking your prized collection of videos and will obtain other equpiment to deal with broadcast and cable. There are also services for copying video cassettes from one standard to another and these may represent an alternative to lugging the equipment with you.

Small Appliances

Specific recommendations will depend on the actual devices inside the appliance - motors, heating elements, timers, and so forth.

- For appliances containing ony heating elements - no fans or other motors - any type of voltage converter will be suitable. For example, the very inexpensive and light weight thryistor type of 220 VAC to 110 VAC type should work fine with a waffle iron.

- Where motors are involved, a true transformer will be best but may be excessively heavy or expensive.

- With timers, the line frequency will also be important.

- If the appliance is powered by a wall adapter outputting DC, a substitute wall adapter may be the best option.

Clocks

Electric clocks using a synchronous motor would require a motor or gear transplant - not worth it. Of course, you could just live with shorter or longer days :-).

Clocks using the power line to drive an electronic display may have a jumper to select 50 or 60 Hz. Even this may not be worth the effort to locate as it is likely not going to be labeled.

Fluorescent Lamps

For those using iron ballasts, both voltage and frequency will be significant. Though it may be possible to come up with a formula which incorporates both, the best thing to do is to only use the line voltage for which the unit was designed.

Where the frequency isn't the same, the current through the lamp may differ, most likely too high in going from 60 Hz to 50 Hz, too low the opposite way. If the current is too high, there could be shortened lamp life at the very least or even a serious fire hazard. If the current is too low, the lamp may not remain on in a stable manner, flickering, or constantly restarting. Initial starting could also be affected.

If they use electronic ballasts, the frequency probably won't matter. Some "universal" types, can accommodate an input voltage from 90 to 250 VAC up to 400 Hz or even DC.

In all cases, it is best to consult with the manufacturer if the product label doesn't explicitly indicate "50/60 Hz" operation. When in doubt, leave them behind since there is really no way to be sure of the safety issues.

Audio Equipment

These include tuners, amplifiers, receivers, tape decks, CD players, etc.

Except for the tuner or tuner portion of the receiver, the only issue is power. Audio equipment almost always uses a transformer type power supply so the comments in the previous chapters should apply. A voltage converter will be needed to go from 110 VAC to 220 VAC or vice-versa. In this case, it really should be a true transformer.

Anything else is quite likely to introduce unaccceptibel interference in the form of a hum or buzz even if it doesn't result in any damage to the equipment. As noted, going from 60 Hz to 50 Hz could intruduce problems of transformer core saturation in marginally designed equipemnt as well.

Radios, Tuners, Receivers

In addition to the power issues (see the section: Audio equipment, station frequencies and channel spacing differ from country to country.

Microwave Ovens

If the voltage is different, sell where you are located and buy a new one at your destination. The power involved would require a large, heavy, expensive voltage converter - preferably a true transformer. It doesn't make sense for a $150 microwave.

Line frequency doesn't affect the performance of a microwave that much (perhaps a 5 percent increase in cooking power from 50 Hz to 60 Hz) but the timer and clock will likely be affected and may not be easily adjusted - not at all in the case of a mechanical timer though there may be a jumper for an electronic timer. However, the turntable and cooling fan motors will also be affected and attempting to account for all the variations is probably just not worth it!

PCs and Laptop/Notebook Computers

Check your equipment. Most PC power supplies have a switch to select between 110 VAC and 220 VAC. Some have universal power supplies that will work within a range of voltage between 90 and 240 V AC (up to 400 Hz) or DC. The latter is generally true of laptop/notebook power packs.

Similary, monitors may use a switch or jumper to select voltage or have a universal power supply.

PCs and monitors do not use the line frequency for anything - not even the real time clock.

Laser Printers

These may use a switching or transformer based power supply. This is not the real problem. What is, is the power for the fuser - several hundred watts. Therefore, if using a true transformer for voltage conversion, a large one will be required.

Some may have universal power supplies - check your instruction manual!

Non-Laser Printers

These will usually use a power transformer type power supply so a voltage converter will be needed. The frequency will only matter with respect to transformer core saturation. Nothing in a printer depends on line frequency.

Taking Equipment Overseas (or Vice-Versa)

When does it make sense to take an appliance or piece of electronic equipment to a country where the electric power and possibly other standards differ?

For anything other than a simple heating appliance (see below) that uses a lot of power, my advise would be to sell them and buy new when you get there. For example, to power a microwave oven would require a 2kVA step down (U.S. to Europe) transformer. This would weigh about 50 pounds and likely cost almost as much as a new oven.

Note that some places like Japan may even have varying power specifications in different parts of the country. Isolated areas such as islands may have their own power generators with very erratic and voltage and frequency. The following discussion assumes power

from a large (national) grid.

There are several considerations:

1. **AC voltage - in the U.S. this is nominally 115 VAC but in actuality may vary from around 110 to 125 VAC depending on where you are located. Many European countries use 220 VAC while voltages as low as 90 or 100 VAC or as high as 240 VAC (or higher?) are found elsewhere.**

2. **Power line frequency - in the U.S. this is 60 Hz. The accuracy, particularly over the long term, is excellent (actually, for all intents and purposes, perfect) - better than most quartz clocks. In many foreign countries, 50 Hz power is used. However, the stability of foreign power is a lot less assured.**

3. **TV standards - The NTSC 525L/60F system is used in the U.S. but other countries use various versions of PAL, SECAM, and even NTSC. PAL with 625L/50F is common in many European countries.**

4. **FM (and other) radio station channel frequencies and other broadcast parameters differ.**

5. **Phone line connectors and other aspects of telephone equipment may differ (not to mention reliability in general but that is another issue).**

6. **Of course, all the plugs are different and every country seems to think that their design is best.**

For example, going to a country with 220 VAC 50 Hz power from the U.S.:

For electronic equipment like CD players and such, you will need a small step down transformer and then the only consideration power-wise is the frequency. In most cases the equipment should be fine -

the power transformers will be running a little closer to saturation but it is likely they are designed with enough margin to handle this. Not too much electronic equipment uses the line frequency as a reference for anything anymore (i.e., cassette deck motors are DC).

Of course, your line operated clock will run slow, the radio stations are tuned to different frequencies, TV is incompatible, phone equipment may have problems, etc.

Some equipment like PCs and monitors may have jumpers or have universal autoselecting power supplies - you would have to check your equipment or with the manufacturer(s). Laptop computer, portable printer, and camcorder AC adapter/chargers are often of this type. They are switching power supplies that will automatically run on anywhere from 90-240 VAC, 50-400 Hz (and probably DC as well).

Warning: those inexpensive power convertors sold for international travel that weigh almost nothing and claim to handle over a kilowatt are not intended and will not work with (meaning they will damage or destroy) many electronic devices. They use diodes and/or thyristors and do not cut the voltage in half, only the heating effect. The peak voltage may still approach that for 220 VAC resulting in way too much voltage on the input and nasty problems with transformer core saturation. For a waffle iron they may be ok but not a microwave oven or stereo system. I also have serious doubts about their overall long term reliability and fire safety aspects of these inexpensive devices..

For small low power appliances, a compact 50 W transformer will work fine but would be rather inconvenient to move from appliance to appliance or outlet to outlet. Where an AC adapter is used, 220 V versions are probably available to power the appliance directly.

As noted, the transformer required for a high power heating appliance is likely to cost more than the appliance so unless one of the inexpensive convertors (see above) is used, this may not pay.

Fortunately, the standard for the CDs themselves is the same everywhere in the explored universe Yes, even Australia :-). Thus, there should be no issues of incompatibility. The differences will relate only to the power supply.

First, check your user's manual (which you of course have saved in a known location). It may provide specific instructions and/or restrictions.

Most component type CD players use a simple power supply - a power transformer followed by rectification, filter capacitors, and linear regulators. These will usually only require a small step up or step down transformer to operate on a different voltage. Since power requirements are minimal, even a 50 VA transformers should be fine. WARNING: never attempt to use one of those cheap lightweight power adapters that are not true transformers to go from 220 V to 110 V as they are designed only for heating appliances. They will smoke your CD player (or other equipment not designed to handle 220 V to 240 V input).

Some CD players may have dual voltage power transformers which can be easily rewired for the required voltage change or may even have a selector switch on the rear panel or internally.

The frequency difference - 50 or 60 Hz should not be a problem as nothing in a CD player uses this as a timing reference. The only slight concern would be using a CD player specified for 60 Hz on 50 Hz power - the transformer core may saturate and overheat - possibly blowing the internal fuse. However, I don't really think problems are likely.

For portable CD players, if your wall adapter does not have a voltage selector switch, obtain one that is rated for your local line voltage or use a suitable transformer with the one you have. As with power transformers, a frequency difference may cause a problem but this is not likely.

Microwave Ovens

Microwave ovens are high power appliances. Low cost transformers or international voltage adapters will not work. You will need a heavy and expensive step down or step up transformer which will likely cost as much as a new microwave oven. Sell the oven before you leave and buy a new one at your destination.

Furthermore, for microwave ovens in particular, line frequency may make a difference. Due to the way the high voltage power supply works in a microwave oven, the HV capacitor is in series with the magnetron and thus its impedance - which depends on line frequency - affects output power.

High voltage transformer core saturation may also be a problem. Even with no load, these may run hot even at the correct line frequency of 60 Hz. So going to 50 Hz would make it worse - perhaps terminally - though this is not likely.

- Going from 50 Hz to 60 Hz at the same line voltage may slightly increase output cooking power (and heating of the magnetron). The line voltage could be reduced by a small amount to compensate.

- Going from 60 Hz to 50 Hz may slightly decrease output power and possibly increase heating of the HV transformer due to core losses. Using a slightly lower line voltage will reduce the heating but will further decrease the cooking power.

The digital clock and timer will likely run slow or fast if the line frequency changes as they usually use the power line for reference. Of course, this may partially make up for your change in output power! :-)

> "I have the following question for you specialists:
>
> Can I buy a TV in any west-european country and use it in any other west European country? For example, buying a TV in the Netherlands and use it in Greece or buying in France and using in England.
>
> Any help would be appreciated as I do not really trust the sale people at the store."

Neither would I.

Along with the multiple audio/video formats, there may be differences in channel frequency assignments between the various countries.

Channel 5 in country X may not be on the same actual frequency as Channel 5 in country Y or Z. The channel spacings or modulation may also be different.

(From: Phil Nichols (in5379@wlv.ac.uk).)

Plus, in different countries the audio signal can be transmitted at a different frequency relative to the vision signal. Great! Perfect picture, no sound!

I believe most continental European countries use PAL B (narrow vision bandwidth; sound carrier 5.5MHz higher than vision carrier), whereas the UK and Ireland use PAL I (wider vision bandwidth; sound carrier 6MHz higher than vision carrier).

The wisest thing is to decide which countries you are most likely to want to visit with your TV, find out what transmission system they use, then go looking for a TV which can use that/those system(s).

Almost all TVs in west Europe are compatible (PAL-B/G), except

Britain (PAL-I) and France (SECAM-L). Greece is also using SECAM, but on very few channels and not all the time.

(From: Wolfgang Schwanke (wolfi@berlin.snafu.de).)

This is correct, but maybe not the whole story.

There are differences in the broadcast bands used. At least Italy uses different channel allocations than the rest of the PAL-B/G crowd. Germany uses frequencies on cable that are unused elsewhere, which only special tuners can get. Also, there are different methods for transmitting stereo sound (NICAM vs. analogue).

New TVs nowadays (sold in Europe anyway) are often all-world-standard all-frequency-bands, because it's easier for the manufacturer to make a "one for all" set instead of having so many different designs for every country. But don't rely on it.

(From Jeroen Stessen (Jeroen.Stessen@philips.com).)

Oh boy, here goes another long story:

PAL-plus is an attempt to extend the life-cycle of terrestrial PAL transmissions by including compatible wide-screen (16:9) transmissions. It is an advanced variant of the letterbox format, this means that when you receive a PAL-plus widescreen program on an older 4:3 receiver you will see black bars top and bottom. It was originally developed in Germany (university of Dortmund in cooperation with German terrestrial broadcasters and some setmakers). Later a large consortium of European and Japanese setmakers took over and finished the job. Strangely, the German broadcasters seem to use PAL-plus only very rarely.

The PAL-plus standard comprises three extensions to the PAL-standard:

1. **Vertical helper. In order to compensate for the fact that 1/4 of the**

video lines are not used, which would deteriorate vertical resolution for the widescreen viewer, the missing vertical information has been coded into the black lines in a manner as to be nearly invisible on a 4:3 receiver (you see some dark blue). The 16:9 PAL-plus receiver combines 432 visible lines plus 144 helper lines into 576 new visible lines.

2. Colour-plus. The PAL colour carrier is modulated in a slightly different way (making use of correlation between 2 fields) in order to give a cleaner Y/C separation in the PAL-plus receiver.

3. Signalling bits from which the receiver can conclude whether the transmission is 4:3/16:9/PAL-plus and adapt the display format accordingly. The bandwidth of these bits is low enough to survive recording on a VHS recorder.

In order to enable a poor-man's PAL-plus receiver, the standard permits using the mark "PAL-plus" if at least the vertical helper reconstruction is included. Colour-plus is optional, so you will find sets on the market with only half of the PAL-plus extension.

PAL-plus may also be combined with teletext, ghost cancellation reference, digital Nicam stereo, VPS, PDC and what-you-have more. Theoretically it can be broadcast over a satellite channel too, but it was not designed for that and some aspects of a satellite channel do indeed give interesting technical problems.

There are also sets marketed as "PAL-plus compatible". These are mostly widescreen sets without any PAL-plus processing at all, but they allow switching of the display format between 4:3 and 16:9. They may well do that automatically, based on the signalling bits.

There are 2 methods for displaying a 4:3 letterboxed signal on a 16:9 display, without using the PAL-plus helper lines:

1. Increase of the vertical deflection amplitude to display only the centre 432 lines.

2. Vertical interpolation without using the helper, to convert 432 lines into 576 lines and display on a 576 lines display.

Both modes may be called "movie expand". Only when you really convert to full-resolution widescreen will it be called "widescreen".

And there are 4 methods for displaying a regular 4:3 signal on a 16:9 display (regular PAL, has nothing to do with PAL-plus):

1. Decrease of the horizontal deflection amplitude, this gives black bars left and right.

2. Horizontal interpolation, to convert N pixels to 3/4*N pixels. Both modes may be called "4:3" or "normal"

3. Non-linear horizontal deflection waveform, called "Panorama mode" by JVC, works by increasing the S-capacitor value.

4. Non-linear horizontal interpolation, called "Superwide" by Philips, works with an advanced sample-rate convertor.

With both modes, the left and right edges of the picture will be stretched to fill the left and right bars, but the aspect ratio of the centre part of the picture will hardly be affected.

Interesting, ain't it ?

(From: Allan Mounteney (allan@amounten.demon.co.uk).)

RE: Is there a TV set that covers international standards?

The answer is YES.

Reason I know is that I was with a company that made computers with TV-OUT for world wide use and wanted something that could show that the TV Out worked for various countries.

This ONE and ONLY one we could find Three years ago came from Germany and covered PAL, SECAM and the American NTSC systems and came with a note that said from the time of making/selling that set it would not work in just one small country in South America. All features (including audio) were adjustable from the front panel menu and it was a Grundig 17" job. I am advised that there is a load of others on the market now.

The company who seemed to know all about these international sets and gave us good service at that time was Andrew McCulloch Ltd in Cambridge UK. Phone: 44(0)1223-351825

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Items of Interest

TV, Shortwave, Power Worldwide

(From: Mark Zenier (mzenier@netcom.com).)

A book, "The World Radio TV Handbook" published by Billboard that covers TV, along with where all the world's shortwave radio transmitters are, and what sort of power comes out of the wall plug all around the world. It has a new edition each year and costs around $25 to $30.

About the Vertical Scan Rate

TVs never ever used the line frequency for vertical rate. The vertical rate is not even equal to line frequency, actually 59.94 Hz (NTSC). It was set originally to 60 Hz to minimize the visibility of interference between the deflection and power transformer. When NTSC added color, it changed to 59.94 Hz. And, TVs no longer have power transformers.

Determining Unknown Connections on International Power Transformers

Most likely, you can figure this out if you can identify the input connections.

There will be two primary windings. Each of these may also have additional taps to accommodate various slight variations in input voltage.

For the U.S. (110 VAC), the two primary windings will be wired in parallel. For overseas (220 VAC) operation, they will be wired in series. When switching from one to the other make sure you get the phases of the two windings correct - otherwise you will have a short circuit! It is best to test with a Variac so you can bring up the voltage gradually and catch your mistakes before anything smokes.

An multimeter on the lowest resistance scale should permit you to determine the internal arrangement of any taps.

With any luck, the transformer wiring will even be labeled on the case!

Running Three-Phase Motors on Single-Phase Power

This may be an issue if you picked up a South Bend lathe with a 10 foot bed at a garage sale for $1 or more realistically with professional shop equipment like large saws or planars.

A three-phase motor will run on single-phase power once started - but at somewhat reduced output power (horsepower). The very simple approach (compared to complete conversion) is to just provide a means for starting. The motor will then run at the correct speed (assuming the line frequency is the same) but will not be able to develop full torque before stalling. Actually converting single-phase to three-phase will likely be more expensive than replacing the motor.

There is some info at the Building a Phase Converter site.

A Note on Voltage in Europe

(From: Michael Salem (4ms2u$ms@michaels.demon.co.uk).)

Until recently voltage in the UK was 240 VAC nominal, +- 6%. Voltage in most of the rest of Europe was 220 VAC. A few years ago voltages throughout Europe were harmonized to 230 VAC. This caused very little disruption; no change to power stations or distribution systems, no equipment problems caused by the change.

Why so trouble-free?

It was a politicians' change: Voltage didn't change at all (at least in the UK). The permissible voltage in the UK used to be between 226V and 253V (240+/-6%). It is now 230V -6% +10%; i.e., anything between 216V and 253V. The actual voltage is exactly what it always was, it's just *called* 230V. Presumably as power stations and distribution equipment age and are replaced the actual voltage will decrease; but I have certainly measured the maximum permissible 253V in June 2000.

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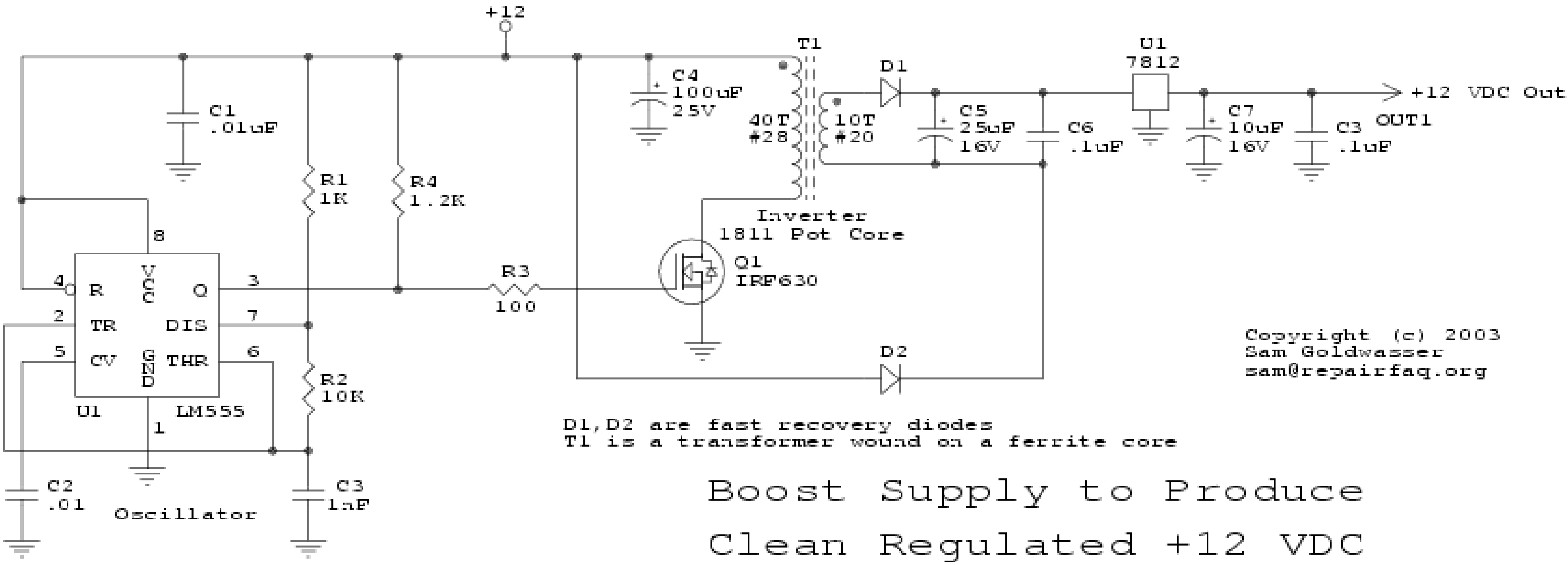
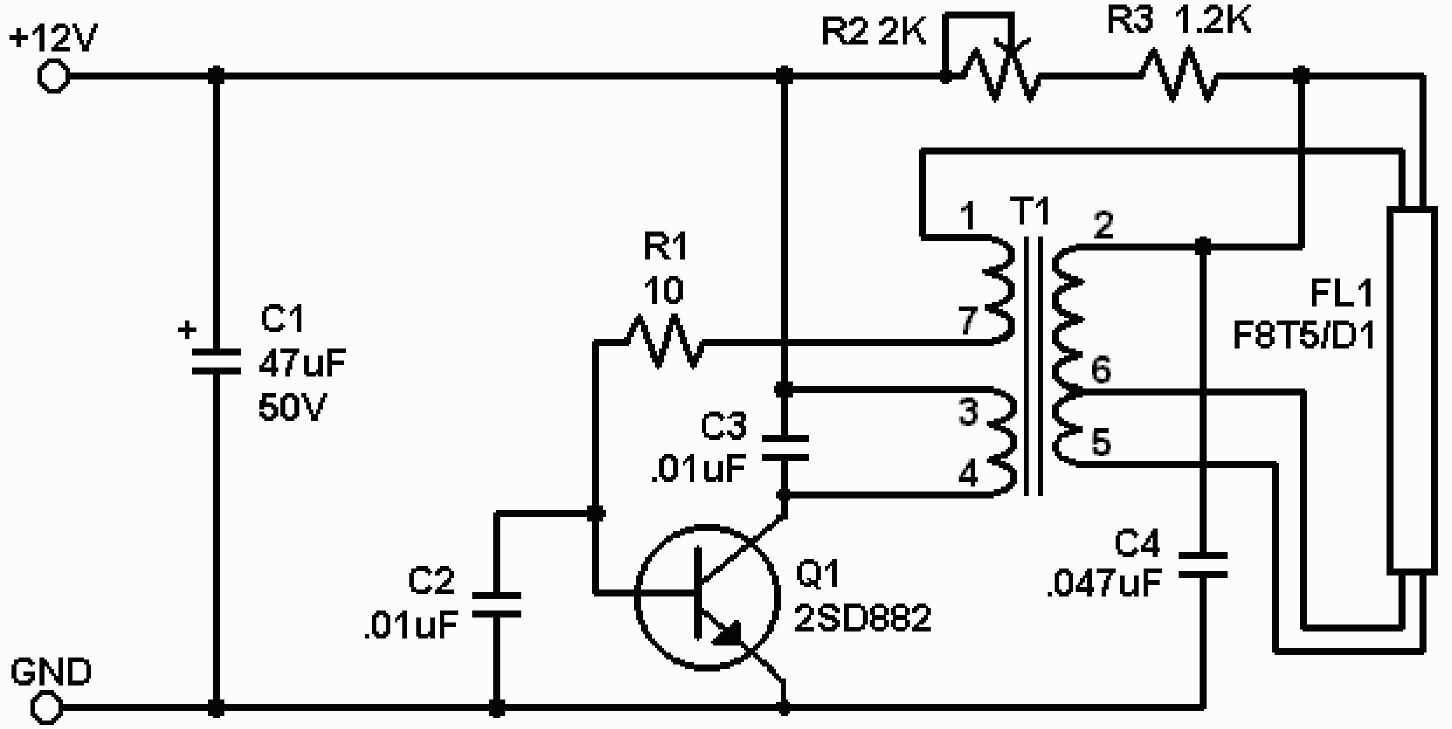
-- end V1.12 --



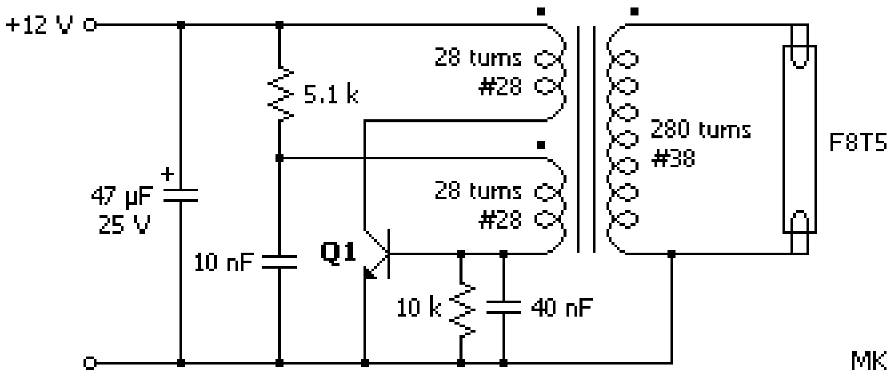
Boost Supply to Produce Clean Regulated +12 VDC



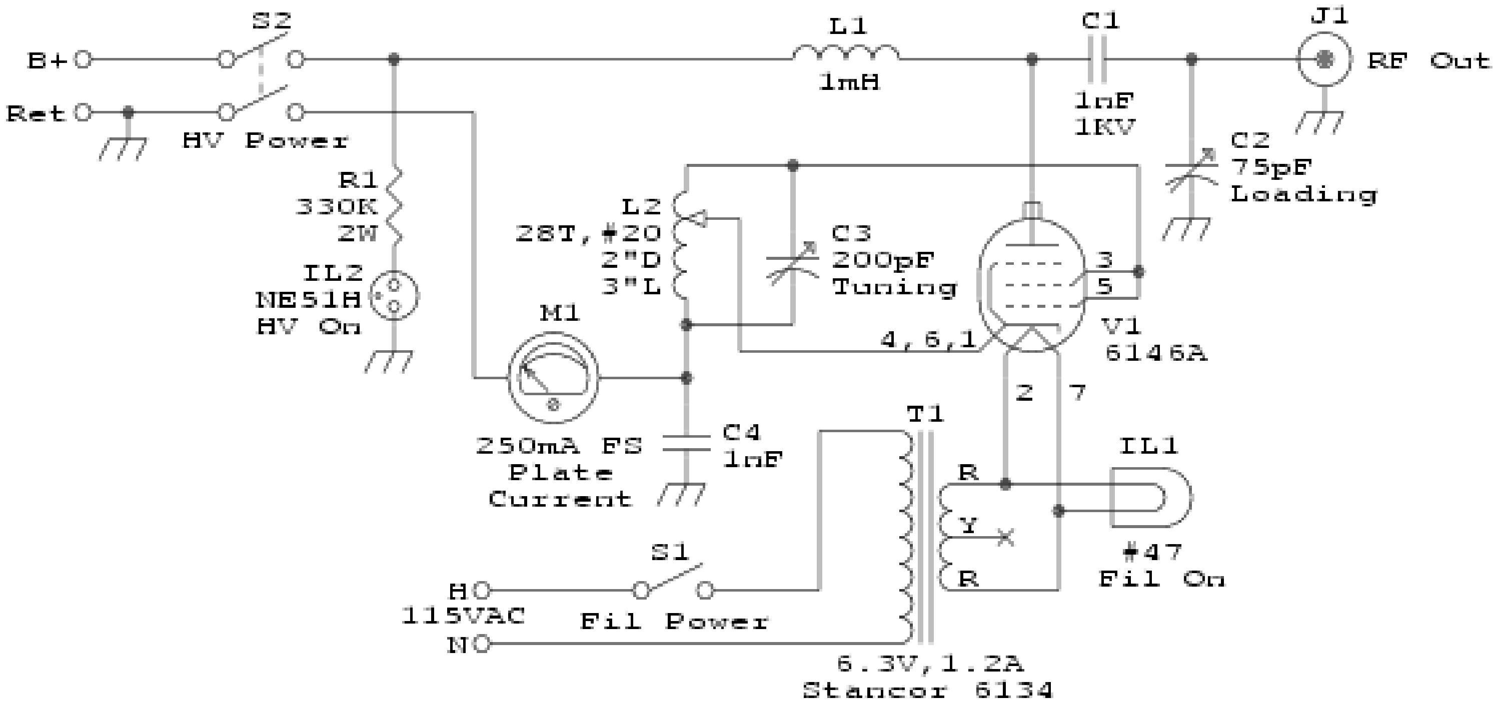
Notes:

1. All resistors are 1/4 W in ohms
2. Transformer resistances: 1-7=0.4, 3-4=0.5. 5-6=0.6, 2-6=4.9

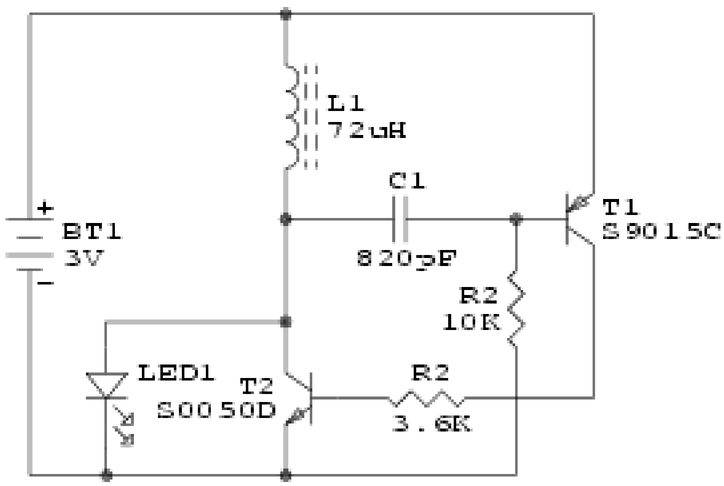
AmerTac Fluorescent Lamp Ballast



Automotive Light Stick Inverter



Sam's 6146A RF Power Oscillator



Brinkmann LED Light


T.C. VACUUM GAGE & PUMP PROTECTOR
Q-2173B-1
LOAD HOLD
RESET
POWER
ON
OFF
T.C.
1
2
LOAD
ON
OFF
HASTINGS VACUUM GAUGE

Basics of High Voltage Probe Design

Version 1.27

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

The devices, equipment, circuits, and other gadgets described in this document may be dangerous. Much of it deals with potentially lethal voltages. Getting electrocuted could ruin your whole day. Using an inadequate or improperly designed or fabricated high voltage probe to measure high voltage can be equally dangerous.

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

For really high voltage equipment, also see: Tesla Coils Safety Information.

WARNING: The microwave oven is perhaps the most dangerous equipment you are likely to encounter around the house. The high voltage (up to 5,000 V) along with the high current (1 A or more) availability make this an instantly lethal combination. It is highly recommended that NO measurements be made on a powered microwave oven. Only after the plug has been pulled and its high voltage capacitor has been safely discharged should you even think about touching or probing anything. Most troubleshooting can be done with at most an ohmmeter. See the document: Notes on the Troubleshooting and Repair of Microwave Ovens for more information. By comparison, TVs, monitors, and even large helium-neon lasers, are tame. While still very dangerous, they don't have quite the deadly quality of the microwave oven!

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Introduction

Scope and Purpose of This Document

There are all sorts of times when being able to determine the value of a high voltage DC source is desirable. Most multimeters have a maximum range of 750 or 1,000 V. (One exception is the workhorse Simpson 260 which has a 5,000 V range). Whether testing a TV with a dim picture, a helium-neon laser power supply that does work quite right, or troubleshooting some home-built high voltage project, the ability to measure 10, 20, 30, or more kV can come in handy.

This document provides information on constructing very basic high voltage probes suitable for measuring the high voltages found in consumer electronic equipment like TVs, monitors, and microwave ovens (though the latter is not recommended for safety reasons).

These simple approaches will work for DC and low frequency AC voltages but no effort is made to compensate for stray capacitance - which will seriously limit high frequency response. However, some of the issues are discussed.

If you will be making HV measurements regularly, by all means invest in a real HV probe for your multimeter. A commercial HV probe will still be a far better long term investment than some cobbled-together unit. However, for occasional HV testing, what is described below can be built and used safely but probably won't have the accuracy, consistency, or frequency response of a good commercial probe. Aside from purchasing a HV probe new, these do show up surplus as well as on eBay, possibly at greatly reduced prices. Even if a model isn't available for your particular multimeter (which is likely), it should be possible to adapt almost any commercial probe to work with it, requiring at most a scaling factor when taking a reading.

SAFETY

Read the associated document: Safety Guidelines for High Voltage and/or Line Powered Equipment before attempting to work with high voltage systems. High voltage can jump amazing distances when you least expect it. The direct or indirect consequences of this can ruin your entire day or a whole lot more.

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High Voltage Probe Design

Basic Considerations

CAUTION: DMMs may not be particularly forgiving of voltages on their inputs exceeding their specifications. Autoranging DMMs may be even more likely to blowout as they are selecting the correct range - if there even is one. Depending on your electrical and mechanical components, the chance of excess voltage due to arc-over, leakage, or component breakdown may be a major consideration. My analog VOM has survived many close encounters with HV. You should not assume the same for the typical low cost or even expensive DMM. There is a reason for the high cost of commercial HV probes - these kinds of factors are incorporated (hopefully) in their design.

A simple high voltage probe for a DMM or VOM may be constructed from a pair of resistors. This is suitable for DC measurements but without compensation, will have a unknown AC response due to the very high impedance and stray capacitance forming a filter - low pass or high pass depending on the amount of stray capacitance and input capacitance of your meter or scope. However, this simple design is sufficient for the majority of consumer electronics work which are mostly DC measurements. I have not characterized the AC response of this probe design. However, if there is AC riding on your high voltage, it may mess up your readings if there is no compensation provided as it may act as a high pass filter.

To design the voltage divider, the input impedance of the meter must be taken into account. There is a minor but significant difference between DMMs and VOMs.

- DMM: Z-in is usually constant, often 10M ohms.
- VOM: Z-in is the voltage range (full scale) times the ohms/volt rating of the meter.

Here is the basic circuit:

```
  High Voltage <------/\/\/\/\/\---------+-------------> + to DMM/VOM
                         R1              |                    |
                                         \                    \
                                      R2 /                 R3 /
                                         \                    \
                                         /                    /
                                         |                    |
  Ground Clip  <-------------------------+-------------> - to DMM/VOM
```

R1 together with R2||R3 form a voltage divider where R3 is the internal resistance of the DMM or VOM on the scale for which the probe is designed.

While R2 is not strictly needed, it is recommended that it be included and approximately equal to the Z-in of the meter on the scale you will be using. The reason to include R2 is to insure that high voltage never can reach the meter. The ground clip should be securely connected to the metal chassis of the device being tested - the frame of a microwave oven or CRT grounding/mounting strap of a TV or monitor - before it is powered up. Both R1 and R2 should be located in the probe head.

The only difficult part is locating a suitable resistor for R1 that has high enough resistance and physically is long enough such that arc-over is avoided. The only difficult part is locating a suitable resistor for R1 that has high enough resistance and physically is long enough such that arc-over is avoided. Caddock, OhmCraft, Victoreen, and Vishay are among the major companies that manufacture suitable resstors. But don't expect them to pay much attention to you for an order of 5 resistors! However, it may be possible obtain free samples if you explain what you're doing - and their lawyers don't get involved! If this doesn't work out, electronics surplus outfits occasionally come up with odd lots of strange components such as these and they even show up on eBay from time-to-time.

The high value high voltage resistor can also be constructed from several equal lower value resistors in series if they are all approximately the same size. Another possibility is salvaging the focus divider networks from dead flybacks or TV/monitor voltage multiplier assemblies. Even if the unit was discarded as being faulty, where there are no internal shorts in the HV rectifier or resistive network itself, the entire unit can be used intact.

In addition to basic safety precautions when working around high voltages, some form of equipment protection should be considered in provide an arc-over path to ground should there be arcing over the surface of the resistor as well as if the resistor should somehow decrease in value. There is no telling what can happen under less than ideal damp or dirty conditions.

A 'corona', 'arc', or 'discharge' ring could be placed around the resistor near the low voltage end securely connected to the ground cable. The idea is that any arcing over the surface should find this as its destination before obliterating your meter.

A variety of devices could be placed across R2 to limit the maximum voltage present in the event of a breakdown. Suitable devices include neon light bulbs (NE2s without resistors); zener, avalanche, or ordinary diodes; or other semiconductor junction devices. Traditional surge suppressors like MOVs and Tranzorbs may work but their off-state impedance may be too low compared to R2). The neon bulb is good since its impedance is essentially infinite until its breakdown of 90 volts or so is reached. In some cases, these devices will be destroyed (semiconductors may short) but they will have served their protective function and are a small price to pay to prevent you and your meter from being blown.

Frequency Response

Probe compensation similar to that used on oscilloscope probes can be implemented. However, the determination of the capacitor values is beyond the scope of this note. To put it simply, the ratio of the capacitance C1:C2 (where C1 is across R1 and C2 is across R2||R3) needs to be equal to the ratio of R2||R3 to R1 (or equivalently, to the inverse of the voltage divider ratio). C2 includes the stray capacitance and input capacitance of the meter or scope probe. The capacitor across R1 would need to sustain the HV so that is another complication. Since a 10x scope probe usually has an input impedance of 10M, the same design as used for the DMM would work with a scope. Although I have not pursued this issue, it sounds like based on the ratio (1000:1 would mean that C1 would need to be extremely small, probably smaller than the stray capacitance of the R1 and the associated wire) you would need to add a capacitance for C2 and that there will be enough stray capacitance such that no physical C1 will be needed.

If you are only interested in DC measurements, putting a .1 uF capacitor across R2 should smooth out any 50/60 Hz or higher frequency ripple.

The implementation of full probe compensation is left as an exercise for the motivated student.

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Simple High Voltage Probe Design Examples

50,000 V Maximum Using a 10Mohm Z-in DMM

By my rule above, I will select R2 to be 10M ohms. Fine adjustment of calibration could be made by making R2 out of a combination of a fixed resistor and a multiturn pot.

To minimally load the circuit under test, R1 should be as high as practical. Practical here means (1) low enough so that leakage over its surface is not a problem, (2) low enough that a reasonable voltage can be developed across R2||R3, and high enough so that loading of equipment being tested will not change the readings by more than a few percent.

R2||R3 is 5M ohm. Selecting R1 to be 4,995M ohm will give a 1000:1 ratio so that 50,000 volts will read out as 50 V on the DMM. 4,995M ohm is high enough that loading of a 250M ohm focus network should not be an issue (5%). 1000:1 is a nice easy to remember ratio. You could go to something higher if loading is still a concern but then leakage current over the surface of R1 becomes an even greater concern. Even 5,000M ohm is about as close to an open circuit as you can get - any contamination whatsoever will change the calibration significantly. You may find that using a resistance around 1,000M will result in less of a problem and accept the circuit loading that this value implies.

For all practical purposes, you can use 5,000M instead of the exact value of 4,995M. The error of about 0.1 percent will be less than the error spec of most portable DMMs and much less than the error spec of any VOM. And, you probably aren't going to risk your expensive precision bench multimeter on this lunacy anyhow!

50,000 V Maximum Using a 30kohm/V VOM

This is a little more complicated because you need to pick a range and then calculate the Z-in for that range. for example, for the 100 V range of a 30kohm/V VOM, the Z-in will be 3M ohms. For the same 5,000M ohm R1 and 10 M ohm R2, you would get a reading of 23 V (roughly) on the 100 V scale for a 50 kV input. The divide ratio in this case is about 218.

It is a simple matter to determine a scale and an R2 such that the actual high voltage measurement is easily calculated from the meter reading. What you want is the ratio of R1 to R2||R3 to be a nice round number. Note that switching ranges will produce some peculiar behavior due to this current division between R2 and R3. A unique R2 must be selected for each range of interest. You are already using nearly the maximum sensitivity of the meter and switching to a lower range will only slightly change the position of the needle unless you construct a range switch box as shown below.

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Sample Circuit

I have constructed a high voltage probe from the surplus bleeder resistor from a defunct video terminal. For the probe tip, I used a discarded probe from a VOM. The resistor and probe tip were mounted inside an insulating plastic tube with R2 included at its base. A ground cable with an allegator clip provided the connection to the chassis. A second pair of wires with banana plugs connected to the meter via a switchbox which could select between a DMM or a couple of different scales on a VOM. Potting the entire HV head is a good idea to minimize the possibility of arc-over. Remember that 50,000 V can jump several inches (2 inches in dry air approximately). See above text for other suggestions on equipment/you protection (which is not shown).

This circuit uses only a 203M ohm high voltage resistor. Since the internal resistance of a typical focus divider network is 200-300M ohm, this probe would obviously load such a circuit excessively.

```
                                      .
   High Voltage <----/\/\/\/\-----+--------+------------+----o + to DMM/VOM
                        R1        |   .    |            |
                       203M       |   .    \            |
                  (15W HV rated)  |   .    / R4         |
                                  \   .    \ 360K   SW1 o
                               R2 /   .    /           /
                               1M \   .    |        3 o o o 1
                                  /   .    |          | 2 |
                                  |   .    \          \   \
                                  |   . +->/ R5   R6  /   / R7
                                  |   . |  \ 25K  1M  \   \ 810K
                                  |   . |  / Adj      /   /
                                  |   . |  |          |   |
    Ground Clip <-----------------+-----+--+----------+---+--o - to DMM/VOM
                                      .
                      Probe Head      .    Range Switch Box
                                      .
```

- SW1 - SPDT Center Off Toggle Switch.
- All resistors except R1 are 1/4 watt 2%.

- 50,000 V maximum based on the particular R1 I had laying around. 1000:1 voltage division.

- SW1-1 = Radio Shack DMM on 3, 30, or 300 V scale (10M Zin).
- SW1-2 = VOM, 25 V scale (30K ohms/V, 750K Zin).
- SW1-3 = VOM, 100 V scale (30K ohms/V, 3M Zin).

Modifications to use a higher value R1 are straightforward.

Calibration

Unless you have a calibrated HV supply, a working TV for which you have the service manual makes a good starting point. The proper high voltage is usually specified to within 5-10%. If you have a line-transformer based HV supply (e.g., neon sign transformer, rectifier, capacitor), then this would be pretty accurate based on your power line voltage. For a DMM with a constant input resistance, you can use a low voltage (like a few hundred V) on a lower range and extrapolate for the HV range. However, for a VOM, you cannot use this technique since changing ranges also changes the parallel resistance of R2||R3. You are already using nearly the full sensitivity of the meter.

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More Information on High Voltage Probes

Construction of High Voltage Probes

(From: Duane C. Johnson (redrok@pclink.com).)

1. When you make the resister strings make sure that the maximum voltage rating of the resisters is not exceeded. Most resisters have a maximum rating of 200 volts. In this case I would not exceed 100 volts per resister.

2. Don't place the scope directly in series with the higher resisters. The first resister should be in parallel with the scope and and ground or the scope chassis.

   This detail is important for safety reasons. If the connection to the scope becomes disconnected then their will not be a dangerous shock hazard as would be the case if the scope was in series.

(From: Larry G. Nelson Sr. (nr@ma.ultranet.com).)

You can do this with a high voltage resistor divider network. That is what is in a high voltage probe you would buy. This can be very dangerous to you and your equipment in the event of a failure. Please be very careful. I suggest a fuse at the probe input and an MOV across the resistor to ground that will connect to the scope and use a plexiglass tube to put it all in to contain the bits if anything blows up.

(From: Kevin Astir (kferguson@aquilagroup.com).)

With respect to preventing high voltage arcing and corona, *do not* use RTV.

Places that carry the GC line will have some 'anti corona discharge dope' often called 'Q-dope'. This is *the* stuff to use at HV. You can clean it off with acetone when you discover that you didn't clean flux off good enough and have an arc underneath. Epoxy and RTV have no such advantage, and RTV releases corrosive acid while curing to boot.

Heed the warnings of other respondents WRT resistor voltage. As they said 100 V per for garden variety resistors will yield a safe margin. 200V is typical max rating.

There are special HV resistors (up to 10 kV or so) made, available into the G Ohm range. I don't know of a hobbiest source however. If you know anyone who works in nuclear instrumentation field they may be able to snag one for you. (HV used as detector and PMT bias in radiation detectors). This is what will be inside "real" HV probe from Fluke, or Tektronix.

Finally, I have a lot of experience, and am fairly blase' around HV, but in addition to "normal" 115V AC rules, (no rings, one hand in pocket, etc.) I *never* work on HV stuff (not even a TV or hi-pot test) alone. And, I make sure the 'observer' knows CPR, even if I have to wait 2 days to fix TV, so girl friend can 'help'.

High Voltage Probe Frequency Response

(From: Winfield Hill (hill@rowland.org).)

You can calculate this for yourself. The parasitic lead-to-lead capacitance of a typical small resistor is 0.05 to 0.2pF. The capacitance from the *middle* of the resistor and from any connection node between series resistors, to ground, may range from 1pF to 5pF or more depending upon your choice of a shielding scheme. Longer glass resistors intended for high voltages have lower lead-to-lead capacitance, but higher distributed parallel capacitance.

As a worst case, imagine a 1000M ohm probe made with a 2-inch long resistor. To start, place the capacitance to ground from the midpoint. If you assume 5pF of parallel capacitance, you'll see you're in trouble even at 60Hz!

- HV probes with usable high frequency response may have cleverly arranged shields which can be connected to ground, the attenuated signal output, and the input. Some shields may overlap and may be adjustable, to provide an adjustable capacitive divider that can swamp the remaining effects of the resistor's capacitance.

- These probes can be very accurate at DC and high frequencies, but the skill of the designer is tested in the transition between resistive and capacitive divider action. They can be very badly behaved in this transition region. Basically the "center" of the resistor experiences a bypass to ground (a severe dip in gain) or due to other HF components, a severe peak in gain. This can easily be 50% and cover a decade. Typically it'll happen at 20 to 100 kHz.

  One solution invokes the capacitance from a few carefully-placed concentric sleeves connected to the input and the signal output, plus an overall shield or guard connected to ground.

- Poorly designed probes can suffer from mid- or high-frequency errors and from severe pickup sensitivity to nearby rapidly-changing voltages. For example, I've seen probes that provide an output even when the measuring tip is grounded!

The classic low-voltage probe architecture of a pair pf RCs doesn't work for HV scope probes, unless (1) you're willing to have an overly high capacitive loading, or (2) you don't care about mid-frequency or pulse-shape response accuracy. This is because the RES1 value will be very high, 100M or more likely 1000M ohms, and physically long and large. So the real circuit is like:

```
+------------ CAP1 -------------+
|                               |
```

```
Probe tip o--------- Rs -*- Rs -*- Rs -*- Rs -------- etc
                         |      |      |
                         Cs     Cs     Cs
                         |      |      |
                        Gnd    Gnd    Gnd
```

Because the Rs are so high, the probe becomes a good antenna, and a shield is mandatory. Therefore the Cs "stray" capacitance is higher than you might think. I think you see the problem.

One solution is to make C1 very large, but it's just a matter of specs - if you want 1% performance over the whole range, C1 is a severe load. There is a good overall solution, which I think is fairly clever (after thinking of it, I discovered the experts had beat me to it!).

High Voltage Probes for AC Measurements

(From Winfield Hill (hill@rowland.org).)

The usual method is simply to use a capacitive divider, a small 1 kV capacitor, etc., or make the HV capacitor yourself for really high voltages, like 5 to 20 kV, use an air neutralizing capacitor, etc.

Say for example, its a 3pF capacitor. With shields. With another more conventional capacitor, say 3000pF for the bottom of the attenuator, followed with a voltage buffer if desired, and you've got a nice wide-band 1000:1 HV probe installed in the system, good for mucho kV.

More on Measuring High Frequency High Voltage

(The following was prompted by a request to measure the pulses in a capacitive discharge ignition system.) (From: Winfield Hill (hill@rowland.org).) You want to measure the voltage pulse or spike, so you'll need a high voltage high-frequency probe. Many popular HV DC probes are not suitable, such as the Fluke 80K-40 probe. Fluke does have a high-frequency HV probe, the PM9100, which is a 200 MHz, 4 kV probe. For voltages higher than 4 kV, use a Tektronix P6015A probe (buy one on eBay), or you can make a probe yourself.

First let me strongly say that designing HV AC probes which include a resistor for DC measurements is not trivial. See my comments:

- http://fstewart.ne.mediaone.net/DaEtiHhoaNews.shtml#ssE0B35885A28B1949
- http://fstewart.ne.mediaone.net/DaEtiHhoaNews.shtml#ss1F147631D050E473

Also, read the rest of this document including my other comments on this subject in the previous sections.

You can see details of an impressive 500 kV five-foot probe design, Rob's High Voltage Probe Page. Lacking a shield, this probe is suitable only for DC or low-frequency AC use.

For your purposes a simple ac-only probe should suffice. Happily they are relatively easy to make. The basic principle is to make a capacitive divider. For example, a 3pF HV input capacitor with a 3000 pF load capacitor will make a 1000:1 divider with perfect high- frequency response. You can use a home-made 3 pF, 30 kV air capacitor.

Used with a standard 1M scope input the probe will have a 3 ms droop time constant and low-frequency roll-off of 53 Hz. This is suitable for measuring all kinds of fast HV signals like auto ignition pulses, camera-flash triggers and discharges, TV flyback transformer outputs (before the HV diodes), Tesla-coil primary voltages, atomic-trap ring voltages, etc. A 30 kV input will present a safe 30 V to the scope.

```
     3pF     3000pF
  O---||--+--||-- GND
   \      |   _______________
    ''--> '--)______________)-- scope
  oops!
```

Sounds simple, but there are a few problems. A big one is labeled oops! on the drawing above, namely unplanned capacitive paths from your HV signal to the divider junction. To prevent this you'll need some cleverly designed shields.

Because your 3 pF capacitor must be able to withstand 30 kV, it'll be much larger than you would at first imagine. For example, I have used two 1/4-inch thick 4-inch diameter discs placed 1/2-inch apart, IIRC, held in place by metal bars to a long ceramic rod located off to one side. Both discs had 1/4" rounded sides to prevent corona discharge. The "lower" disc was grounded to act as a shield. The low-voltage sense electrode was a thin copper shim-stock disc with a slightly smaller diameter, stuck to the ground disc with double- sided mylar tape. A hole in the ground disc allowed a coax cable connection to the copper sensing disc.

```
                                              ,------------- HV
                                             /
     ,---------------------------------------+--,
    |                                           |
     '------------------------------------------'


        ________________________________________
     ,------ | -------------------------------,
    |        |                                |
     '------ | -+-----------------------------'
             |   |__________
             '--)__________ cable
```

Keep in mind that you should get zero output with the HV probe tip grounded - with the wrong shield layout this is a tough requirement.

A smaller design might use two concentric metal tubes, with an outer shield and an inner low-voltage electrode. The HV would be presented on a wire held in place in the center, making only 3pF of capacitance to the inner tube. Holding the wire in place with a sturdy tip mount without unduly increasing the capacitance would be a design issue.

Calibrate the probes with low voltage AC signals and an AC RMS DVM.

A second issue is protecting the scope. You have to absolutely sure your homemade 30 kV capacitor will not have a small breakdown event and destroy your scope! One solution is to make a 1:3000 divider so the output is limited to 10 V and use a diode-protected opamp follower. Also, with the 10M resistor the droop time constant is better, 100 ms and the low-frequency -3dB point is lower, 1.6 Hz.

```
     3.33pF  0.01uF
  O---||--+--||-- GND          pair of diodes to +/-15V
          |  __________            |     FET opamp
          '--)_________)- 10k -+-+---|\  follower
             coax      |       |     | >--+-- 50 ---o To scope
                      GND     10M  ,-|/   |
                               |   '------'
                              GND
```

Commercial High Voltage Probes

(From: Frank Miles (fpm@u.washington.edu).)

Both Tektronix and Hewlett Packard sell HV probes rated at 5kV and up. Bandwidths are (at least) into the 100kHz area, probably more. I imagine there are others.

The older Tek probes even had ports to refill with now-banned chemicals. The newer ones don't, but are more expensive.

Frequency response is a significant concern. Designing and manufacturing a decent HV probe is definitely non-trivial if you need flat frequency response. Many parts have significant voltage coefficients, too, as well as breakdown voltages.

(From Winfield Hill (hill@rowland.org).)

A significant part of the design effort (and cost) deals with, the problem of how to go smoothly from a resistive divider at low frequencies, to a capacitive divider at high frequencies, while keeping a constant attenuation value at mid-frequencies. This isn't easy. Consider for example, that an overall shield is clearly needed and must properly prevent the high-Z end of the probe from simply acting as an antenna (as some HV probes do! i.e. ground the tip of the probe and *still* see large signals at the output). This shield acts as a capacitance to ground for the HV resistor, routing some of the high-frequency current which is supposed to go to the output, to ground. Hence at some middle frequency there's a dip! This is solved in various ways - with shields connected to the probe tip (but inside the ground), capacitors bypassing the resistor, special resistor construction, etc. Most solutions can just as easily cause a region with a response hump, as well as a dip, or even both. BTW, these problems are much harder if one seeks to make a probe with very low capacitive loading and high frequency response. The Tek P6015A probe is 3pF, and you'll also note it has a veritable raft of response adjustments on the scope-input end.

Much of the cost of the probe is knowing how to do all this!

Incidentally, a low-cost intermediate-range HV probe is the Fluke PM9100, which is a 4kV 100:1 probe with a 200MHz bandwidth. Also the Tek P5100 is rated to 2.5kV. Most of these probes also have a derating above some d frequency.

Most of this mess you can avoid entirely by not attempting to make the probe measure DC (or at least not the whole frequency range).

(From: Sam.)

The person who contributed the following comments may not be totally unbiased but the information is still valid.

(From: Cicel Clenci (cicel@cic-research.com).)

I used many different probes on high voltage measurements and found out that their performance is terrible when exposed to even relatively low common mode voltage transients (100 V or more). Even when using differential probes like Tektronix's P5200 or P5205 measurements can be influenced by common mode voltage transients. You will get glitches on the output that are not there, these will confuse the engineers. One big problem is the high input capacitance of the probe. In order to get the best common mode rejection of the various transients and an accurate representation of the input waveform, you must reduce the input capacitance. 4 pF or 3 pF input capacitance is too high, when dealing with high voltage fast transients, and the compensation is not as easy as it might seem. Look for 0.5 pF or lower input capacitance. There are many issues that need to be addressed when designing high voltage (differential probes). Just take a look at CIC Research HV Probes Page for probes that outperform Tektronix's or LeCroy's probes.

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-- end V1.27 --

Sony TV Tuner and IF Solder Connection Problems

Version 1.31

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

The procedures described in this document require access to potentially dangerous voltages, proximity to the CRT and its implosion risk, and other possible dangers lurking inside a television set. Furthermore, while your symptoms may fit those described below, there is guarantee that resoldering the tuner or IF module WILL fix your problem. The actual cause could be elsewhere.

We will not be responsible for personal injury resulting from attempting these repairs nor damage to the equipment that may result from lack of soldering experience or inadequate desoldering or soldering equipment.

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Introduction

Scope of This Document

Problems with bad solder connections, mostly in and around the tuner and IF boxes are very common with several series of late model Sony TVs. The repairs are straightforward though perhaps tedious and on some models, removing the tuner and IF boxes from the mainboard can be real fun.

Some of the common symptoms include:

- Picture turns to snow or shows other reception problems.
- Inability to tune blocks of channels.
- Channels change randomly as if TV doesn't like what you are watching.
- Loss of picture - just raster and high pitched whine.
- Noisy or muted sound, volume buttons have no effect.
- Controls have no or unexpected affect (console or remote).

Note that many other manufacturer's TVs are also susceptible to similar symptoms with similar causes.

The articles in this document have been compiled over the last few months from postings on the USENET newsgroup sci.electronics.repair.

Contributions are welcome to increase the coverage of this set of notes as well as those for the very similar set of problems and solutions for late model RCA and GE TVs: "RCA/GE TV (CTC175/176/177) Solder Connection and EEPROM Problems".

Proper attributions will be made for all providers of solutions. I apologize if I have incorrectly referenced you or left your name off. I will be happy to make any necessary corrections in the next revision. Please email me with any additional sections. I would very much like to improve the details of the repair procedure if possible.

Corrections and additions to any specific symptom or solution are also welcome.

I have no connection with Sony Electronics or any other manufacturer of consumer electronics. These articles have been included unedited except for some spelling, grammar, and format cleanup.

Safety

Before removing the case on any TV or monitor, make sure you understand AND follow the safety guidelines provided in the document: Safety Guidelines for High Voltage and/or Line Powered Equipment.

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Solder Connection Problems and Solutions

Symptoms of Cracked Solder Connections

Here are some typical sets of symptoms resulting from bad solder connections in and around the tuner of this series of late model TVs. Most of these problems are characterized by erratic behavior of one form or another. However, total failure of reception is possible:

> "I have a two-year old Sony Trinitron TV. When it is turned on, picture perfect. But it can only last about 30 mins, then it looks like it has difficulty to receive signal. On its hardly seen screen, you can see all channel display only one TV station signal (I am using cable). After I turn it off for a while and turn it on again, I got good picture again. The time it last depends on the time I turn it off. Occasionally, if it past the first 30 mins, it seems it will be good forever."

> "I have a Sony KV-27TS20 tv that upon power up will drift back and forth from a clear picture to a whining static fill mess. This happen for about five minutes then the clear picture stays."

> "My Sony 27" (Model KV-2782R) is having a problem with the tuner (I think). When the TV comes on, I have no control over any of the functions. The channel changer, display controls, TV/Video selector all have no effect on the TV. I can, however, see the source (VCR/Laserdisc) that is plugged in to my Video 1 jack, but the picture is very dark."

> "I have these 2 practically identical (at least on the outside) 13" TVs, and they both have the same problem: they act like if someone was messing with the antenna - the picture comes and goes, or just 'jumps' vertically every couple of seconds, the sound sometimes goes away too (turns into just noise). On the KV-1395 the problem sometimes stops - either the picture is already good at power-up or it just acts up for about 20 seconds and

tunes in, the other one is totally unwatchable.

I assume that this is a common problem with these and some other Sony TVs - I remember long time ago someone had posted repair tips on Sony tuners, but I could not find them on the FAQ sites."

One more detail: At power on both the TVs cycle through channels 2-6, with no picture on screen. You have to select a channel for the picture to come on. Is this normal with these models?"

"I'm having a problem with my KV27XBR55 (mines in the XBR series). I realize now that the problem started many months ago when I heard the sound degrading (I thought the sub-woofer had blown). But after moving recently the sound got very bad just before the picture dropped out too.

If I unplugged the set for a while (minutes to hours) it would work for several minutes to several hours after plugging it back in. And... (forgive me! :) a well place thump on the cabinet could get either some video/audio static or actually restore the picture and sound.

I thought the jarring of the move may have loosened some circuit boards or connectors, so I opened the back and reseated every card/connector I could easily reach. That seemed to work but the next day it died again.

When it's having its "problem" I can get a picture by selecting a video input (like the VCR) but no sound."

"This TV works fine for a few minutes, but after warming up it demonstrates a tuner problem. When a channel is switched to, it will take ~5 seconds to lock into the station. Then it will not stay locked in, but instead drift to an adjacent channel for the audio.

I have been reading here for several months, and based on other postings of similar problems, thought I could try to fix this. I read the pertinent parts of Sam's FAQs, and I photocopied parts of the Sams' Photofacts.

The photo of the A-Board shows one tuner box, while I have a box labeled RF-AGC [IFB-450M 1-464-598-11 AE7C20] and Tuner [1-463-603-13 BTP-201 D7011BY]. Adjusting the blue turn knob in the top of the RF-AGC did not improve the problem. I have not adjusted the white turn knob that is in the RF-AGC box. It is difficult to get to because of the proximity of the adjacent Tuner box.

My questions are:

- Should I adjust the knob inside the RF-AGC?
- Should I solder out the Tuner box and replace it?

- Should I solder out the RF-AGC and replace it?
- What will a tuner and/or RF-AGC cost and where can I get one?

I admit to being a novice, but I have enjoyed reading the troubleshooting advice that is discussed here. Although I could take this to a shop, I would like to try and fix it myself." Do not touch any of the adjustments! Problems that happen suddenly or have significant consequences are rarely due to adjustments drifting!

None of the modules need replacing but if you screw up :-) the IF is about $90 and the tuner is about $100. Resoldering all suspect joints will cure your problems.

> "Would like to know if any users have discover why the tuner or TV signal fails to work until the set has been on for about 10 minutes. This problem shows up on the VHF channels - the UHF channels will work. A number of the same vintage sets are starting to show the same problem. Any suggestions would be most welcome."
>
> "I turn it on, and after 5 minutess, it goes to static. I can't even play a tape in the VCR (which the signal runs through first)."
>
> "I have a 4 year old SONY TV with a trinitron tube. When the TV is switched on, it does not receive a few station. For some stations it just snows, on others it shows a very distorted view of some other channel. The problem goes off automatically after 4-5 minutes and then there is no problem as long as the TV is on. The lower frequency channels take the longest time to come back. It is a cable ready TV and when we are viewing cable, the lower channels have the same problem. Most of the time the higher band cable stations are ok from the start.
>
> We are thinking that it may be a problem with the tuner. It does not look like heating problem as the problem is there only during the startup. Can it be a problem of the tuner PLL? or is it something simpler?"

This may be an actual electronic problem but would still recommend doing the resoldering first.

"Does anyone know how I can go about fixing a tuner problem with the Sony TV? The tv signal will come in and out, the signal will come in only for about 30 seconds and is gone for about 15 mins. I have checked all electrical cables, cable TV and antenna cables too.

I have tried contacting Sony, they seem don't care about their consumer services. I have emailed them and contacted their Sony Store dealers, and they would only say it would best to buy a new Sony. I personally will not buy another Sony every again.

"I have a Sony 32" console type TV and the model number is KV-32TW75. The TV set is about three years old. It worked perfect until few month ago. When the set is direct connected to antenna through the UHF/VHF terminal, it worked perfect for about 1 minute then lost all the signals and had no picture. Then I connected the antenna to a VCR first, and connected both the UHF/VHF and video output from the VCR to the TV, it worked all the time. I thought maybe the signal was weak, by turning on the VCR may increase the signal so I didn't pay that much attention. Yesterday it started getting very poor picture quality. I disconnected the video input it got no picture at all. With the video input connected, it doesn't make any difference with or without the UHF/VHF input connected and the picture quality is way low. By connecting only the VCR UHF/VHF output to another TV (this one is a 19" sony with no video input terminal), the picture is perfect. Anyone have any idea what cause this problem and how can I fix it? Thanks in advance.

"This small electronically tuned Sony (Sony KV-13TR14) has this problem:

After about a minute of power on, picture snaps to another (cable) channel for an indeterminate amount of time and then snaps back to the original channel where it operates okay for periods of time (a few seconds to a minute or so). This goes on for several minutes then usually stops and doesn't happen again until the set is turned off, etc.

The local cable company told me that this model Sony had "a bad 'board' grounding problem" or some similar 'grounding' flaw.

I wrote to Sony asking if they were aware of a manufacturing problem with this model and they replied no.

Of course its out of warranty and there's the judgment of taking to the repair store or just buying new.

I'd sure like to repair this myself and any help greatly appreciated."

"I have two Sony TVs that seem to have tuner problems.

The first one is a 13" TV about 4 years old. After about 1 hour of use, the VHF channels go away and all I get is a scanning type picture and a high pitched whine. The UHF and Video input still work. (I do not have cable.) Turning the set off for a while will fix the problem. Also, the TV has the problem faster when it is hot out.

The next one is a 27" TV about 5 years old. When I first turn it on, it works fine for 1 minute or so. Then the VHF channels start to dissapper in the same way as the other TV. This starts at channel 9 (the top VHF station) and works its way down. The problem only affected channels 9 and 7 but not 4 and 2 go out too. After 5 or so minutes they are all back. UHF and Video input still work.

Would you suggest re-soldering the tuner modules for these TVs?"

"I'm wondering how easy it is to replace a tuner module for my 13" Sony. Repair shop said

> that it is a very expensive part and is very difficult to replace. I'm skeptical about the expense because the same shop replaced a tuner module on another tv I had and they listed the part as $5. If it's easy, any ideas about where I can find a replacement part?
>
> A replacement tuner for a Sony 13" tv is a little expensive. I would suggest that you check the solder connections in the IF block before investing in a new tuner."

General Repair Considerations

Caution: See the document: Troubleshooting and Repair of Consumer Electronic Equipment before attempting to repair or replace the tuner module. You *must* have proper soldering equipment and desoldering tools. Attempting to remove, solder, or replace the modules(s) without these *will* result in a mess and a very expensive bill when you finally take your TV to a professional.

Someone brought me a TV to look at. After a little prodding, it was learned that he had lent it to a friend and it died after six months or so. The 'friend' then attempted to replace the tuner module based on the description on a refused estimate from a TV service shop. He did not have proper soldering equipment - perhaps only a Weller 100W soldering gun. Needless to say, the TV did not work - nearly every pad on the PC board under the tuner had been destroyed. I had to run wires from the pins on the tuner to the their destinations on the mainboard. It was not fun. Luckly, no permanent damage was done but it could have easily been a lot worse.

You need to remove the two metal boxes (if there are two - one is the tuner and the other is the IF). On some sets like the 13 inch models, these are readily accessible once the rear cover is removed. On some 19" sets, the pins that need to be desoldered to remove the modules are partially blocked by the plastic bottom frame that holds the mainboard.

Once these are pulled, snap off the *bottom* shield of each and go over all solder connections - both through-hole and surface mount. You may be able to pinpoint some hairline cracks. The pins that go to the mainboard on the tuner and a coil on the IF module seems to be popular locations for problems. Also check the solder connections to the metal case shield and the fingers that need to make contact when the cover is snapped in place.

Don't touch any of the top-side components. Take care not to introduce any solder bridges or overheat anything. However, you may need more than a 15 watt iron to adequately heat some of the (shield) connections.

Descriptions of the Solutions

Here are some of the responses - many from experienced techs who fix (too) many of these sets:

(From: Davetech (dnesbitt4@ vcom.is.net).)

If that is the one with an IF (VIF?) module beside the tuner, shoot some freeze spray into the module while it is playing. I had a Sony last week that turned out to have a bad solder joint in that module, and freezing it pinpointed it. It too, was "searching" through the channel.

(From: Gary Klechowitz (klechowi@execpc.com).)

On Sony TV/monitors of the early 90s there were problems with solder connections in the AGC module. This module was a solder-on board enclosed in a metal box very much like the tunner. There were tunable coils inside and one or two of the legs from the coils would crack free from the circuit. This caused a gray screen effect but also caused the audio to drop out as well. This may be a similar problem. Look for any delay line modules. They are in small plastic cases sometimes orange colored and solder edgewise onto the main board. Inspect the solder connections there as well. If I remember right there was a delay line that had three legs and one of the solder connections would crack and you loose things like low level B & W. That would cause your problem.

(From: Jeff Rigby (jeffg2@ix.netcom.com).)

If a sound and picture problem then look for bad connections in the tuner and the IF module. The IF module generally has bad connections at the pin connections for the Coils (IF, AFT, Disc). The tuner has bad grounds on the outer edge of the tuner board. This problem is generally temperature related=> it will work when cold or hot but in one condition or another will give problems.

As a check, with the back off and the set operating lightly tap the IF can and the tuner and see if the picture or sound changes.

Sound *only* problems are usually due to surface mount caps on the MPX decoder board.

Video only problems are a surface mount capitor problem in the comb filter board.

Both of the above are temperature related and usually get better as they heat up.

(From: Tom Cat (kanduit@juno.com).)

Remove IF 450, solder connections around AFT coil... and any other connection that looks bad... (very common problem).

(From: Mr. Caldwell (jcaldwel@iquest.net).)

Open the IF assembly and resolder the coils, tuner should not need resoldering but if the problem persists you can resolder the ground connection in it if it does.

(From: Brian Leeman (bryboe@mint.net).)

I have run into a few of these...

In every case it has been due to one of the grounding "fan" leads that runs from the PCB to the metal case having a cold joint.

It has always been the lead that fastens to the top of the case directly to the left of the AGC trimmer (looking at the trace side).

These problems are gravy for techs, but it is a shame how poorly Sony executes the manufacture of their consumer electronics. Talk about mass produced junk...

Sorry for the rant, but if you work on this stuff, you have to agree!!

(From: Mister M. (mister-m@ix.netcom.com).)

You should start by checking for these symptoms. If the signal goes to snow then tap on the tuner to see if the signal returns. If it does then proceed to pull the tuner out and pop the shield to solder all grounds around the perimeter of the tuner. (being very careful with the solder splashing). If your signal seems to drift out and come back not snow but a smeared picture or a detuned like symptom then pull out you IF201 if block pop the shield and look for a AFT coil. Resolder and your back in business.

(From: Viawest (viawest@azstarnet.com).)

Invariably, the Sony KV-13TR14 and most of the ones near it are famous, and plaqued with bad solder joints. be very careful not to cause any solder bridges when resoldering the pc board. you must remove the shields from the tuner assembly to accomplish this repair. By the way, check the rest of the board *before* tearing your tuner apart. Sometimes it is a bad spot other than in the tuner itself - usaually the power supply.

(From: Raymond Carlsen (rrcc@u.washington.edu).)

It sounds like you're describing the classic "tuner with bad solder connections". You'll have to remove the tuner and pop the covers. Resolder all the grounds around the outside of the little PC board. Also solder the ground tabs where the metal can pokes through and grounds the foil in half a dozen spots around the middle of the board. Look at the top side of the board to see where the metal goes through the PC. Work carefully! Don't get any solder "bridges" in there. Use a large enough (and hot enough) iron that will fully heat the connections without having to heat them for too long a time, but not so large a tip that will cause bridging. Re-install the tuner and pull the little can next to it. The PC connections that run from the board to the chassis need to be gone over. Resolder any connections that look flaky. Re-install that sub-board and you're done. That should take care of it. I've never had to do one twice.

Successes from Non-Techs

(From: Bill Somrak (cooncat@ncweb.com).)

Well, thanks to all those that suggested that I look at the I.F. assembly for poor grounds and soldering.

I pulled the unit from the main board last night, removed the tin covers on both sides. On the side with the coils and chips in it, there wasn't much to be done, so I left that pretty much alone. The other side was mostly surface mounted stuff. I didn't see anything that was grossly under soldered. Several joints looked "cold". All I did was touch up as many ground connections as I could .. re-solder the cold looking ones, re-do the two chips. I also bent out the little tabs that are on the covers of both sides of the unit .. these tabs apparently make contact with ground spots on the unit. After all this I resoldered the unit back onto the main board .. crossed my fingers, plugged the set back in and powered it up.

Success! No matter what channel I tuned to, the set came on (with picture) instantly. I powered it down several times to let it cool down again, and tried the experiment over and over ... never a failure. So, this morning, before going to work, I put the cover back on the 13" Sony and its working as well as the day I got it (1991). I did note that this is the ONLY Sony that I've had problems with. It was assembled in Mexico (strike 1???), and the I.F. tuner was made in Korea (strike 2???). I wonder if other's have found "non-Japanese" made Sonys to have less than the expected reliability?

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Miscellaneous Problems

Erratic Picture and Sound

> "At start-up, picture comes on OK, then goes dark - loud Crash-Boom sounds from set. After turning off - letting sit - on -- repeats -- several times, seems to stabilize, stay on, and function Ok. I'd appreciate any advice so I know if the repairman has a clue."

This may be tuner/IF related but other bad connections could be involved.

(From: Mr. Caldwell (jcaldwel@iquest.net).)

What should be done anyway:

- Resolder all the TO220 package regulators on the main board.
- Resolder the Horizontal Output Transformer.
- Remove open and resolder the IF pack coils.
- Remove the power supply itself and resolder the output diodes.

There is a capacitor in the power supply that's caused some problems, it's the 22V/27V line I think, a 1000uf@25v or 1000@50v. I've just been replacing it with a 1000uf@50v.

If you do all of this you should not have much else to worry about with this TV.

Noisy Audio

> "I bought a Sony TV (model KV-27TS27) in 1992 and had some problem with the tuner right after the warranty expired but fortunately my Visa card's extended warranty covered some of the repair cost. Now the sound is getting very noisy and I suspect the audio module is not working properly. The TV is not covered by any warranty and I'd like to take care of it myself. I wonder if any one out there knows where I can order an audio module for my Sony TV."

(From: Mr. Caldwell (jcaldwel@iquest.net).)

The MPX 'IC' is a custom mini ceramic PCB with components masked onto it. It is easy to spot and as it is a DIP but you can see the components on the 1" x 1" ceramic 'board'. Capacitors on this board leak and cause a failure in the audio. It will do all sorts of weirdness and then fail.

Call Sony and politely gripe.

(From: John D. Carder (jonetek@aloha.net).)

I buy the Sony SBX1637 MTS module from Matt Electronics for about $7 compared to Sony's price of $68! I have never had a repeat failure yet.

Intermittent Audio

> "My Sony KV-32TS20 television (4 yrs. old) has developed an audio problem. The stereo LED no longer lights ups and I get intermittent popping/crackling along with the audio. I have tried switching between mono and stereo and the audio sounds the same in either mode (sounds like mono in both modes to me). This set had the infamous Sony tuner solder joint problem in the past which was resolved by resoldering the tuner to main ckt. board connections. Now I resoldered the audio section solder joints on the main circuit board but the audio problem remains."

(From: Mr. Caldwell (jcaldwel@iquest.net).)

Defective IC on audio pcb. Little green part with tiny caps on it smack in the middle of the board with the a/v jacks on it. It's a ceramic PCB, about 1" square and it will have corrosion because the capacitors start leaking.

Periodic Audio Noise

> "I have a SONY KV-A2522U (U.K.) TV. About every hour or so it gives out, through the R. hand speaker, a very loud thunder like noise. (and just as loud) Even when the volume

is set low? If I tap the set with my hand the noise stops. Telling me it's a loose connection?"

(From: Steven Turner (steven.turner@amigabee.org.uk).)

Very common fault this. Locate the Metal heat sink running front to back resolder all the IC pins on the heat sink. That will fix it.

Intermittent Picture

(From: John de Rooy (solaris@dds.nl).)

A few months ago someone gave me a Sony 27" KVE2911d television, which was repaired by Sony about 8 months ago. The set came up ok with sound and stereo LEDs but no picture at all. After warming up about 15 minutes the picture returned and stayed until switching off.

I talked to a Sony technician about this case and told him the set was already repaired by them 8 months ago for a lot of money and asked for help. While I think the Sony service is very poor by luck this time he told me about the bad solder connections from the tuner and IF boards.

I was very happy with this information and started taking off the cover for a check! But bad luck! Sony already had resoldered every connection of the tuner and IF boards. After a long time trying to locate the problem (only 15 minutes a day to measure!), I found out the problem was on the small CRT board located on the neck of the CRT. I resoldered the entire crt board (10 minutes of work) and the set has been OK since then.

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Service Information, Costs, Reliability

Getting Out-Of-Warranty Repairs

If you are not inclined to tackle these sorts of repairs for whatever reason, you may still have recourse with Sony. If pressed, they will often cover at least part of the cost of the repair.

(From: Mr. Caldwell (jcaldwel@iquest.net).)

Call Sony Customer Service and explain the problem to them and see if they may cover parts. It's more than likely the tuner and while it can be resoldered and repaired in most cases you can do nothing wrong by asking Sony to cover some of the costs. A 3 year TV isn't that old.

Call Sony and see if they'll pay for the parts and then call a Sony service center and get an estimate and THEN tell them you've got authorization for the part from Sony. ;-)

Warning About Sony Tuner Repair on Certain Models

(From: Gary Warner (warner1@airmail.net).)

Lately I caused myself a lot of grief quite innocently. I thought it might stop a problem before it happens to share this:

On a Sony KV-27S15 I needed to replace the tuner. The tuner is on the "A Board". Looks easy enough to get out but, one end of the board won't clear a metal frame that runs across the center of the main PCB. It's only a small part of the frame and was easily bent out of the way. Unknown to me, bending the frame caused the "solder land" that's under the frame where I bent it, to twist and cause an open connection all around the land. After replacing the tuner and the "A Board" I plugged the unit up, turned it on and POW, the power supply and the horizontal output were all bad.

After a day of troubleshooting I found that the crack had opened the only ground reference for the "feed back" loop of the transformer in the power supply (pin 12 of T603). The power supply lost it's ability to regulate and it ran at "full throttle".

What an embarrassment for me as this was an in-home tuner replacement and now I "Blew up the set". Anyway, everything is okay and the customer understood when I explained all this to them. It was one of those hard lessons that I thought some of you could appreciate and might avoid yourselves.

BTW, the tuner was bad like the tuners in the JVC's, where it intermittently looses the tuning but it's not a physical (connection) or thermal problem. My guess was the PLL IC was checking out. Until now, this model was free of any tuner problems for me.

Sony Service Bulletins

(From: Lynn H. Blakely (lynns@arkansas.net).)

I thought you should know about the service bulletin #203R3. This covers a lot of different models. It shows where to solder the grounds and they have a new cover to replace the original one for the tuner. Also, many of these and similar models have sound problems these can be repaired many times by replacing the SBX1637-11 module. The Sony part #8-746-371-20.

Also see the section: Noisy Audio.

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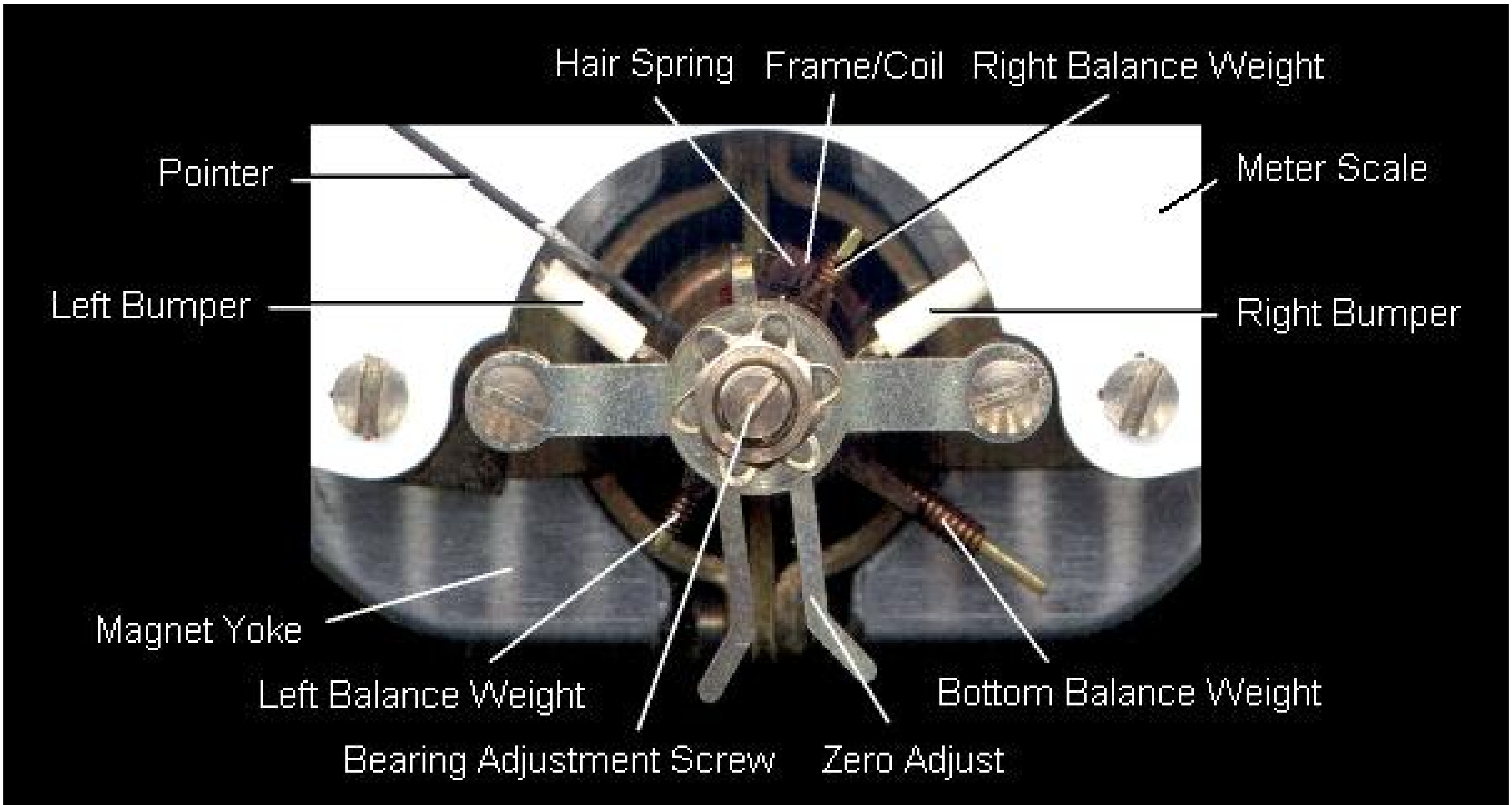

D'Arsonval Meter Movement Anatomy

Printer and Photocopier Troubleshooting and Repair Collection

Version 2.66

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Some of the procedures described in this document require access to dangerous voltages, hazardous laser radiation, moving mechanical parts, and other potential risks to personal safety and damage to equipment and property. The authors and contributors to this document will not be held responsible for any direct or collateral damage which might result from following the suggestions or recommendations contained herein including but not limited to: shock, burns, electrocution, vaporization, meltdowns, torn flesh, destruction of the equipment, and local or planetary wide power disruptions or implosions.

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Introduction

Most of the articles in this document have been compiled over the last few years from postings on the USENET newsgroup sci.electronics.repair. I cannot vouch for the accuracy of all of the recommendations they contain but have edited out anything I felt was totally bogus. I apologize if your response is not here - it could have been that I missed the posting and will welcome contributions.

Note that many of the problems and solutions are listed with respect to specific models. Even though your model and problem may not be included, there is a good chance your problem is covered but with respect to some other model printer or copier. Therefore, search for a generic description of the symptoms and you may get lucky.

Since the operation of laser printers and photocopiers is very similar, check both chapters to see if your problem is covered when dealing with either type equipment.

There is also a chapter on fax machine problems though it is pretty sparse at the moment.

Eventually, this document may be expanded into a full "Notes on the Troubleshooting and Repair of Printers and Photocopiers". For now, be happy that it exists at all! :-)

As always, comments, suggestions, and corrections are welcome.

Portions of this document also appear at PrinterCartridgesInk.com under "Printer Advice". As far as I know, this was done without my permission but since he included the appropriate attribution and copyright notices, I'm not complaining. The formatting may even be a bit better. :)

See the document: Troubleshooting and Repair of Consumer Electronics Equipment for general information on tools, test equipment, tips, techniques, and much more.

SAFETY

Also see the document: Safety Guidelines for High Voltage and/or Line Powered Equipment.

While printers are not generally considered dangerous pieces of equipment (compared to TV, monitors, and microwave ovens, at least), some types - laser printers in particular - present a variety of hazards that should not be underestimated. In addition, photocopiers - particularly larger high speed machines - need to be treated with great respect while servicing.

There are minimal dangers in servicing most printers. However, there may be exposed line voltage near the line cord and long hair or neck-ties may be sucked in along with paper! Laser printers have their lasers but these are generally located such that accidental exposure to the beam is minimized. The toner in copiers, plain paper faxes, and laser printers may be harmful if inhaled and is a potential fire/explosion risk if carelessly vacuumed. Each of these possible safety issues is discussed below with additional specific information in the chapters for the equipment to which it applies. All in all, working on printers is relatively low risk.

The first set of items applies to all line operated printers:

- The input power is 110 VAC (or 220 to 240 VAC depending on where you live). If it is necessary to work inside with the power on, identify the location of any exposed terminals and cover them with plastic electrical tape or block accidental access in some other way. This is much more dangerous than the high voltage present in laser printers and photocopiers (see below).

- Some equipment of this type uses switchmode power supplies. Their internal voltages may exceed 300 VDC, include large capacitors, and the entire front-end is likely line-connected. Aside from staying away, if power problems are suspected, one must take extreme care in troubleshooting these types of power supplies both for personal safety and because it is extremely easy to destroy them (and possibly the powered equipment) due to a misplaced probe. If there is NO large power transformer near the power input but one or more smaller transformers (possibly with HV warning labels) amid-ships on the power board, you probably have a switcher! See the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies for more information.

- Moving parts can grab dangling neckties (yes, I know, you haven't worn one of these in 17 years!) and jewelry - remove any you may be wearing.

- There will be all sorts of sharp sheet metal and other parts to gouge flesh. Avoid sudden uncontrolled movement.

- Dot matrix and thermal print heads may be HOT - stay clear.

- The inks, while probably not toxic, are certainly indelible, so don't wear anything you care much about!

The following apply to laser printers and photocopiers:

- In addition to the AC line input, the fuser lamp is usually powered from the line. Thus, dangerous voltage may appear (come and go as the fuser cycles) at contacts deep inside the machine - possibly hidden from view but not touch. The main motor drive may also use line voltage.

- The main drive motors and gear trains in this equipment are quite powerful, especially in large photocopiers. There is no telling what can get sucked in due to carelessness.

- The fuser is very HOT (heat-wise) and can cause a nasty burn. It remains hot for a long time after power is removed.

- There are several high voltages used to charge the various corona wires. For most modern equipment, the maximum current available from these is extremely small (less than 1 mA) so actual danger is minimal. However, some older copiers may have more dangerous high voltage power supplies. Don't assume all are the same! Interlocks are *supposed* to prevent operation except when printing but they can be defeated.

- Powdered toner is not something you want to inhale (in addition to getting all over EVERYTHING). Also see the additional toner warnings at the start of the chapters on laser printers and photocopiers.

- The photosensitive coating on the imaging drum may also be toxic if it should flake off or become powdered. Avoid direct contact.

And finally, for laser printers and laser photocopiers:

- The laser in all but very old (or high performance phototypesetters and other specialized imaging systems which this document does not address) are IR - invisible. So, you cannot detect it by eye - an IR tester circuit, IR detector card, some camcorders, or other means will be needed to determine if the laser is actually working. The beam will also be well collimated and thus especially hazardous to vision since it will be focused to a fine point on the retina.

  Fortunately, under normal conditions, the laser beam will not be turned on unless all interlocks are closed and a page is actually being printed and/or will be in constant motion as a result of the scanning mirror (which reduces the risk considerably). (It is virtually impossible to get to the laser beam before the scanning mirror without total disassembly.) However, certain failure modes could result in a stationary beam which ignores the interlocks so take care whenever working on a laser printer with the covers removed.

- If your printer does use another type of laser (like helium-neon), there may also be a high voltage power supply for that which can really bite.

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Printer and Photocopier Technology

Dot matrix printer operation

These are the only type of impact printers still in wide use. A set of steel pins - typically between 9 and 24 - strikes the paper through a fabric or carbon film ribbon. The pins are activated by solenoids which are controlled by the printer's control logic. Multiple passes may be used to increase the effective number of pins and improve print quality (letter versus draft mode).

For text, an internal character generator (ROM) converts ASCII codes to pin firing patterns. For arbitrary graphics, the actual bit map is read out and used to control the pin drive.

The paper, carriage, and sometimes ribbon movement use stepper motors. These, their drivers, or interconnect cables, are common problem areas.

Daisy wheel printer operation

These may still turn up at yard sales and flea markets but have virtually disappeared due to slow speed and limited flexibility with respect to graphics. In their defense, for basic text, their quality is superb for a low cost printer.

Instead of pins, these use a wheel with all the possible characters molded on 'leaves' around the perimeter. The wheel spins to the correct character position and a hammer than taps the leaf to impress the character (via a ribbon) on the paper. Carriage and printhead movement is similar to that of dot matrix printers.

(From: Peter (hedgieus@yahoo.com).)

Some history/trivia:

The daisy wheel printer (interestingly) was patented before World War II! It was GE or a GE engineer, but only commercialized by Diablo, which was later bought by Xerox in its expansion to California. Later spinoff was Qume, and then lot of companies got into it, some Japanese, some local (California). Daisy wheel technology was killed by the laser printer becoming cheap and having better quality. Original impetus for it was speed: IBM Selectric was able to print at 10 char/s (good for 110 baud modems!). It moved the whole ball (big inertia). Daisy wheel only moves one spoke, (to print one character) and got 30 chars/s.

Near the end of the era, 'on the fly' printers got as fast as 80 char/sec.

Ink-jet printer basics

(From: Tony Hardman (AHED_CIJ@f54x19.demon.co.uk).)

There is a US publication called 'The Hard Copy OBSERVER' from Lyra Research Inc. Tel: (617) 322-0708.

This discusses the latest technologies and who does what. It may not cover the print head technology very much but is a good read if you are into print technology in general.

There are many companies that sell variable print processes. One I have heard of is RALFLATAC. They do a brochure that does an excellent brief of most technologies available for printing. They have UK (and many other sites in europe) and US sites. UK Tel 01732-583661, US Tel (704) 684-3931.

I have no idea if you can easily get copies of either publication from them so here goes a very very brief description.

Ink jet printing has two main types, continuous ink jet (CIJ) and impulse printing (DOD) (drop on demand). Each of these can be a single jet, or an array of jets.

- CIJ as a single jet is used on product identification (sell by dates, serial numbers) on high speed industrial applications.

  CIJ is a continuous jet of ink cycling round a system and occasionally (when required) a drop is deflected out of the stream onto the paper. The stream is modulated to break it into a consistent drop size. The deflection works like the beam on an oscilloscope. If you charge 1 drop and pass it between two high voltage plates it is deflected. This system also requires cunning mechanics, but the support electronics is much more complex, and probably one of the reasons for its performance limitations being not up to what you might expect. The calculations of the aerodynamics of drops being deflected is no small task, even if look up tables are used.

- DOD is often an array of small jets used on desk top printers.

  DOD works in principal like an old Dot Matrix pin printer. Instead of firing a pin at a ribbon, a drop of ink is fired at the paper. The drop is fired by either a piezo crystal squeezing the ink out of a small tube, or by boiling the ink and the vapor forces the ink out of the chamber. The key to both of these processes is in the mechanical design of very small components if 300 dpi is required. The control electronics is a bit cunning, but I figure it is the easy bit.

A primer on priming

The priming station of a typical ink-jet printer (e.g., HP DeskJet 500C) includes a rubber seal ('boot') and small pump to actually suck on the end of the print cartridge to free up nozzles (there are 50 or more in a typical print cartridge) that have dried up or become clogged. It may fire all the nozzles at some point during this process as well. It also includes rubber 'flappers' which the end of the cartridge pass over to wipe off excess ink.

Priming and cleaning are normally done automatically upon power-on and possibly between pages. However, additional cycles may be needed at times.

With the water based ink, even if the printer is powered off properly which seats the cartridge(s) on a rubber seal, some evaporation occurs so priming will often be needed after it sits idle for a while. Note: Don't kill power to an ink-jet printer as soon as your printout pops free - it needs to position the printhead and cartridge(s) on the rubber boots. Wait until the printhead stops moving and clunking. Some (older) printers don't even have a seal in which case letting it sit idle is even more likely to result in problems.

If there has been ink spilled into the priming area, it may clog up the little hose connecting the priming station to the pump - I have used a wooden toothpick to clear the hole though this may be risky if it should break off. With care, a wire rounded off at the end so as not to puncture the tubing can also be used. Complete disassembly and washing of the parts is probably the best but is probably a pain.

A bit of ink-jet history?

(From: John Nagle (nagle@netcom.com).)

The original ink jet printer of this type was the Teletype Inktronic, which introduced the concept of video-type distortions to printing. It appeared around 1970, and was so bad nobody tried again for years.

(From: Tony Hardman (AHED_CIJ@f54x19.demon.co.uk).)

I guess that is why it was used in industrial applications I guess. Were the 'video-type distortions' a deliberate feature or just a coincidence of how they turned out?

Who are/were Inktronic???(apologies to anyone connected with them) I guess that may have been spin off development from some work contracted out by IBM, but it was so....?? (costly/low res/unreliable - choose one) they lost interest. Although one of the very early machines still runs well on a textile mill. It had a large number of jets side by side, and may be multi color too. I've only seen the patents so don't know exactly what it looks like.

I thought original ink jet printer was a chart recorder developed in the last century. It was just a nozzle on deflection mechanism, and was not modulated so it was always printing. It was a lighter mechanism than actually trying to move a pen and so had some performance advantages over other technology available at the time...

The same reason CIJ still sells world wide, even when high resolution DOD is biting at its heals.

Inkjet types (at least from a Xerox perspective)

(From: Peter (hedgieus@yahoo.com).)

Here are history/trivia. (I used to work at Xerox marking technology group, working on ink-jets and daisy printers.)

- Type 1 (or "push") ejects continuous stream (under pressure). The discovery goes back to Hertz (one who has the unit named after him) and theory is described in the book: The Theory of Sound, by John William Strutt, 3rd Baron Rayleigh.

  Type 1 was commercialized first for printing postal labels and other similar applications. It was a big machine - 5x5x5 meters! Clumsy but fast. This was before laser printers. IBM published detailed (and definitive) research paper on this - circa 1985.

- Type 2 (or pull) uses electrostatic field to extract the drop. It was never commercialized.

- Type 3 (push-pull) or DOD is what we use in small printers now. Xerox put lot of money into developing this in the seventies, than (just when it achieved some 10 kHz (drops/second/nozzle) in the lab, (considered necessary minimum for viable printer) Japanese companies introduced first machines on the market. (I think first was NEC or Ricoh) and Xerox dropped the project. (Manufacturing people in Webster estimated that they can never produce it at profit, facing this competition.) Later, Xerox was using Sharp inkjet heads and printers, under Xerox label. Some research was then revived, (I suppose in cooperation with OEM supplier (Sharp).

Response times of resistance heater elements in ink jet printers

The ink drops that make up the 'image' on the paper from an ink jet printer are expelled by microscopic resistance (thin film or the like) heaters with response times in the 10s of microseconds if I recall correctly. When living in the macro world, it is often counterintuitive to realize that a resistance element can have such a fast thermal response.

(From: John Eaton (johne@vcd.hp.com).)

The trick is that a lot of the energy that you pump into the resistor leaves the printhead with the fired dot. One way to detect Out_of_Ink is to mount a thermistor on the printhead and watch for a sudden rise in temperature as you are firing.

How many colors can an ink-jet printer can produce?

> "I use a HP680C in the office, and it have two cartridges, one for black and one for color (yellow/cian/magenta?). If the printer fire one drop of each ink at a given point, we can have only 6 different colors (ignoring white and black). If it can fire two or more drops at a given point, maybe we can have more colors, but I suspect that the printer use this to control quality of the presentation, not the number of colors. Anybody knows for sure? With dithering it can make more colors, with reduced resolution."

Like most print processes you only have a limited selection of inks to use. Full colour can be derived from three primary colors, just like a monitor. For monitors, these are Red, Green, and Blue because monitors emit light resulting in an additive color process. Inks, on the other hand, absorb light so printing is a subtractive process. The resulting inks should then be cyan (blue+green or -red), magenta (red+blue or -green), and yellow (red+green or -blue).

Therefore, the colors used in common ink-jet printers are not really capable of producing true full spectrum photorealistic quality results since they are red (not magenta), blue (not cyan), and yellow. These are optimized for nice saturated primary colors when used independently. Also see the section: Why are red, blue, and yellow inkjet primaries?.

In addition, the combination of the three primary colors should be capable of being combined to produce black but due to misregistration and the pigments used, this black would be somewhat muddy and brown. Therefore, a separate black ink cartridge is normally used for black printing.

(From: Tony Hardman (AHED_CIJ@f54x19.demon.co.uk).)

With printing there are more problems than solutions and I do not know which method HP use in their printing.

If you can vary the drop size, you can change the drop spread on the paper. This can be done by firing bigger slugs of ink, or multiples of the drop at the same position. As you can figure the ink will either spread and make a bigger drop, or stay the same size and become denser. Depending on the resolution you want these could both improve colour density. This depends on two key components.. The ink, and the paper.

The problems with laying down multiple drops on paper is that if you do a large block the paper will curl up and the overall image becomes worse. This is why you can pay 1$ a sheet for 'quality' paper.

Another problem with this is speed. Firing two drops in the exact same place is difficult... Unless the head is stationary but that is not good either. You may notice that most DOD printers in high resolution mode do a number of passes over the same place. This does allow dithering and other techniques for resolution / colour enhancement. They usually only print while going in one direction for improved mechanical control.

In the 1600 printer there is a heater to assist with the drying times and reduce the curling problem.

Inks are a problem too. They can dry at different times because of the different dyes used, or they may not mix how you expect if you place two colours on top of each other. Its only ink ... but to get the best balance of surface tension, drying time, viscosity, colour, stability.... and more is not as straight forward as it might seam. I have noticed that the water based inks are improving, and there are some that do not run if they get wet (after drying on the paper).

I think the spec in your manual may suggest what method they use.. The printer resolution (best) is 600dpi (I guess), and I recon the best full colour resolution is lower. Also the print head is only 300dpi so you must do two passes to get 600dpi black (single black ink cartridge). This suggests a partial step of 1/600 inch between the passes. What happens when you print black using the colour head? How many passes, how much slower? The resolutions quoted may also be 600 * 300, or what ever. If they make blocks of colour from a potential 600dpi machine, the resultant image is probably only 75dpi (possibly less). This still might be called 600dpi, because the drop placement uses this resolution, but it is not 600dpi at full colour. The resolution of quality picturers / poster is several thousand dpi, but not a variable image (not ink jet).

In the Lyra publications they did publish the real print head specifications for the machines they review. They also include some of the methods of colour printing.

After all this I have noticed that I have not answered the question of how do HP et all get their colour resolutions. All I have mentioned is a few of the parameters that the designers have to deal with.

Why are red, blue, and yellow inkjet primaries?

For a subtractive printing process, the 'optimum' primary colors for a 3-ink system would be closer to magenta, cyan, and yellow. However, these are not generally used. Why?

I don't know the precise answer but it is no doubt a tradeoff between cost and which colors are used most often. For non-photo printing, the straight red, blue, and yellow are far more useful since they can be use by themselves or in simple combination to produce a wide range of vibrant, if not realistic colors. For example, pure red is far more likely to be used for simple graphics than magenta. To make something that looks like pure red using magenta and yellow requires a precise combination - not easy to do with an inkjet printer!

About inkjet printer ink

No, you can't refill your HP DeskJet cartridges with fountain pen ink!

(The following is from someone who also sells inkjet refill kits so this may not be an entirely unbiased writeup.)

(From: John Connolly (toner@idirect.com).)

There are at least 10 ingredients in inkjet ink, starting with triple distilled, de-ionized water, dye or pigment color of a known particle size, humectants such as glycol to minimize evaporation (and head clogging), surfactants to balance the surface tension and paper wetting, resins to get good paper adhesion, biocides and fungicides and buffering agents for the correct pH. These considerations ensure that properly reverse engineered inks not only work, but produce a print comparable to the OEM. For printers like Epson, with fixed permanent print heads in the printer, expensive repairs are also avoided.

To make matters worse HP has rigged their most popular black cartridges for the Deskjet 500 & 600 series to curb refilling, with air bladders, constantly changing maze/ venting assemblies at the bottom, and logic to change the signals to the micro-resistor jets on the 3rd or subsequent reinstallation of the cartridge. The color cartridges for these MUST be refilled before air locks occur, particularly in the yellow chamber.

Some people still manage to get an acceptable refilling success rate with these Deskjets, but we feel it is a bad introduction to refilling for the first time refiller. Deskjet series 700, 800 & 900 are better bets to refill.

But, the current Lexmark, Canon, Xerox and Epson cartridges are by far the easiest to refill.

Image Control's refill kits for the Canon 4000 series refill the BCI-21 black 40 times, or the BCI-21, 12 times EACH color.

More details on inkjet inks, a description of our refill kits which are larger than most offered, references and printer/cartridge tips are available at Image Control's Web Site.

Laser printer and photocopier operation

Copiers and laser printers have a lot in common. The major difference is in how the image is formed on a photosensitive drum:

- A copier uses a bright light and lens to focus an image of the original (actually, a strip at a time which is scanned in most modern low to medium performance copiers) onto the drum. Adjusting the lens-to-original and lens-to-drum distance is used to vary the reduction or magnification.

- A laser printer uses a low power sharply focused laser beam to scan one line at a time on the drum. Modern laser printers use infra-red solid state laserdiodes similar to those used in CD players and optical disk drives while older ones used helium neon lasers.

  The digital image is generated from a bit map stored in the printer's memory and modulates the laser beam. Scanning is mechanical - a high speed motor spins a multifaceted deflection mirror to get the X-axis and the paper moves to get the Y axis.

  LED printers use a large array of LEDs as the image source but are otherwise similar to laser printers.

Plain paper fax machines use similar techniques in their printing mechanism.

Beyond this, copiers and laser printers are nearly identical (at least in principle) except that copiers use a positive process (dark areas in the original result in marks on the paper) and laser printers commonly use a negative process (a spot of light results in a dark mark on the paper).

The most sophisticated machines are now actually scanner-laser printer combinations with buffer memory so that multiple copies can be made without rescanning the original, sorting and collating is more flexible, scaling and rotation can be done digitally, and other features not possible with simple copiers.

(Portions from: Copenhagen Cowboy (cowboy@fastlane.net).)

The photosensitive drum is the heart of the laser printer or copier. In larger machines, it may be a separately replaceable unit. In most laser printers and smaller copiers, it is part of the 'toner cartridge' and is a throw-away (or may be recycled).

The drum is coated with a photosensitive material which has an extremely high resistance when in darkness. It's resistance drops to a low value when illuminated.

All of the following takes place as a continuous process as the drum rotates. Note that the actual photosensitive drum in most copiers and laser printers has a circumference that is much smaller than the length of the printed page. Therefore, only a portion fits at any given time and the charging, exposure, transfer to the paper, cleaning, and erasing is a continuous process:

- The drum's surface is charged to a high positive voltage (typically 5 to 6 kV) by a set of charging corona wires in close proximity to the drum.

- The exposure process differs for copiers and laser printers:

  - For copiers, a swath of the original is focused onto the drum. As the drum turns, a quartz lamp and strip mirror moves along the original and second strip turning mirror moves at half this speed. The result is that the entire original's image is kind of 'peeled' onto the rotating drum. (Look through the glass platform that supports the original of a copier as it is copying and you will see what I mean.)

  - For laser printers, the negative image of the page stored in the printer's buffer memory (the laser is turned on where the print is to be black) is read out and scanned onto the drum one line (i.e., 1/300th or 1/600th of an inch) at a time.

  Where the light hits the drum's surface, its resistance drops dramatically and the charge in these areas is dissipated.

  At this point, a swath of the image of your ultimate copied or printed page resides as areas of electrostatic charge on the drum. This is a 'latent' image and must be 'developed'.

- As the drum continues to turn, the latent image rotates past the 'developer unit' which contains a mixture of developer and toner. For the most part, developer is not really used up during the printing process but some is lost and may need to be replenished from time-to-time (depends on design).

  - Developer is a material which includes powdered iron or other powder which is attracted by a magnet.

- Toner is the actual 'ink' and consists of very finely powdered thermo plastic particles. These are 'fixed' in the fuser by literally melting the image onto the paper.

  Depending on design, the developer material may be separate or actually combined with the toner.

  A magnet in the developer unit which is as long as the page is wide causes the developer along with trapped toner to stand out following its lines of force off of its long N-S pole pieces. This forms a kind of brush of toner and developer material which is in contact with the drum as it rotates with its latent image. Normally, the developer material brush is C-shaped, and toner particles are carried in the C-shape (the back of the 'C' is against the drum).

  Here is where the developing processes of copiers and laser printers differ:

  - For copiers, the relative charges of the drum and toner are set up so that toner is drawn to the unexposed (dark parts of the original) portions of the drum resulting in a positive image on the paper.

  - For laser printers, the relative charges of the drum and toner are set up so that toner is drawn to the exposed (where the laser beam was turned on) portions of the drum resulting in a negative image on the paper.

- The drum continues to rotate around and comes in contact with the paper.

  Below the paper is another corona, the 'transfer corona'. Another high voltage is applied to the back of the paper (once again, around 7 or 8 kV DC) to draw the toner from the drum to the paper. (Remember, all this is going on in a continual cycle and it is all in motion).

- Depending on the manufacturer of the machine, you may or may not have a third corona, the 'separation corona'. This is needed to separate the paper from the drum, but not disturb the toner on the paper (the separation corona is usually 4 or 5 kV AC (if it was DC, you would separate the paper, but have *very* smeared toner all over the page as to make it unreadable). The separation corona usually has guides over it to keep the paper from 'dipping' down too far into the corona shell.

- Paper is then transported to the fuser which 'fixes' the toner to the paper via heat (to soften the toner particles) and pressure (to embed them in the paper fiber). There are parts in the fuser which also keep the paper from sticking to the hot rollers. A thermostatically controlled quartz tube lamp provides the heat inside the anti-stick (Teflon coated) fuser roller.

- Finally, your copy or printed page is ready!

- However, we are not done as there is still some toner on the drum - it is not possible to get it all off electrically) so there is usually a rubber or plastic blade which rubs in direct contact with the drum. This 'drum blade' scrapes the toner off the drum, and the 'recovery blade' catches it to keep it from falling back into the machine. A 'used toner auger' transports the used toner (which is now changed both physically and electrically and is also contaminated with paper dust (don't reuse your used toner) because it can eventually damage the developer unit, cleaning blades, fuser sections and other parts of the mechanism.

- Now that all the toner has been scraped off the drum, there is still some residual charge on the drum from the previous exposure process. You can't scrape the static charge off the drum, so the cleaned drum is now fully exposed to a bright light to discharge the drum surface and prepare it again for a new charge, which comes right after the discharge lamps.

That is the basic process. Many variations are possible and depending upon the machine and manufacturer, some of this may be a little different. Where a (disposable) toner cartridge is used, many of these components are replaced with the cartridge - typically the drum, toner itself and developer (usually combined into a single powder), developer magnet (really neat!), cleaning blades, some of the corona wires.

There is also some photocopier information at:

- Diverse Devices

Laser printer operation summary

(Portions from: Zaki (zg@ix.netcom.com).)

In general the principle of electrostatic laser printing is as follows:

1. Charging a photoconductive selenium (or other) coated drum.

2. Discharging the drum with the laser steering engine in accordance with the input image rasterized pattern. (the laser is modulated to generate a predefined pixel pattern on the face of the drum - the focal plane).

3. The rotating drum attracts toner to the charged pattern (latent image) generated by the laser.

4. The toner is transfered from the drum to the moving papaer to generate a full image.

5. The paper carrying the toner moves through the heater to fuse the toner to a fine non-erasable image.

The laser steering engine is combined of the following components:

- Infra-red diode laser, 3 to 4 mW in basic units, up to 30 mW or more for high performance printers.

- Beam expander to form the required size of the collimated input beam which generates the beam spot size in the focal plan.

- Cylindrical lens to reshape the laser elliptical beam to a round one.

- Spinning polygonal mirror to deflect the laser over the focal plan.

- F-Theta lens to flatten the inherent circular plan of a rotating mirror. This lens is a very special lens which only few in the optical community know how to design and fabricate. The one that you own is particularly special because it is a Sectioned F-Theta lens which are typicaly more expensive (most of them are spherical).

  If you need to scan or to print in high resolution 500 dpi or higher, you end up using a glass F-Theta lens.

Cleaning and Handling of Photosensitive Drums

Where the drum is located inside a replaceable toner cartridge, there is no need for special handling. However, where the drum is a separate unit, the following applies. Or, if for some reason, you need to disassemble (gasp!) a cartridge:

(From: David Kuhajda (dkuhajda@locl.net).)

Whatever you do, do NOT use alcohol on an organically based drum, it will ruin it. The alcohol causes the material to crystalize. I use to do copier service and this was stressed a lot by the manufacture as they switched from the old selenium drums to the new opc drums. Direct sunlight will immediately destroy the drum. A couple of minutes under normal lighting is no problem, just place it in a dark area and put a black cloth over the top of the drum while it is out. If you are replacing the drum cleaning blade or cleaning the crud off the blade, make sure you powder up the drum completely and the blade before reapplying power. The toner actually is a slight lubricant and the rubber cleaning blade directly on the drum will also ruin it. Just print a few low text copies after reassembling to allow the blade to reseat properly.

(From: hapticz@email.msn.com.)

Short periods (less than 5 min) under fluorescent lighting is safe.

Direct sunlight kills them immediately.

Just have a clean brown paper bag to shove it into while it sits on the table outside the machine.

Often more damage is done to them physically during insertion/removal. just be careful.

Xerox used to clean the 10" diameter drums with 90% isopropyl alcohol and some kind of "Kim Wipes" in our office, that was years ago though.

Book on laser printer maintenance and rapair

(From: Michael (ncacaver@aol.com).)

Get the book: "Easy Laser Printer Maintenance and Repair by Stephen J. Bigelow".

Your local library should have it or be able to get it. Stephen J. Bigelow has several other books on printer repair, both laser and non laser types. All are very good.

Discussion on laser diodes in laser printers

> "I just acquired the optics from a dead laser printer and have been trying to understand it. There are two functions I have yet to grasp. One is something which it has but for which I see no need. There seems to be a heater (Contains mica) and a thermometer, with PCB markings like "T1" and H2" or something similar. If these the laser is temperature controlled, why? There seems to be a control photodetector to monitor the laser diode so temperature control appears like overkill unless the photodiode itself has too much temperature dependence and the drum exposure is very critical."

(From: Jonathan M. Elson (jmelson@artsci.wustl.edu).)

There is a heater inside the fuser roller. This is what melts the toner into the paper. It is thermostatically controlled, and then has a safety thermostat in case the control fails.

There are two photodetectors for the laser. One compensates for dimming of the laser over years of use, the other picks up the beam at a particular angle of the polygon mirror, and synchronizes the raster electronics to the polygon rotation.

> "The other thing is something I cannot find, the aperture defining the nice well-formed pixel. So far I must admit the study has been a bit superficial but the aperture ought to be pretty obvious if there is one!"

The laser is the aperture. With an optical path of 0.5 m or so, the laser is a pretty good approximation of a true point source. A simple lens makes it look like a very good point source.

> "Finally, how are the correction lens made? They look like slices out of the middle of some fair sized lenses, but that would be a very wasteful way to make them. Can they be diamond formed to nearly the final shape and with such good finish so only a simple polish completes them. Grinding the old-fashioned way on a sliver of glass looks doomed to generating all sorts of defective approximations to a sphere. (As far as I can tell they are glass, or some wonderfully hard plastic I would like to know more about!) Can they be molded to sufficient precision? (The sides are ground or sawn.) Thanks to anyone who can bring me up to date on lens fabrication technique."

I think they mold these lenses to near correct shape, then grind and polish to the desired aspheric shape with specialty machines for that purpose. (Note that almost all eyeglasses are aspheric for astigmatism correction.) Yes, these lenses are glass, I've had a few printers apart myself.

Types of toner

(From: Lionel Wagner (ck508@FreeNet.Carleton.CA).)

There are two basic kinds of toner: magnetic and non-magnetic. If your laser printer has a Cannon 'engine' it most likely uses magnetic. NEVER use the wrong type. The imaging process is extremely delicate and specific toners are important. Use of toner that is slightly different could result in all black or all white copies.

So you put in the wrong type of toner?

> "I have a 3M Model 6312 copier. I believe it is a re-badged Lanier. I didn't pay much for it but it worked well. When the toner warning light came on, I made the mistake of adding the wrong kind of toner. I removed the wrong toner as much as I could by vacuum. Is there anything I should do before adding the right type of toner? Did I do serious damage to the system? What to do if the warning light remained on even with the right type of toner added? Any suggestion will be greatly appreciated."

(From: Lionel Wagner (ck508@FreeNet.Carleton.CA).)

If your copier uses non-magnetic toner, it is mixed with iron powder, called the Developer. Both have to be removed and all residue vacuumed out. If the copier uses magnetic toner, less of it will remain in the machine. Try to get as much as possible out. Do not scratch the roller on which the toner sits.

WARNING: See the section: Warnings about vacuuming laser printer toner before using a household vacuum cleaner to do this!

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Dot Matrix and Daisy-Wheel Printers

So you took your printer apart....

> "I stupidly took apart my Panasonic KX-P1123 to attempt a head swap (the cable was too short!), now that

> it's back together it just beeps when I try to print. The only things I touched were the rod that the head assembly slides on and the toothed belt also had to come off (I don't think it's a timing belt.. there's no clear markings suggesting that). When I try to print, the head moves to the center, there's no pin action and it starts beeping at two second intervals (and won't stop). It's not the paper sensors because they seem to work properly...any ideas?"

(From: Filip M. Gieszczykiewicz (filipg@repairfaq.org).)

Greetings. A few:

1. Make sure you didn't trap and crimp any wires .. there SHOULD be a 'Column 0' sensor - either a photo-interrupter or a switch. The print head will activate it during the self-init.

BTW, move the carriage all the way to the right, close the cover and turn it on - does the print head move or does it just sit there and beep?

2. Ensure that you have the ribbon cable correctly hooked up between the printer & head .. some [smarter] printers can tell... I am not sure about that one, but some printer have an optical (IR) sensor that detects ribbon presence (or am I spoiled with fixing $$$ printers? :-)

3. This should be obvious - but does the print head move FREELY all the way from the left to right and back? Don't forget to oil (not too much!) the rails!

4. Did you reconnect all the cables? Is the front-panel (display+buttons) attached?

More depends on the answers and results of the above. BTW, most newer dot-patrix printers just need 2 screws to be removed to release the head. I know the Epson LQ-1050 works like that (and many of that Stars as well). Anyones needs parts from the former? I have one with a dead head (and it's not economical to repair).

Print head repair

> "I have a few Epson dot matrix print heads with stuck or sunken pins. Does anyone have experience with disassembling these things for cleaning/repairs? It looks like you just have to pop a few clips to get them apart."

(From: Chris Serrano (brace@loop.com).)

I resurrected one by hanging it pins downs in an ultrasonic cleaner. A lot of old dried up ink floated right out and the stuck pin became obedient again.

(From: Filip M. Gieszczykiewicz (filipg@repairfaq.org).)

Greetings. If one does not have the use of an ultrasonic cleaner, I have found a different way to get these suckers working again.

Go to your local plumbing store and look in the chemicals department for 'CPVC-PVC-ABS CLEANER' (used to clean plastic pipes). This stuff is a combination of groovy chemicals Methyl Ethyl Ketone and Acetone. It will 'melt' most plastics so be sure the print-head's any plastic parts are safely taken off.

Pour some of this stuff into a GLASS container and put the print head, business-end first, in it and leave it there for a few minutes. When the stuff turns dark-purple (all the ink and goo from the print head) you are done. Let it dry (few minutes) and then oil it with LIGHT OIL. Note: Do NOT use WD40 - we're interested with something that sticks around for a few months... WD40 just leaves a 'protective layer' with almost zilch lubricating properties (it's a Water Displacer (WD), after all).

I have done this for a few DataSouth DS-180, Infoscribe 1000s, and Xerox [monster] printers that see a box of 132 column paper a month (each) for a number of years with excellent results. Note: YMMV... these printers have rugged print heads (7/9 pin)... I don't know how a 24-pin Made-in-China feather will respond.

Ribbon does not advance after replacing flex-cable

Have you actually confirmed that your 'new' ribbon cables are making proper contact - with an ohmmeter? Assuming that the thing worked better before the cables were cut, then there are only two possibilities: your replacements aren't quite right or something was damaged by the 'event' or through later actions.

Print head stepper

Confirm that you simply don't have bad solder connections around the plug to the motor. This is common in printers and will result in erratic or incorrect motor movement.

(From: Ralph Wade Phillips (ralphp@gcstation.net).)

What's common in some older Okidata 32x's and 39x's is that the lithium battery *above* the stepper driver will spring a leak, and drop the lithium compound onto the legs of the stepper. I do not know for sure if it's corrosive, conductive, or just plain nasty, but it kills the stepper deader'n'snot.

I'd LOVE to find a replacement - I've got a service customer that has about 2,500(!!!) 320's and 321's in the field, and I am not looking forward to having to exchange all those boards over the next several years.

Motor driver blows fuses

The following was in response to a dot matrix printer blowing the power fuse whenever the paper advance motor was driven. A 74LS273 was getting hot as well:

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

I'm going to guess (based on what I've seen in other printers) that there's a set of power transistors (either H-bridge drivers or 1 per coil, depending on the motor) that drive the stepper. These transistors are driven from the printer's microcontroller via an output port - in this case the '273.

Now, if a TTL chips is getting very hot, then either something is drawing too much current from it, or something is overvoltaging one of the pins. A particularly unpleasant failure mode is when a PNP power transistor, with the emitter tied to the V++ rail (the 20V + rail that supplies the motors) decides to short and apply said voltage to the output of whatever device is driving it. If you're unlucky, the next stage is that the output port device breaks down as well, and the CPU data bus gets 20V or more on it. The result is blown chips all over the printer. Please don't ask how I found that out ;-)

My guess is that there's at least one shorted transistor in the stepper motor drive circuit. If the system uses an H-bridge driver (an equal number of NPN and PNP transistors) then if one transistor shorts, its companion is connected across the power rails. When it turns on, the supply is effectively shorted.

I think you'll have to trace out the driver circuit for the stepper motor. Figure out what drives what. Test the transistors, and then replace the defective ones _and_ that '273, which is probably now blown.

Ribbon on electronic typewriter does not advance

> "My wife has a "Smith Corona" Model SD800 electronic typewriter that will not advance the ribbon. Everything else seems to work fine. We have been unable to find a local repair for this unit. I think I can fix it with some advice from someone familiar with these machines."

Can you determine if it is a mechanical or electronic problem? For example, with the ribbon removed, does the gear or post that drives it appear to try to turn or not at all?

Modern electronic typewriters are a combination of keyboard, microprocessor, and printer. Therefore, the same sort of troubleshooting approachs can be used as for computer printers.

Common electronic problems include bad connections to the motor that advances the ribbon (cold solder joints, cracks in traces on flex cable to carriage), bad motor driver chip, or bad motor.

Mechanical problems include stripped or broken gears, misalignment preventing advance mechanism from engaging, and defective ribbon cartridge.

(From: Roger D. Waddell (rwaddell@peachnet.campus.mci.net).)

This problem is usually caused by a broken 'E' clip on the bottom of the print hammer solenoid. The clip holds on a lever that works in conjunction with the ribbon/correction feed solenoid near the right front of the print carrier.

When the clip breaks, the lever falls out of position and never trips the lever that assists in feeding the ribbon.

I have seen this problem many times!!

Apple Imagewriter II squeal

> "My Imagewriter II, after many years of faithful service (~8), is starting to squeal. It squeals when the carriage moves. It still prints perfectly fine, but....a new noise can only mean trouble. Does anyone have any experience with this problem and his solution? I imagine it would take only a drop or two of lubricant. But where?"

(From: Chris Jardine (cjardine@wctc.net).)

I would suggest that you might have a problem with the ribbon mask. A few years ago I was the service manager at an Apple dealership. I can't tell you how many ribbon masks I replaced for many different problems, including wierd noises. It could also be a problem with the carriage drive motor. I can't remember which side of the printer it is on, but, it is below the gear/pulley that drives the toothed belt. You might try some very fine (maybe silicone) oil there and you might want to clean and then re-oil the carriage guide bar (the shiny round bar) and the bushings on the carriage that ride on the bar. The only other possibility would be a problem in the gears below the ribbon that are responsible for driving the ribbon.

Compaq Pagemarq 15 printer service mode

(From: Darren Mckillop (Darren.Mckillop@gecm.com).)

Try powering on while holding escape, this will put you into service mode. Press the up arrow to start the engine test, if this works you may have a problem with the xerox controller board.

Try disconnecting all the n/w cables and reseating the cables on the system board. Remove this by the two thumbscrews at the back and slide out as far as you can then pull the cable off.

I have a Compaq Pagemarq 15/20 service manual that I am selling, but I am in the UK, where are you?

Epson FX-286e printer problems

> "I just received the above printer in a non-working condition. It exhibits the following symptoms:
>
> When power is applied, the head appears to try and move, but will not unless you manually get it started. Then it goes to its home position. You then hear three beeps, and nothing else can be done to elicit any response from the printer. The power LED comes on, but the paper-out will not, regardless if there is paper installed or not. The paper detect switch is working properly (checked with ohmmeter by inserting/removing paper while across switch). Also, I hooked up a resistor and +5 V to the paper-out LED, and it lit up ok. I have also mapped out the stepper motor leads, and resistance checks show that it appears to be ok.
>
> MY question is if perhaps I lost one of the outputs for one of the stepper phases. The controller seems to be one large power-ic from what I've traced out."

Could be. Do you have a scope? You could check the phases.

> "I know if you keep voltage across one phase, you can lock a stepper. If you lose power to one phase, will the other phases keep it going provided you manually start it like I'm doing?"

Also check for bad connections to the stepper from the logic board - I have seen these on printers.

It doesn't explain your other problems, however. Once initialized, even though the print head doesn't move properly, I would expect the printer to work in other respects.

(From: Joe Wagg (jwagg@fs.cei.net).)

The 3 beeps tell you there's a carriage error, probably from an incorrect number of steps needed to reach the home position. Since you've already checked the motor, the next step is to check the motor drivers. Using a meter with a diode check function, put the red lead on ground and the black lead on each phase coming from the board (disconnect the motor first). The readings should be within 20 percent of each other, not open or shorted. Also make sure the motor, pulleys, and carriage are all relatively clean and move freely. The other symptoms are caused by the carriage error, which halts the cpu to prevent damage. Clear up the carriage error and the other problems should go away. You should also make sure that all socketed chips are properly seated and don't have dirty contacts.

Paper debris clogging Epson LQ-570

> "I have an Epson LQ-570 series dot-matrix printer that has developed an intermittent paper feed problem over the past year or so. It uses a push tractor for sprocket-feed paper, and paper tends to bunch up under

> the platen. There doesn't seem to be an obvious way to remove the platen to see what the paper's catching on, indeed the FAQ on Epson's website says it can't be removed, and to bring it in to the dealer for repair."

(From: Asimov (Asimov@juxta.mn.pubnix.net).)

Remove everything that is normally accessible. Then flip the printer on its back and play a vigorous drum roll all over it. This should dislodge a huge amount of "holes". Didn't you always wonder where those perforations went? Well, some of them make it into clogging up under the platten.

Flip the printer on its side and with a thin brush dust the remaining grime away. If the jam didn't clear up you might try manually inserting a stiffer paper (postcard, greeting card, etc) a few times before dismantling the platen assembly any further.

IBM X-24 Proprinter print head jumps around

> "Got a problem with a real nice 24 pin dot matrix printer I bought used. Was working fine for awhile then all of a sudden it will be printing fine an the printhead intermittently will jump to the center of the carriage and start printing from there. Also, when you turn it on, many times the printhead jams over to the right side of the carriage and the gears grind and you have to cycle it on and off to get it to start up right. Then you now almost for sure it will have problems printing. Help, any ideas? Do I just change a control chip? How do you scope out something like that? Can I get a manual somewhere? I want to keep the printer."

Also check for bad connections. If the printhead motor is a servo (DC instead of stepper), you have an intermittent feedback problem, again could be bad connections or bad parts.

(From: Ralph Wade Phillips (ralphp@gcstation.net).)

First off, have you changed the RIBBON? Second, clean the print head carriage rails. They need a VERY LIGHT coat of VERY LIGHT oil, then wiped clean.

Usually, when I see this, either the printer is just plain wore out, or the ribbon is snagging. Since the ProPrinter family drive the ribbon off of the carriage drive, if it ever snags, you'll get these symptoms.

NEC P5200 Printer problem

> "I have a NEC printer that has an intermittent CE (ribbon cartridge empty) problem, only the cartridge is new and good. Anyone knows what senses this condition and what part could be affecting this? NEC wants $20.00 just to talk to me. Thanks for any help."

(From: Paul Weber (webpa@aol.com).)

Look at the old ribbon. Does it have a short piece of transparent tape at the end of the ribbon? If so, the printer probably has an optical end-of-ribbon sensor; a LED/phototransistor pair that looks through the ribbon. Does it have a short patch of aluminum foil tape (probably on the back side of the ribbon) ? If so, there is probably a pair of contact fingers that rub the back of the ribbon as it feeds. Look for bent contacts or debris in the ribbon holder mechanism.

Look at the ribbon holder mechanism in the printer. Is there switch or contact pair that could sense the motion of the ribbon cartridge's feed reel? If so, check for free movement and cleanliness. Does the ribbon holder move with the printhead on this machine? If so, check that the ribbon cable connecting the carriage with the remainder isn't damaged and is connected properly at both ends.

OKI Microline 391 Elite Problem/Error

> "I am having a problem with a OKI Microline 391 Elite. I opened it up and cleaned out the dust and paper from inside. On putting it back together and powering up, The SEL light, the COURIER font light, LW and 10 cp light are all flashing and the stepper motor for the platen is jigging back and fore about once every 3 secs."

(From: Glenn Allen (pclogic@xtra.co.nz).)

These printers generally need just a clean out and put back together.

I would try to reseat the main logic board first, also try cleaning the edge connectors. There is a plastic joining bracket between the print head cable and the main logic board.

If you are getting bad carriage movement then check that the carriage can move freely back and forth, also check the black teethed guide lying on the bottom for clogged teeth. The print head ribbon can be removed for better testing. if the carriage doesn't move freely then you may need to adjust it's position by loosening the two screws on either side of the print head carriage and then adjusting back and forth until good movement is achieved.

Star SD15 printer self-test problem

> "This printer has a problem I am lost with. When I power it up and attempt to have it perform the self-test printout (FF on power up), the print head moves back and forth, the paper feeds, but the pins don't actually fire. However, if I connect the printer to a computer, the printing is just fine."

You are complaining? :-) Usually, it is the other way around!

(From: Ralph Wade Phillips (ralphp@gcstation.net).)

Eh? On the SD-15, the FF SelfTest is for checking HEAD MOVEMENT only. It sounds like it passes just fine!

Try holding down LINEFEED button instead. :-)

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Ink-Jet Printers

HP DeskJet problems

This of course also applies to other HP printers as well!

Hewlett Packard has on-line information and documentation at:

- HP Support.

Types of HP ink-jet technology printers

(From: Paul Grohe (grohe@galaxy.nsc.com).)

The PaintJet printers are 180 DPI and the DeskJet printers are 300 DPI. The resolution of the PaintJet is about that of a poor 24 pin printer. The PaintJet and ThinkJet printers are also PCL, so you can use a HP laser printer driver set to 150 DPI.

There seem to be currently four levels of HP ink-jet printers:

1. ThinkJet/QuietJet: The original. Small see-through bladder cartridges. These are small, compact, quiet, form-feed printers. Text quality was about that of a 9 pin (I still love the little ThinkJet printer; damn near indestructible, small, and built-in Epson emulation). (BTW, look in the 1989 HP Optoelectronics handbook for the datasheet of the miniature ThinkJet cartridge). Original cartridges needed special paper for best printing. Replacement cartridges that print on plain paper are now available.

2. PaintJet: The first color printers. Cartridges are bigger, 'squarish' and usually are mounted horizontally. Resolution is the same as their 'little brothers', the Thinkjets (180 DPI). There are black, combined color and separate color cartridges (and sizes) available for the different printers. Printers were generally form-feed.

3. DeskJet/DeskWriter: 300 DPI. BIG improvement. Cartridges mount vertically. Black and combined color cartridges are available. Printers are sheet feed and plain paper printing.

4. DeskJet 800 series: 600x300 DPI B&W, 300x300 DPI color. Cartridges are tall and narrow and mount vertically. Damn near laser quality w/special paper.

Dissertation on HP DeskJet repair

These comments are in response to: "Repair Brief #49 - Part 1: HP DeskJet Professional Printer - Dead" and its followups. My text is indented. See those articles for details. The quick summary is that I picked up this printer at a garage sale and first had to dry it out and repair some cold solder joints before it would print at all.

(From: Paul Grohe (grohe@galaxy.nsc.com).)

I've dealt with a few of these buggers before! ;^)

Is yours a DeskJet, DeskJet Plus, or any of the DeskJet 500 or 600 series?

> I believe it to be an original DeskJet.

If not, then ...well....then I may as well tell you this anyways because you will probably run into these some day....(some of the below can apply to other ink-jet printers).

> Now, how to do a self test? Fortunately, the complete HP users' manual was part of the deal. "Hold the FONT button while turning on power". OK, no problem.

Try holding down 'FF' during power-up, you may get a different test page. One of the pages should have a jet-test pattern (A slanted diagonal line separated by 11 vertical marker lines and little jet ID numbers).

The first page of the standard self test results in that pattern.

I first tried the cartridge that looks exactly the same as the one that came with the printer (though the part number is different). Then, I tried another somewhat larger one that apparently has identical connections.

The different part numbers are the 'standard capacity' and the 'high capacity' cartridges. They're interchangeable.

> Going back and forth, they are consistent. I am not sure if one of the two missing lines are the same on both cartridges. Could something be marginal or is the priming not working? However, all other nozzles seem to be rock solid. Reseating the connectors to the print head makes no difference. If I knew which drivers were involved I could look at the signals but it will be difficult to trace the circuitry from the driver board to the actual nozzle.

I assume you have cleaned the contacts (with a Q-tip, on both cartridge and socket). Use a magnifying glass and check *each* of the gold 'bump' contacts. Repeated cartridge swapping, or improper insertion, can cause a crack to form around the base of the 'bump' and the pad (or the pad and the trace). The 'bumps' can also be 'flattened' by cartridges that were forced in at too much of an angle. There should also be some 'give' or 'sponginess' to the contact area to assure even contact with the cartridge.

Check for broken/bad traces in the flex-cable that goes from the driver board to the cartridge. Ohm out the cable between the supply commons and the individual driver lines (at the PCB) with the cartridge in place. I think the jet resistance was about 50 ohms (It's been a while). There were four separate jet sections (commons). All four commons were tied to the +20V supply through four separate (12 ohm?) series current limiting resistors. The driver outputs seemed to be grounded emitter, open collector (w/clamp diode?). The jets themselves are driven individually and are not multiplexed.

To test, I printed an all-black page (with an empty, but installed cartridge) and watched for activity on each of the lines at the PCB end. Good pulses are 'bi-levelish'. Normally negative going 20V, with pulses down around 15 V, and going all the way near ground for that particular jet. The commons 'bounce' because of the shared series current limiting resistor, causing the numerous smaller pulses around 15 V (caused by the firing of other jets sharing that common). A bad connection will show up as a weak or distorted pulse. An open or broken line will show up as 0 V. I theorize that a bad driver would show just the smaller 'line bounce' 15 V pulses and a shorted driver would show 'GND' (and also would blow out that jet!).

The current involved to drive the 'jets' is a pulse of short duration and pretty high current. Any poor connections will cause excessive I/R drop and the jet may not fire hard enough. A sign of this is drops (dribbles) of ink that form on the head during printing.

While you are in there, check and clean the rectangular rubber seat that the cartridge rests on in the 'parked' position. Dry ink can cake up on it, causing a faulty seal and resulting in dried-up cartridges ($$$!). The rubber seat pulls off and is easily cleaned with a wet paper towel (wear gloves, or you will suffer the dreaded 'black finger syndrome'). Also clean the 'nose wiper' that sticks up about a centimeter to the left of the cartridge seat. This always cakes up and can cause printing problems.

To manually prime an uncooperative cartridge, you do not have to suck on the business end. You can gently blow into the top vent (located on the top of the cartridge, inside the green arrow) to prime it. But be careful!; If the jets are severely plugged, ink may blow out the check-valve on the bottom (under the plastic 'flap' with the 'maze-like' area). Very messy! Have a towel ready!

The old DeskJets were (and still are) notorious for paper feed problems as they age. This is caused by the three big paper pick-up rollers drying out and becoming hard and smooth. Roughen them up with some rough sandpaper. The HP FTP site has a article about this in the DeskJet DOC directory. A free kit is available from HP (to qualifying S/N#'s) that 'dresses' the rollers (basically forces the rollers to turn and sandpapers them).

OH! Biggie! Another big 'failure mode' of the early printers is that the paper sensor lever will jump out of position and jam if the printer has suffered some rough handling (especially if it was turned upside-down or on it's side). The paper sensor lever (pivot) is located on top above the middle roller. The other end breaks the beam of a photosensor. The 'interrupter' end will move over just enough to wedge itself above the photosensor. This is cured by simply raising the lid and wiggling it until it drops back into position (I have 'fixed' many an alleged 'broken' printer this way). The 'interrupter' end seems to have been made larger on the later printers to prevent this.

From time-to-time, the cartridge's nose should be wiped clean with a soft, moderately damp cloth (~ every 100 pages). Keep the 'business' end pointed down when handling/cleaning the cartridge (Yes, this means hold it above you and clean it from the bottom!). This keeps the galleys and jets primed.

> Comments: I suspect the original problem resulting in the dead printer to have been a cold solder joint on the DC power connector which I repaired. I don't really think that the nozzle problem was caused by the water since the print head driver board was never wet. Since the data connection to the print head driver board is a 20 pin cable, this must be a common bus and thus it is unlikely that any failure on the main logic board could manifest itself as a single or pair of bad nozzles. Stay tuned.

I concur. If just *one* jet is not firing, then it is on the driver/flex- cable/connector/cartridge side. All the nozzle decoding is done on the driver board, so the 20 pin interconnect cable is okay. The DC (well..really 20VAC) power connector does take some abuse in normal service, this could have aggravated the cold joint.

Don't forget to check the buttons for water damage/contamination.

> Been there, done that. The FONT button was Coke-logged.
>
> Do you know what the difference is between the DeskJet and PaintJet cartridges? There is at least one contact that is open on a DeskJet cartridge and wired to something on a PaintJet cartridge.

I also have a color PaintJet 300 with a possible "dead" driver line, but I focused my attention to the ailing DJ500, so I did not have a chance to "buzz-out" the PaintJet cartridge. From looking at it, it looks like the PaintJets are multiplexed in some way (there are more jets/contacts than wires in the flex-cable). I never got around to fixing/looking into it (it's still sitting there).

BTW 1; The DeskJet, DeskJet Plus and DeskJet 500 (non 'C' models) are basically the same (except for some internal fonts). The DeskJets speak PCL, so if a driver for a DeskJet is not available, you can use a basic HP LaserJet driver (but the margins may be cut off, as the DeskJets print area is not as big).

> The missing line problem turned out to be bad connections between the flex cable and the gold contacts on the print cartridge due to the flex cable shifting position on its indexing pads.

These things are so damn simple that not much can happen to them. I have yet to run across one with a severe electrical problem. They are always minor mechanical failures (or missing power bricks...$35 from HP).

> As noted previously, the HP DeskJet series in general is a well engineered design with only a half dozen basic components. While my (DeskJet) printer is one of the oldest models, the fundamental design has not really changed dramatically in the last several years as evidenced by the fact that print cartridges for some much more modern printers work just fine in this old machine.

All the DeskJet/DeskWriter printers, up to and including the 6X0 series, use the same B&W cartridge as the original

DeskJet. Those cartridges will still be available for some time. Your printers life is not over any time soon!

> The print quality with a new cartridge is nearly laser-quality. Yes, HP seems to come out with a new, faster, cheaper, color. etc. printer every few weeks. But, looking inside newer printers shows that their basic design and construction is quite similar.

The DeskJets are good, sturdy and reliable printers (as long as they are well maintained) You did clean the rubber cartridge seat and flap. Right?.

BTW 2: For maximum cartridge life, make liberal use of the "draft" setting for "not-so-important" printouts (or, er, um, drafts!). It also prints faster because it "swipes" once per line instead of twice.

BTW 3: Use the cheap 'Shark' brand inkjet paper for best results. Pretty near laser quality! Regular copy paper tends to bleed, but is fine for general use.

Can you tell I have a 'few' of these printers around???? ;^)

> Just when I thought all was well....
>
> At random times, the print will fade out and require priming by mouth to restore operation. This can be anywhere from a few lines to a few pages. Until it quits there is no evidence of a problem. Blowing into the vent hole will restore operation. This happens with more than one cartridge. It appears as though the ink is just not refilling after being vaporized.

Is the cartridge full? As you get down to the last 20% or so of the cartridges capacity, it tends to start doing this. I guess there is not enough pressure "from above" to force the ink down. If you can start seeing through the cartridge, you are probably near this point.

> CAUTION: I found out the hard way that you really do not want to stick anything into the vent hole - ink all over the place as the vent valve must have been damaged by this mischief. I 'salvaged' the cartridge with a blob of silicone sealer. I don't know what the long terms implications of this 'repair' will be.

In troubleshooting the printer, you tend to "burn up" cartridges a *lot* faster than in normal use.

> I cleaned out the priming tube which was *totally* clogged with dried ink and it seems to be much happier now.

This can be a symptom of the print head not seating firmly when in the "parked" position. Use a dental mirror and make sure the seat presses firmly against the head. One cause of this can be turning off the printer before it has a chance to run through all of it's "housekeeping" cycles at power-up, reset (re-boot), or after printing. During certain parts of the cycle, the head is moved slightly, or the cover is moved. Turning off the printer too soon may leave the head exposed. Always let it finish, then turn it off (warn others about this).

If you haven't already, just pull the thing apart and give it a good overhaul (get your favorite pair of Torx bits ready!). Clean all the rubber tires, seals and "nose wipers". Wipe off the slider bar to remove any old lubrication. If there was a serious ink leak and the printer was involved in some "circus acrobatics", some of the ink can get on the slider bar and contaminate the factory lubrication, causing it to become "pasty". I wipe the slider bar clean with a cloth then apply a *light* coating of a light, teflon-type machine oil with a cloth (I use "Tri-Flow", a spray-on type usually found in bike shops).

BTW 4: In the winter months, with it's low humidity, the rollers will shrink even more, causing even more paper feed problems. This is also compounded by the fact that the paper sometimes develops a static charge and tends to "stick" together. Sometimes it pulls two or three sheets in at once, or the paper sticks firmly together in the tray and the weak, dry rollers cannot pull the paper in. Just remove the stack of paper and "fan" it out to loosen it (especially if it has been sitting there unused for a couple of weeks).

These printers are, like some other things we won't mention, 'Use `em or loose `em'! They work best with frequent use. They do not like sitting around for months unused. Three months seems to be the limit before a 'good' printer will start to dry up from no use.

> Before I 'discovered' the priming problem, I has visions of a serious electronic problem like an intermittent resulting in the nozzle drive pulses getting messed up at random times.
>
> How is pulse width determined in these things?

I never really investigated the timing of the pulses. I'm not sure how they vary the pulse width. I looked at the pulses when it was doing the first page of the self test, which is mostly text, and all the pulses seemed to be the same width.

Happy printing!

> The conclusion: After several years of faithful service (the most serious problem being that I really used the printer so infrequently that the cartridges invariably dried up!), I was given an HP DJ1000C with a couple of broken plastic tangs to which the pressure roller springs were attached. Some overzealous paper unjamming had caused thses to snap - not really a quality problem. Thanks to some stiff wire and Duco(tm) cement, the printer is better than new forcing retirement of my trusty $5 original DeskJet. :)

HP ThinkJet printer repair 1

(From: Paul Grohe (grohe@galaxy.nsc.com).)

The ThinkJet is VERY simple. The ThinkJet printers (and clones) do not employ any type of printhead covers or 'priming stations', so the cartridges are prone to drying out if not used for a while. A quick 'priming' is usually required, even after only a week or two of non-use.

The cartridges also tend to leak if placed in odd positions or subjected to rapid temperature changes. Make sure the cartridge has not drooled on itself and caused ink to cake down on the contacts in the holder. Clean the gold contacts *gently* with a cotton swab moistened with rubbing alcohol.

BTW: Like motor oil, fresh ink is great for cleaning up old, dried-up ink.

The ink is contained in a rubber bladder inside the plastic shell. There is a hole in the 'butt-end' of the cartridge. *Gently* stick a bent paper clip in and push on the bladder to prime it. A drop of ink should form on the printhead. Use a piece of tissue to wipe the drop off and re-install the cartridge.

Note that there are two types of HP ThinkJet printheads. One is the older, original type meant for printing on special 'ThinkJet' paper, and the newer 'Plain Paper' ones meant for, well, plain paper! ('PLAIN' will be printed on the side of the cartridge).

The older cartridges printing will appear very light if printed on plain paper. Make sure you have the 'Plain' type. Note that even with a 'plain' paper cartridge, the printing is lighter than a Laserjet or DeskJet, especially in draft or single pass modes. Don't expect razor sharp printouts. This was the first Inkjet printer!

As for the missing jets, eyeball the cartridge contacts and see if they appear straight and aligned correctly. The contact area could have slipped and may be out of alignment (although rare).

The flex cable/connector assembly is held in place with a pair of plastic bars. The "bars" have two pins that snap into the 'carriage' (they also provide alignment).

If the contacts appear to be out of alignment, carefully pull out the plastic bars to release the contact pad, realign the holes and press them back into position. Make sure the rubber 'bumps' behind the contacts are clean and undamaged.

(This makes more sense when you actually see it :^))

Be careful! Nothing needs to be forced.

HP ThinkJet Printer repair 2

> "I have an HP ThinkJet 2225C printer. I just replaced the print cartridge. It still doesn't print dark enough, and even after I primed the cartridge a few times, it still also misses a dot at the top and the second one from the bottom.
>
> I'm wondering, could the voltage to the cartridge be too low?"

(From: Kevin).

I have seen on rare occaisions the cartridge bad out of the box! Try wiping down the cartridge head & contact points on the printer with a Q-tip & alcohol. Sometimes blowing in the vent holes will force ink out the head, wipe off excess and try it. You may have to repeat the procedure a few times. If this doesn't work get another cartridge. You may want to try swopping the bad cartridge into a working unit or taking a working cartridge and putting it in the suspect printer.

(From: Frank Reid (reid@indiana.edu).)

I agree with all Kevin said. I use blue window-cleaner (e.g. Windex) instead of alcohol; the ink is very soluble in that stuff, and it penetrates the tiny holes in the printhead. After cleaning, hold a rag over the printhead and sling it downward a few times (as if throwing, but don't let go), such that centrifugal force pushes some ink out. If that doesn't work, try blowing on the upper vent.

On a few rare occasions I've encountered bad connections at the fixed end of the printhead cable, fixed by reseating the connectors. Also, if the cartridge has leaked, there may be ink on the gold pads in the moving end of the printhead connector, causing bad contact. Clean as above.

Some of the later models, including the type which takes two cartridges (3-color and black), have screws at the end of the carriage rod which allow adjusting the clearance between printhead and paper. Those may need adjusting if the ink is smearing. If too light, it's probably a printhead problem.

(From: Richard M. (Digitech@bogus.net).)

It is a water based ink. There is no need for any solvent other than water. Warm water works well. Use it all the time on my 1200C and DJ750C... BTW, I never have to touch my Epson. Use lint free cloths to tamp dry. NEVER wipe.

(From: R. Wagner (rwagner@ncn.net).)

I found the cable from the computer to the print head had some open places close to the head. The want 35 dollars for a new one. I went to the auto parts store and got some a rear window defroster repare kit. I got it working but for how long I dont know.

HP DeskJet paper feed problems

(From: John T. Black (cz667@cleveland.Freenet.Edu).)

The paper feed problem afflicts the HP DeskJet 550C and 560C, DeskJet 520 and DeskWriter 520 printers produced between June 1993 and March 1994. The affected units have serial numbers beginning with 'US3' through 'US43.'

The problem seems to be that the rubber rollers become slick over time and then the paper doesn't always feed properly. Last year HP offered a free paper-feed cleaning kit to fix the problem. Try contacting HP at 800/656-2324 or 510/657-1473 (FAX) to find out if the free kits are still available.

(From: Allen E. Amey (a_amey@ix.netcom.com).)

Try contacting the manufacturer. I have heard that HP has a free kit for the 500 series printers. The kit dresses the rollers and is supposed to be a fix for the type of problem that you are experiencing. BTW, using alcohol can actually compound the problem by prematurely drying out the rollers.

(From: FaxRepair (faxrepair@aol.com).)

I believe the only replacement part would be the entire paper pickup assembly which may need to be replaced because the gear train is damaged from ink having dripped onto it. Once the gear train is out of timing there is no known cure. Clean the rollers with rubbing alcohol and a soft cloth. If it doesn't pick up the paper after cleaning the rollers, then remove the entire print assembly and look for signs of ink on the gears at a location directly below the ink cartridge's home position. On a few occasions I have had success by flushing the gear mechanism with warm water to wash away dried ink.

(From: James E. Burke, Jr. (jeburke@ibm.net).)

I fixed one for a friend a couple of months ago. Parts are not available (well, you can get them, but they're too expensive).

In the one I fixed, it was a broken plastic part that caused the misfeeds. To get to the part, I had to disassemble the whole printer.

If you decide to to this, check the two 'fingers' that are behind the print head when it's in the parked position. The hook on the tip of one of them was broken off. I found the broken part inside the printer and glued it back on with JB Weld (twice--first time backwards). The pair of 'fingers' are identical so you could probably swap parts from one of the other machines instead of attempting the repair of the "fingers".

(From: Paul Grohe (grohe@galaxy.nsc.com).)

I have the same problem.

The rollers dry up and become glazed-over and smooth. You need to 'rough' them up.

Try sandpapering the wheels with coarse sandpaper (100 to 200 grit).

You'll need to trick the paper sensor. Take the cover off and lift-up on the black paper sensor lever. Then hold the piece of sandpaper firmly against the wheel and hit 'FF'. You'll need to do this repeatedly, as the wheels will only spin a sheets' worth each time.

Do this until the wheels feel 'sticky' again.

It also helps to keep the paper tray full at all times (but not overloaded).

Unfortunately, they'll never be like new.

(From: Frank Reid (reid@indiana.edu).)

I've had very good results cleaning the rollers with naphtha or mineral spirits, no sanding. It removes the glaze from the clay content of the paper, and makes the rollers softer.

(From: (Egiglious Giggles" (chsoccer@prodigy.net).)

The thing I have come across, is the spring which is directly under the roller itself. The purpose is to allow tension on the roller for pulling the paper in one sheet at a time. If you look directly in the middle under the roller from the front there is a guide that is spring tensioned. You have to take the roller assembly apart to get to it. But, if cleaning the rollers doesn't do the job, this is probably the culprit.

(From: Tony Dunlap (tdunlap@odot.dot.ohio.gov).)

The "Glaze" that gets on the rollers is often due to the rag content of many cheaper papers (especially "Recycled"). To clean the rollers:

1. Remove the paper and paper tray.

2. Send a short test page to the printer with the paper out. This will cause the form-feed light to blink.

3. Wet the rollers one at a time with a cloth (not a paper towel) dipped in alcohol, while pressing the paper feed button.

4. While it is wet, rub it with something rough and non-porous (I modified a toothed chip extractor that came with a pentium upgrade kit), again while pressing the paper feed.

5. Wet it again with a fresh part of the cloth dipped in alcohol.

6. Dry it with a fresh part of the cloth.

7. Put it back together and let it print the test page.

Cartridges drying out on early HP DeskJets

Note that unless the cartridge is almost empty anyhow, it can usually be revived by patting off the caked ink with a damp lint-free cloth and then gently blowing in the vent hole on top until a drop of ink appears at the print head. Sometimes this may have to be done more than once. NEVER poke anything into that vent hole or you will have a mess!

(From: Paul Weber (webpa@aol.com).)

HP had a free upgrade kit for the 560 to solve this, maybe for the 500 as well. It was a replacement for the silicone rubber park-position nozzle seal. Also remember that the 500 came with a cartridge storage box with an elaborate rubber seal in the bottom; they encouraged you to remove the cartridge from the printer and put in the box whenever it wasn't in active use to prevent dry-outs. Finally, HP cartridges have expiration dates - and they mean what they say: If they're out dated, they work poorly or not at all.

HP DJ340 shuts off during printing

(This may also apply to other battery powered printers.

> "Whenever I send a heavily formatted print job to a DJ340 printer, it prints 1/3 to 1/2 a page and then power shuts off! This so far has happened in TTAX97 and Netscape 4.03. OS is Win95 and I'm using the latest driver for this printer. The printer otherwise prints test pages and simple jobs OK."

(From: Paul Grohe (grohe@galaxy.nsc.com).)

I know this sounds silly, but how old are the batteries?

My guess is that the battery is probably getting weak. Heavy graphic content and "fancy" fonts users (of which TTax and Netscape qualify) will "swipe" the head more per line than the "text and lines" of the test pages. Moving that print head uses a lot of power!

Does the unit work on the adapter - without the battery? If not, then it relies mainly on the battery for power, and the adapter just charges the battery in between jobs. A weak battery could be drained after a short time.

If it works without the battery, then the battery could be going bad, causing the charger to dump too much current into the battery and "rob" some of the power from the printer.

There is a "Troubleshooting" note in the printers "FAQ" on HP's site.

- HP Support.

It basically says to check the batteries and make sure you are using the correct power supply.

Try replacing the battery. If you bought it at a local store, take it back and see if they have another battery to check it with.

HP DeskJet 520 - Crunch!

> "I just picked up an HP DeskJet 520 printer that doesn't work. On startup, the print head moves right an inch, then all the way left, where it slams into the left side of the carriage and grinds away for about a tenth of a second before stopping."

(From: Tech Guy (patrickmcardle@sprintmail.com).)

You may wish to check the undercarriage (no pun intended).

The printhead location sensor microswitch may be on the fritz The printer uses this switch to determine the starting point of the printhead after which it uses assumed location by how far the data has sent the head every time the unit gets a reset code, it checks this switch and if the signal is not detected, it may slam the head to either rail end or not move at all. If this is the case you can make sure that the platen is not clogged with label or paper debris. Gently move the head by hand to the right. If you shine a bright light into the area where the printhead usually calls "home" you may be able to see this switch (it may however be located under a cover triggered by the belt) if the switch is defective, replace it. If in fact it is jammed by debris, simply clear it and you may have solved the problem. Beyond this, you may have a logic problem (bad chip or other component) I make a good practice of doing a thorough cleaning of all machines that have left my shop to reduce the possibility of other problems during my warranty period. (it also makes the customer think that they have gotten something for their money)

I have replace a switch or a fuse on many machines, charged my base fee and heard the response upon their pick-up by customers that, "I can tell right away that you have found and fixed the problem" without even so much as a demo.

(From: michae98@ix.netcom.com).

There is a clear plastic strip strung between the both ends of the printhead pathway. This strip of plastic has microscopic vertical bars which the printhead can read and sense what position its in the pathway. The strip may be contaminated with excess ink which may confused the printhead. Take a soft cloth or Q-tip dampened with water and wipe of the strip (the ink is water soluble) and the printer should work.

(From: Raymond Carlsen (rrcc@u.washington.edu).)

Closely examine the toothed belt that drives the printhead. Look for a few missing teeth at one end. I managed to make one work again by shifting the belt over a bit (past the bad teeth). If that's it, the belt should of course be replaced.

HP DeskJet 560C Detailed problem description and possible solutions

> "I have a HP DeskJet 560C, Model C2168A that is behaving badly. When I power it on initially, it appears to run through a diagnostic self-test (as evidenced by the sequence of LEDs on the control panel). It gets to the point where it moves the print head and that is where things go bad. I think it is attempting to report some sort of error code because it then flashes some of the LEDs in a repeating pattern (more on that later).
>
> First let me describe mechanically what it is doing. When it gets to the point in the power-up routine where it moves the print head, it should do the following:
>
> 1. Move print head to the extreme right.
>
> 2. Prime the print head (???), a stepper motor on the right raises a mechanism to contact the print head.
>
> 3. Position the print head in a ready position.
>
> OK, here is what it is doing (please forgive my feeble attempts to describe in words what is happening):
>
> 1. I hear three distinct sounds (whirring of various stepper motors I think) before the print head moves.

2. The first two sounds seem normal from what I can remember when the printer used to work.

3. The third sound is the loudest and doesn't sound at all normal. It sounds as if the stepper motor that does the priming is oscillating back and forth between two "steps" (the sound is like a stripping gear).

4. The print head moves approx. 1" to the right.

5. The print head immediately moves approx. 1.5" to the left (note, this sequence of print head movements happens bang-bang (no delays between movements).

The end result is that the print head winds up about 0.5" to left of the position it was in when the unit was powered on. If I continue the power on sequences enough times it will end up at the extreme left and will be accompanied by a much uglier, more sinister sound of the print head slapping against the leftmost guard (as if the printer is attempting to throw the print head through the case).

Now let me describe the sequence that happens with the LEDs. The control panel has 9 LEDs arranged in three columns of three LEDs each. The leftmost column of LEDs lies between the "CLEAN" button at the top and the "Font" button at the bottom. The middle column of LEDs lies between the "Alignment Test" button and the "Status" button. Finally, the rightmost column of LEDs lies between the "Install Print Cartridge" button and the "Quality" button. Here is some ASCII art:

```
                             CONTROL PANEL
===========================================================================
||                                                                       ||
||                                  Alignment         Install Print      ||
||  RESET          CLEAN            Test              Cartridge          ||
||                                                                       ||
||                 ,--,              ,--,              ,--,              ||
||                ( #1 )            ( #4 )            ( #7 ) o o o       ||
||                 '--'              '--'              '--'              ||
||                                                                       ||
||                 ,--,              ,--,              ,--,              ||
||                ( #2 )            ( #5 )Busy        ( #8 ) o           ||
||                 '--'              '--'              '--'              ||
||                                                                       ||
||                 ,--,              ,--,              ,--,              ||
||                ( #3 )Condensed   ( #6 )Ready       ( #9 )Econo Mode   ||
||                 '--'              '--'              '--'              ||
||                                                                       ||
||  Load/Eject      Font             Status            Quality           ||
||  Paper                                                                ||
||                                                                       ||
===========================================================================
```

I have numbered the LEDs (using my own numbering scheme) so that I can reference them below.

Here is the sequence that the LEDs progress through each time the unit>is powered on. The sequence is always the same.

	LEDs On	Duration	Description
1.	123456789	2.5 secs	Happens immediately when I switch the power on. Then LEDs 234789 turn off.
2.	1 56	0.5 secs	This is a flash (longer than a blink). Then LED 5 turns off.
3.	1 6	2 secs	Then LED 7 flashes on.
4.	1 67	0.5 secs	This is a flash. Then LED 7 turns off, LED 5 blinks on.
**5.	1 56	----	Here LED 5 just blinks on then off.
6.	234 789		This starts the alternating sequence where I believe the printer is trying to report an error code.
7.	1 6		This is the rest of the alternating sequence. The printer then repeats these two patterns forever (LEDs 234789, followed by 16).

** Step 5 is the point where the printer starts moving the print head."

(From: Jason D. Pero (JDP6640@ritvax.isc.rit.edu).)

The grinding sound from priming area is the jammed lever black stick that is pushed towards a bit towards right. If it good, it should be in upright position. If stuck too very right, unstick it by pushing it back to upright position towards left. This stick can be seen between the carriage rod and the printhead's purging rubber nipples and wipers. Also clean (gently!) the clear plastic strip with that fine black lines on it. First the clear strip must be removed first before doing this operation: The sensor is behind the printhead riding the clear strip, remove it by unengaging two triangular fingers inwards from outside and pull the sensor unit outwards towards back. Dust off inside that sensor gap and snap it back in.

Finally clean and oil both carriage rod and the angled underside area where the bearing block contacts upward onto it. Oil that carriage motor carefully and all stepper motors.

That should solve everything. This have happened to my 520, and my friends' 540 and 560C. Pretty common problem! Usual action when misbehaving is slamming either stops or do a "rushed start/stop" and some odd scary noises. All complains with pretty, interesting alterating flashes from the LED's on the control panel.

Pure or almost pure alcohol stuff is best as it does not melt anything or rub marks off and some 2 in 1 heavy duty oil "blue band" can. Top and bottom white shells comes apart easily after unengaging four snaps, doing one at a time and pulling gently and with a small flat screwdriver. Top off, the engine is free. disconnect with care to both ribbon cables one for carriage motor, and the flat white ribbon, or in some models that uses dual printheads, unplug another stepper motor. All connections you need to worry about is only from the mainboard side. Then the print engine lifts out without any fastening hardware.

WELL DESIGNED 5xx series compared to many printers past and now! I have a 520 chugging away after this fix and real cheap for that printer from a owner who does not want it.

Only problem is cost of cartridges. :($50 of two versus $13 can of toner powder for an Okidata 400 that will last thousands of papers. Only problem is Oki. 400 LED laser thinks (processing graphics) very slowly. Is there a hack to swap the proper circuit boards from other similar Oki 400/800 series to make it work faster and more useful than a pokey 186 cpu equipped Oki 400???

Your comments and suggestions on which brand of refill inks that is perfect for those cartridges. I know how to refill it right after experimenting on a bad cartridge and successfully refilling one good cartridge from a bad cartridge (dead jet out of 48 jets I think).

(From: Glenn Allen (glenn@manawatu.gen.nz).)

It is not a stripped gear is it?

The old DJ500 used to have 2 levers on the right hand side at the back that went up and down. Sometimes these got stuck and noises could be heard. Normal paper feed problems here.

A problem with a DJ850 was that paper got stuck and to get it out I had to remove the paper feed motor on the drive shaft, when put back it would bang the left hand side of the case. Needles to say it needed the cog setup back to right place it expects when powered on.

Those printers have an index strip that the printhead follows doesn't it? Is this clean, i.e. Not ink all over the place.?

Lastly if you are repairing and turning your printer up and down, check you do not lose the rubber cap where the printhead sits, and clears the guns, If you do your cartridges will become clogged in no time.

Also clean the print head shaft, any gunk on it will cause the printhead head to stick thus giving error light or worst powers down the printer.

Cartridge detection on HP DeskJets

(From: Fred Keen (fkeen@repeatotype.com).)

The HP printers test for the presence of a cartridge by checking the electrical voltages on the contacts between the cartridge and the cable. The slightest amount of dirt on the contacts can give a false reading making the printer think that no cartridge is present. If cleaning the contacts does not work you will have to buy a new cartridge.

HP Deskwriter 660 printer problems

> "My HP Deskwriter is just over the warranty of one year and when I print text instead of white lines through the type which would indicate to clean cartridges or replace them, I get black thin lines almost smearing slightly the text."

(From: Dennis Bathory-Kitsz (bathory@maltedmedia.com).)

1. Take out the cartridges and clean their sides, which pick up hair.

2. Clean the cartridge-cleaning mechanism itself on the right, especially the foam pad.

3. Take out the cartridges and clean the bottom of their carriers.

For this last, there may be some diagrams accessible via the HP Support Page.

Little plastic parts in HP DeskJet printers and HP service policies

(From: Wayne Van Beelen (wbvanb@nbnet.nb.ca).)

The bad news is that the plastic these parts are made of seem to be a Teflon hybrid and even the best epoxy doesn't last real well.

The even worse news is that DeskJets are disposable, just like Bic lighters.

HP will NOT sell you any internal parts.

They will not sell them to your dealer.

They will not even sell then to a so called HP service center.

All DeskJet service takes place in Corvallis, Oregon. A second possible location is Mississauga, Ontario but I think they just forward printers to Corvallis.

Here's the deal as I've been told; you pack up your printer and courier it to Mississauga, ($40 Cdn.), pay $175 Cdn. for a refurbished version of your Deskjet, and then pay another $40 Cdn. to ship the refurb back to you. That's $255 Cdn for a used printer when there are any number of new printers that can be had for a comparable price (and would also have a warranty).

That, to me, means DeskJets must be disposable because nobody in their right mind would pay that much for a three or four year old printer. It's bad enough when you consider 540's, which back then had a 3 year warranty, think about all the poor suckers buying newer HP's with only a 1 year warranty...

That's got to be enough harping on my part, the short of it would be that if you've got it working and your cartridge parks okay, it might be best to leave it alone. You won't get any worthwhile out-of-warranty help from HP. Check on parts availability on any future new printers you might ever buy. You can't assume that they won't forget you the day your warranty expires.

HP DeskJet 560C - stripping gear sounds and more

> "Does anyone know where the problem might lie with my HP printer? The problem is that when it is turned on, it goes through the reset sequence until it reaches the park zone, then it seems to miss a gear or something by the sound of stripping gears, then the lights flash alternately. My workaround to this is to turn it on, let it start across on it's reset sequence, turn it off, then right back on, and it will initiate just fine. Another anomoly is that when printing large color graphic files, occasionally, it will make it part way through the page and just stop with the same flashing error. After resetting it, it of course will print garbage unless I resend the data to the printer all over again. Any ideas? I've left a message on the HP site, but there has been no response."

Call HP - After much hassle they finally admitted it was a defect and replaced it with a new 600 series. I had the same problem - but had to call Idaho to get results.

HP600C DeskJet produces too much black ink

In addition to cleaning the cartridge, replacing the cartridge, cleaning the ink "well" and rubber wiper used for wiping cartridge head, using "approved" paper, printing in econofast mode (less ink), and setting up "transparency" print mode (gives more time for drying), one thing is often overlooked:

(From: Ralph Wade Phillips (ralphp@techie.com).)

Did you also clean the cartridge HOLDER? See HP's web page for more details, but I've seen SEVERAL of the 600 family that have "dust" collected under the cartridge holder. Since the black hits at a different angle than the tricolor cartridge, it is more prone to hitting the dust buildup, causing excessive smearing.

- How to clean HP DJ600 printer to prevent black ink streaks.

BTW, beware of flipping the entire printer over to unlatch the top - you may get a shower of the last n years excess ink from the holding tank!

HP DJ power supplies/wall adapters

It seems that this is one part that HP may not totally gouge you on!

(From: Paul Grohe (grohe@galaxy.nsc.com).)

Go to this page below, scroll down to the "power module options" section, and pick the correct adapter part number for the UK.

HP DeskJet 500 Printer - Printer Product Specifications.

Then do a net search for that part number, or, contact HP directly. Last time we ordered some, they were about $35US from HP.

HP 600 series DeskJet printer smears even with new cartridge

(From: Bill Rothanburg (william.rothanburg@worldnet.att.net).)

I had a similar problem with a HP 693C. The problem was the spacing between the paper and the carriage. A suggestion: if you're not mechanically adept, don't tackle this, get someone who works on printers to lend a hand.

I have not taken my 600C apart, and will not do so unless it fails, so the following information is based on the 693C, a similar printer.

The top cover is held in place by some latches, and a couple of screws under the paper tray. Be careful while tipping the printer, there is a catch-basin for the ink, and if this spills you will have ink dripping inside the printer. Remove the upper cover. Be careful with the thin cable to the electronics board. At this point you should be able to check for any gobs of ink that have turned to paste. Clean the dried ink off of everything, especially the bottom of the carriage, and print a test page. If it still smears, it's time to try adjusting the carriage height.

On the 693C the carriage slides on a rod that runs the width of the printer. The anchors consist of a screw through a slotted hole. On the one I fixed, the screws had obviously been loosened (they're torx screws, and it was obvious that something such as a jeweler's screwdriver had been used on them). Anyway, loosen the screw at one end, lift the rod slightly, and retighten. Print a test page, and repeat if it still smears. Of course, if it now smears only at the other end, it's time to switch ends.

I'm sure at the factory they use a gauge to adjust this to within a micron but the empirical approach worked for me.

HP DeskJet 692C - Random lockups

(From: Jess Askey (jess@magenta.com).)

I did a search when BOTH of my HP692C DeskJet printers started getting flaky. I didn't find much except for a post mentioning that cleaning the small plastic 'barcode' may solve most problems. While this is exactly what HP customer service suggested as well, it didn't solve my problems.

What the printers were doing, were randomly locking up. They also started making a 'knock' sound while they were printing. But, the 'knock' sound was more prevalent than the actual 'locking up' problems. But they would still lock up more than twice a day.

What I found was happening was that the stepper motor belt was skipping a tooth when the print head was changing directions. There is a black plastic tensioner arm on the left side of the printer that holds the belt tight and this was getting yanked in enough to let the stepper belt have some slack.

What I did to fix this was to take the spring out from behind the black tensioner arm and stretch it out to put more tension onto the stepper motor belt.

Both of these printers have had heavy use, they both are just over 1 year old right now too. I only moderately stretched the first spring and it still made the 'clicking' noise every so often. On the second one, I probably stretched it about 1/2" to 3/4" in it's fully relaxed position, but I think when putting it back into place it probably bent back a small amount. This worked well, the belt did not feel overly tight and I have not had ANY problems whatsoever. :-)

HP 820Cxi DeskJet Problems

(From: Vic Zane (vic@webworks2000.net).)

I've been having a problem with the black cartridge in my HP 820Cxi printer getting all gummed up with ink on the bottom, making lousy print. Clean it off, and it comes right back. It also was missing a horizontal line or two - thin but noticeable. The "clean" instructions with HP troubleshooting didn't help at all. Interesting that they say there is another thing you can try, but don't do it except with NEW ink cartridges! At $30 or so each, I wasn't interested in trying that except as a last resort.

The other day, after cleaning and refilling, I got an error message telling me that my black cartridge was no longer usable, and that continued use would possibly damage the printer. I purchased a new cartridge, and replaced. The old cartridge again had the buildup of ink on the bottom. So now I got the same "unusable" message, with recommendation that the cartridge be returned for replacement. And again, the bottom was loaded with ink. Obviously this was not just leakage from a faulty cartridge.

Information found on the web indicated that HP has only one repair location, and will not sell repair parts to even their dealers. Probable repair costs, added to shipping two ways, lead me to believe that I would be money ahead by either repairing it myself, or junking the printer. It has been in service (I am a retiree using it at home) for just over three years.

There should be information on this printer accessible on-line which is not included with their on-screen maintenance information:

- HP Support.

I also referred to this document at a Sci.Electronics.Repair FAQ site.

I removed the cartridges, and stood them upright on a multi-thickness pad of paper towel that was moistened with distilled water (from dehumidifier), figuring that this might open any ink jets with dried ink in them. A flashlight helped to see the area at the far right of the printer, where the cartridges park. Those wipers were a real mess. The Q-tip swab technique proved quite unhandy, but with a larger wad of cotton on the tip of a long and narrow needle nose pliers, I was able to clean them. There is a well to the left of the wipers that appears to have a spongy material in it - well soaked with black ink. When I tried to clean it, it just depressed down into the well and stayed that way. The pads that rest against the cartridge bottoms when in the park position were inaccessible, as they retract when the carrier moves away.

The paper toweling soaked up a little ink (I had some plastic under it). I wiped the cartridge bottoms, then replaced them in the printer. Alignment worked well - no skips or smudges. But I kept getting the error message telling me to cancel printing and align whenever I started printing, until the computer had been shut down and restarted.

The printouts are now first class, and there are no more error messages. The "unusable" cartridges both work fine. Of course it has only been one day so far though!

(From: Someone who wishes to remain anonymous.)

I can only add that the cover comes off quite nicely by unscrewing the two screws found on the top of the printer toward the back and by wedging back with wads of folded paper the four plastic clips on the printer's bottom. With the cover off you have good access to the area that needs cleaning. Also, I used rubbing alcohol rather than water. The ink well is just that. There is no spongy material there. Mine was just full of waxy ink that had accumulated there over time. Needless to say, I dug that all out. Hopefully the printer should work well for another two or three years.

HP DeskJet 1200C power supply repair story

(From: Marc Geyskens mgeysken@innet.be).)

A while back, I got this broken down printer, most of the time the power supply wouldn't kick in after pressing the standby switch. After checking elementary things, I got stuck on the PCB that holds the standby switch, on it reside passive components, a few LM431 and a UN3854 all of the components where ok except for the LM and UN chips. Since I had no schematic and no sheet on the UN3854 I turned to the chip directory which led, via a few stops, to the Unitrode site and yes, a data sheet for the UN3851. Plugged my scope (power supply on isolation transformer) onto the ucc line for the UNxxxx, noticed that the voltage was almost 0 raising slowly to 12 V and then fast to 20V after that time the PS worked normal. So I traced the supply back to a FET 2SK537 on the power supply mainboard which is part of a protection, its gate pulled up by a zener ZD1 and a resistor of 680k from 400V and pulled down by a transistor in case of the transformer's output voltage gets to high. Well, it was the 680k resistor, infinitive resistance yet not a scratch on it.

Thanks to the Chipdir site, and the Unitrode people.

HP PaintJet problems

> "My HP PaintJet printer has a problem! When I turn the printer on, the print head moves as if it's cleaning the head but thats it! The "on" light stays on but the "SET TOF", "LF", and "FF" buttons don't work. I've tried a test page by holding down the "FF" button and turning on the printer but it won't print. It just goes through the head cleaning stage again and then stops. If I turn the printer off and manually move the print

> head to the other end of the carriage and then turn it back on again the print head will move back to it's home position."

(Responses from: Paul Grohe (grohe@galaxy.nsc.com))

I am assuming you have the original tractor-feed "PaintJet", and not the sheet-feed 300XL.

It sounds like you have a problem with the "paper out" detector.

Is the second lamp on, even when there is paper loaded?

Here's a clue: If the other light is *on* after you do the self-test key sequence, then it thinks there is no paper loaded, so it does not print. The buttons are useless at this point, too. I have confirmed this with my PaintJet by removing the paper, and it does exactly what you describe. During normal "self test" printing, the paper out lamp is off.

It is very common with DeskJets and PaintJets to have their "paper out" detectors jam after rough handling.

Looking down into where the paper goes in, there is a little black lever sticking up (about 8cm to the right of the left end of the platen). This is the paper detect lever. The other end is a "flap" that goes between a photodetector.

Make sure this lever moves freely.

Open up the case (don't worry, it is very simple). Pull the big platen knob off. Then there are two rubber "wedges" stuck in two oval-ish latch holes on the bottom under the front "lip". Pull out the wedges and squeeze the latches. The cover then lifts right off (nothing is connected to it).

With the cover removed and viewing the printer from the front, look at the bottom left corner of the circuit board. You can see the "flap" end of the paper detect lever and photosensor, right above the "made in USA" sticker. Make sure it moves freely and that it is situated between the two detector "blocks" (I have seen these levers "wedge" themselves against the outside edge of the detector).

My guess is that you will either find paper jamming the lever, the lever itself mechanically jammed, or a piece of paper wedged in the sensor.

While you have the top off, notice that there is a long, plastic strip with fine lines on it running along the front. This is used for sensing the head position. Move the head over and make sure that strip is clean and that no ink has spilled anywhere on it. Also clean out any paper dust or spilled ink.

Don't be afraid to plug in the printer to test it with the cover off. The input voltage is only 20VAC, so you will not get shocked. Just be careful of the orientation of the power plug and watch out for the moving parts.

BTW1: The PaintJet printer is very stupid. It will 'print even with the cartridges removed or the platen motor unplugged, so there are no other sensors that could be causing a problem.

> "The symptoms are that first the color cartridge got weak and stopped working and now the same has happened to the black cartridge. It's not out of ink or clogged and the contacts are all clean."

The 3630 (aka: "PaintJet") was one of, if not *the* first, color ink jet printer. As such, it was plagued by the usual "first-of-it's-kind" problems. HP learned from their mistakes on this one!

We have a few of them around here, and your experience is not unusual. They tend to "dry up" more often than the newer printers. I seriously doubt it is an electrical failure.

Even though the cartridge appears "full", the ink gallies will clog if not used after a certain amount of time. After a week or two, you will need to clean and prime the cartridges.

This printer does not have the automatic "priming" that the DeskJets have. Instead, you have to remove the cartridges and manually prime them with the "plunger" located under the "flap" on the top-left. Then "wipe" them with the rubber "nose-wiper" located on the underside of the cartridge access door.

There is (supposed to be) a slide-out card located on the bottom of the printer with the "cleaning and priming" instructions (The little tab with the "i" on it).

The PaintJet also lacks a rubber-sealed "cover" for the cartridge head when it is in the "park" position. This greatly adds to the "dry-out" problem.

The head connector also creates some problems. The 3930 uses two rows of individual long, gold-plated "fingers" to make contact with the cartridge. These "contacts" can bend back, or become mis-aligned, due to improper cartridge insertion or wear.

Take a look at these "fingers", and just make sure they are even and straight. Don't bend them too much, as they are brittle. Also make sure there is no leftover ink on the contacts. Don't press

It should be easy to fix. However, you may go bankrupt replacing the cartridges.

There are ink "refill" kits available, however, the problem is usually with the clogging of the internal passageways and jets. So new ink won't help much.

My suggestions:

Check the contact "fingers".

Try "priming" and "cleaning" the cartridges.

Try replacing the cartridges with known good ones (or new).

If you will not be using the cartridges for a while, remove them and place them in a sealed container or baggie for storage (place them in the same position as they are in the printer).

> "What other printers are compatible with the PaintJet if I cannot get mine working and I need to use existing software"?

The "PaintJet" is a 180 DPI, "PCL" language printer. Just like the "newer" DeskJets.

If your unit has a parallel or serial interface, you can use any one of the older DeskJet printers (500/600 "C" series, DJ plus) - any that use the "PCL" language) or almost any laser printer (HPII compatible - B&W only). However, the newer printers are 300DPI printers, so the printouts will be 30-40% smaller.

If it is a HPIB interface, look for a HPIB ThinkJet.

Unclogging non-HP inkjet printers

These printers have the printhead separate from the ink supply.

(From: John Hudak (jhudak@sei.cmu.edu).)

Here are a few suggestions:

- Do a Google search on inkjet printer repair. You should find companies that make 'cleaner cartridges' that replace the ink cartridges. Invoke the clean cycle on the printer with the cleaning cartridges (follow both the printer manufacturer and the cleaning cartridge manufacturer instructions. This should remove the blockage. You may have to cycle it many times and/or let it sit overnight and then do cycles in the morning.

- Some companies also sell a syringe kit in which you fill a syringe with cleaner and flush out the print head. In my opinion, this is the best approach.

- Buy a HP in which the print head is integral to the ink cartridge. This eliminates the problem, and a side benefit is that the print quality is always good.

(From: Richard J. Scott (rjscott@telus.net).)

I have a Cannon BJC400 inkjet printer which I only use when I get home every week or so. Of course the ink clogs up the cartridge as always.

In my frustration, when I couldn't even blow the ink through this time, I took about 4 ounces of windshield washer fluid added about 1 ounce of isopropyl alcohol got it near boiling in the microwave and set the cartridge into it for about 1 hour. Bingo it came clean on blowing through the breather hole and printed beautifully. Nice cheap fix!!!

Intermittent light/no print from Canon BJ330

> "I have a canon BJ330 that starts printing light and prints nothing. This only happens approx once every 2 months. The unit has ink and it still thinks it's printing but there is no ink on the paper. This has happened a couple of times and so far I haven't figured out what it is that I do to 'correct' the problem.
>
> I was thinking that there must be a way to clean the printhead that is not in the service manual. Which I do not have, anyway."

On my DeskJet, I just blow gently into the vent hole on the ink cartridge. I then wipe off blob of ink that forms on on the head and it works like a charm - if you don't get ink all over everything. Perhaps, try the following first:

(From: russrite@magmacom.com).

Remove the sponge from the purge cap carefully, try washing in water carefully, and reinstall it:

- Remove the top cover to expose the printer power on the printer when the printhead moves away from home position SHUT OFF the power

- You will see a rubber rectangle cap towards the bottom of it is the sponge (called an 'Ink Absorber')

Canon BubbleJet information

Parts Now! has a set of articles mostly on laser printer engines, but there is one for Canon BubbleJets. These can be found at:

- Parts Now Service Today Archives.

Canon BubbleJet printers not printing after cleaning

(From: Handy (handy@redshift.com).)

Take out the cartridge that you want cleaned. Find that hole that ink comes out of, squeeze the cartridge until ink comes out of that hole - actually drips. Put it back in the machine, clean it at least FOUR times. Usually on the fourth time for some reason, it works. Just clean the one that you think needs cleaning.

Canon BJC 600 problems

(From: Rob Connelly (connelly@ix.netcom.com).)

I have found that sometimes the BJC 600 series gets confused and needs to be reinitialized. If you haven't already done so, unplug it from the wall, wait 60 seconds for the internal supply capacitors to completely discharge, then plug it back in and try again. When you remove it from the AC line it goes through a complete warm up cycle and resets itself.

Also, the contacts that mate with the print head are notorious for oxidizing. You might want to carefully clean them (lightly) with a pencil eraser and some isopropyl.

If these remedies don't work, the Canon 1-800 number will put you in touch with their tech department, and they are really quite good at determining what the problem is over the phone.

(From: Al Savage (asavage@iname.com).)

When I was working on printers, we'd see a few of the 600s in with corrosion on the ribbon cable end under the printhead. NewKote apparently had a venting problem with their copykat ink cartridges, where in some situations ink would spurt (leak? drip?) and somehow corrode the ribbon cable.

I never tried to replace one and see if it could actually be repaired with just the cable, but I did try vigorously cleaning the cable end: no conclusive repair.

BJC 600 print head error - lights flashing

> "Upon powering up the printer the two lights flash indicating a print head error. However by cleaning the electrical contacts (with alcohol) on both the print head and the printer the printer works,,, temporarily. Within a day or two the problem resurfaces. When the printer does print it prints excellent quality. The nozzles seem to be is good working order."

(From: Al Savage (asavage@iname.com).)

Although printhead failures are common on the 600 series, so is failure of the ribbon cable to the printhead. This is an acknowledged problem from Canon, when aftermarket ink reservoirs are used (i.e. Pirana or NewKote). Somehow the ink gets up to the cable/printhead interface and corrodes it. When I was working on them (about 18 months ago) Canon and NewKote were pointing fingers at each other. It appeared to be a reservoir venting problem.

Epson Stylus Color IIS error light problems

> "The error light on the Epson Stylus color IIs keeps blinking. The color cartridge is new. The black and white prints perfect."

(From: Robert J. Brancatelli (bronco@mkol2.dseg.ti.com).)

Most likely, the new color cartridge is not seating all the way. Move the print head to where you normally do to swap the heads. Now, without removing the color print head, lift the most forward lever up as far as it will go, then bring it down to reseat the ink cartridge.

Cleaning totally clogged colour head in Epson Stylus Color 500

(From: Colin Guillas (rguillas@nrn1.nrcan.gc.ca).)

I have an Epson Stylus Colour II printer which had similar problems- this time, which the magenta head.

After running about 50 cleaning cycles, and having no improvement, I disassembled the unit (I am WAY out of warranty already ;-) and manually mopped out the cleaning apparatus- the rubber heads were VERY gummed up, so I wipe them off... the suction tubes were clogged, so I squeezed them out, the sponges were full, so I mopped them up with a kleenex. I then put on a pair of elbow length kleenex gloves, and pulled the cotton cleaning tray/absorbent reservoir out of the base of the unit, and rung it out into the toilet. There was a three year accumulation of wasted ink in there- this printer gets extremely heavy use, but it was amazing at the amount of ink that gets wasted, compared to what goes on paper! I would guess that it's about 30/70, 70% ending up on paper. Incredible wastage. I just don't buy cheap refills. I buy better ones with guarantees on them. I also replace the cartridges that I am refilling every four to six refills. There will be an accumulation of 'junk' if you don't.

The cure to my problem? Pay the price for the genuine epson cartridge and do another fifty cleaning cycles. It worked for me. I had to wring out that @#$%liner again....

(BTW, If anyone else has an epson inkjet, I recommend that they get the liner replaced or at least wrung out. It's a horrible mess which can overflow if you use an awful lot of ink... mine was saturated... you may have a nasty surprise next time you decide to move the printer- all down the front of your shirt. ;-)

Epson Stylus 800 print quality

> "I have an Epson Stylus 800 printer which is only used infrequently. I seem to have a problem with some of the jets clogging up after a while producing a banding effect and/or a blurring of text.
>
> The built in cleaning cycle does not clear the problem. Running the head over a pad soaked in Isopropyl Alcohol clears the problem, but after a week or so things start getting bad again.
>
> The user manual does not mention the need to change any cleaning pads. How does the cleaning cycle work and are there any checks or adjustments which might improve things?"

(From: Paul Grohe (grohe@galaxy.nsc.com).)

Inkjet printers do not like 'infrequent' use. They need to be 'exercised' every once and a while. Use 'em or loose 'em!

I'm not familiar with the Epson products, but on the HP DeskJets, there is a little rubber "seat" that the cartridge sits on when it is 'parked'. If it is gummed-up or damaged, it can cause the cartridge to slowly dry out.

The HP's have a little oval-shaped rubber 'do-hikey' that seals the area around the ink jets. It generally gets gummed up with dry ink, and does not seal completely anymore.

Check and see if there is something similar that covers the print head when it is not in use.

The "banding" can also occur as the cartridge starts getting towards the end of it's life. Also try cleaning the contact areas with a soft cloth. Poor contacts can cause similar problems.

If large ink droplets are forming on the head during printing, this is a sign of poor contacts or a physically damaged head.

However, most of the time it is caused by "clots" in the areas supplying the jets, or in the jets themselves. Sometimes soaking the jets in a tray of alcohol or water for a while can dissolve these "clots", but the success rate is not that great. Better to fix the root of the problem.

BTW: Avoid turning the cartridge upside-down. Always hold it so gravity pulls the ink down to the jets and keeps them primed. Turning it upside-down can allow air to be drawn back into the jets.

Then again, it may be time for a new cartridge!

Epson Stylus Color 800 printer seems to operate but no printing

(From: Al Savage (asavage@iname.com).)

Sorry to be the bearer of bad news, but the both the purge pump and the printhead in the Stylus series (300, 400, 800, ColorII) are very trouble prone. I've scrapped a couple dozen of them. The cost of a replacement printhead is more than the printer on sale.

They do print nicely when they're working, though. My experience is that they don't work for very long.

Epson Stylus Color 800 clogged print head

(From: Alan G. Pope (agpope@phonetech.com).)

PROBLEM: Dryed black ink clog-up in the tube leading from the black ink cartridge to the print head. Black ink flow totally halted. New cartridges won't work.

BACKGROUND: Epson uses very fast-drying, water-soluble, inks in this printer, and if the printer sits idle for some length of time the ink feed tubes and the print heads become clogged with dry ink. Epson issues dire warnings about potential damage to the printer if attempts are made to flush these parts with any solvent, and recommends factory repair only.

On the advice of someone who has vast experience with such problems, I successfully used the following repair. procedure.

REPAIR PROCEDURE: Use a clean small hypodermic syringe with NO needle. Press on to the syringe nozzle, a 3/4 inch long piece of model airplane gas engine fuel tubing. This tubing is available cheaply from your local model hobby shop. It is a pale light blue colored plastic tubing. The MEDIUM size is the right one. The bore (ID) of the tubing is less than 1/16 of an inch. It makes a very tight fit when pushed onto the syringe nozzle.

Remove the cartridge from the printer, and pull the power plug immediately to prevent any further printer movement.

Load the syringe with 2-3 CC's of scalding hot water, preferably distilled water available at your grocery store. Then press the other end of the tubing down over the little black nozzle in the bottom of the cartridge holder. It must be a very tight fit.

Forcibly inject the hot water into the printer. If the clogging is really severe, you may have to press the syringe plunger very hard. Continue injecting until the syringe is empty, while making sure that the tubing does not slip off the syringe or the printer nozzle. Repeat this injection procedure 1-2 more times with more hot water if necessary.

Once the hot water goes through easily, the clog has been dissolved. It may be necessary to wait 24 hours for the water to evaporate, but in my case it was not. I simply replaced the black ink cartridge, and ran the Epson's head-cleaning utility several times until the black ink started coming through. Running the nozzle-check utility, to make a test pattern print, will let you know when the ink flow is OK.

This same procedure should work equally well for the colored inks of this printer. I suspect that the procedure will also probably work for some other Epson inkjet printers as well.

Use this procedure at your own risk. All I can tell you is that it worked beautifully for me. There was NO printer damage.

Non-use and refill of BJC-620 ink cartridges

(From: Roy (royf@iname.com).)

The people who talk about clogging, etc. must have never seen a BJC-620, in which the printhead and ink tanks are separate. I've had a 620 for about 16 months and having printed almost nothing on it (have a laser for most needs) have noticed that the ink tanks last about 5 months. My third set of cartridges at $40 per set have just recently gone dry. (Actually only the color ones are dry. The larger black one lasts longer.) I foolishly threw away the first set of empties, but I still have two sets. I decided that I've sent enough money to Canon and searched the web for a more economical solution. What I found was Bob Nedved and his re.ink.kit refill kit at:

- Re Ink Kit Home Page.

where, for $74.50 I got an amount of bulk ink equivalent to about $800 worth of new cartridges. Included also are 4 syringes and 4 small screws. The procedure is to make a small hole in each tank tank and seal it with a screw. To refill, you remove the screw, inject a few cc of ink, replace the screw, and clean the syringe with a little alcohol or distilled water. Filling the first cartridge was a little messy, but once you get the hang of it, it's a snap. The kit doesn't completely eliminate buying new tanks, because the tanks themselves eventually need to be replaced, but it sure does cut the annual maintenance cost, whether you only use the printer a little or if you use it a lot.

(From: Bill Sloman (sloman@sci.kun.nl).)

Epson uses a piezo-electric print head, and an alcohol-based ink. If you don't like paying for Epson's ink cartridges, use Pelikan's (I think that is the brand I use - it is certainly one of the old-fashioned ink manufacturers). They seem to use a higher molecular weight alcohol than Epson, so the cartridges last me more like six months than three in the old (1993) Epson Stylus Q800.

HP and Canon use a water-based ink, that is actually heated to boiling in the print-head to spit out droplets - so the print head corrodes rapidly, which is why their "ink cartridges" contain an new print-head and only about 15 ml ink, as much as the print-head can reliably spit out.

Inkjet Printer Cartridge Type and Reliability

Here are a couple of opinions. (From: Al Savage (asavage@iname.com).)

Having worked at Epson, Canon, and HP warranty service centers, I tell anyone who asks me for advice about buying an ink jet printer to always choose one where getting more ink also gets you a fresh printhead. The number one service problem with all inkjets is printhead clogging failures. On the Stylus 800 series, for example, the printhead retail cost was $170, and the labor was about half an hour. On the Canon BJC-600, the P/H cost was $250, but the head could be changed by the owner. And with so many folks using third party ink that works like it was brewed up in someone's bathtub (NuKote, Piranha (sp?), etc.), printhead failures scrapped more inkjets than any other three causes combined.

Cheap, owner-replaceable printheads help keep cheap inkjet printers out of the landfill.

(From: Roger Hamlett (roger@ttelmah.demon.co.uk).)

I disagree with the comments about chosing one where getting ink gets you a printhead. I have a bin full of 'dead' HP cartridges, that have resisted various attempts to get them printing again, yet also have an Epson here, that is four years old, and has never given any problems. The bill for cartridges on the HP, (allowing for the part use), would have paid to replace the printer a couple of times over.

Ink cartridge expiration dates

(From: Paul Weber (webpa@aol.com).)

One other thing about HP inkjet printers (DJ 550, 560, 850): Before you buy an ink cartridge, look at the expiration date on the box. Don't buy it unless you expect to use it before the printed date. That number really means that the cartridge will NOT work after the date...no matter how it is stored. Water and/or hot water rejuvenation rarely works on cartridges that are outdated. The reservoir evidently turns to crap and won't wick the water in or the ink out.

Dead Cannon, Compaq, HP, and similar power supplies

Apparently, these power supplies may blow their internal fuse either as a result of an overload, or possibly for no reason at all. In this case, a new fuse will be all that is needed. Of course, it's also possible that there is a fault in the power supply or in the printer which will cause the new fuse to blow but it's worth trying a new fuse before more complex troubleshooting.

(From: Jim Steel (procomputer@telisphere.com).)

Repair instructions.

The power supply is encased in a bonded 2-piece ABS plastic housing. There is a fuse inside but no way to access the fuse without splitting the case.

Splitting the case:

Unplug the power supply and secure the power supply in a utility vice. Use a short-blade utility knife or linoleum knife to slowly and carefully and cut along the seam where the 2 halves of the power supply are joined. Don't try to cut the seam all at once. Work a little at a time until the case halves can be separated.

Replacing the fuse:

On a power supply with an unsoldered fuse socket, simply replace the fuse and test the power supply. Alternately, a leaded fuse may be soldered in.

On a power supply with the fuse soldered into the fuse socket, leave the fuse in the socket and solder in a leaded fuse. (A leaded fuse has lead wires extending from each end of the fuse.)

On a power supply with a leaded fuse, unsolder the old fuse solder in a new leaded fuse.

Testing the power supply:

Ensure that the power supply and printer work before bothering to close the case.

Closing the case:

ABS plastic cement may be used to bond the power supply case halves. Alternately, electrical tape may be used to hold the case halves together.

- Back to Printer/Copier/Fax Repair FAQ Table of Contents.

Laser Printers

Note: also see the chapter on Photocopiers as the operation and problems of the two types of equipment are very similar.

On-line laser printer resources

- There is a complete textbook on laser printers: "A Laser Printer Book" by Steven Burrows, on-line at: http://cp.ru/goods/Inform/prl/books/00-toc.html.

  While this doesn't have much electronic repair information, it certainly would seem to cover just about everything else including some discussion of common image quality and mechanical problems. Note that this on-line book was present awhile back and disappeared. Now it's back but for how long, I have no idea. So, download what you need and save it!

- Parts Now! has a set of articles on specific laser printer print engine maintenance, repair, parts interchangeability, etc. These can be found at:

  - Parts Now Service Today Archives.

- MacIntosh Printer Manuals has many popular inkjet and laser printers.

Warnings about vacuuming laser printer toner

This is less likely to be something you would do in a big way with a laser printer compared to an office copier but if you are contemplating it, see the section: Warnings about vacuuming copier toner. There are several considerations including the risk of explosion and/or fire.

Refilling toner cartridges

If you can stand the mess, refilling some types of laser printer (and photocopier) cartridges can be worthwhile IFF the basic mechanism and photosensitive drum are in good condition. Even if you only get one more use out of a cartridge, the savings can be substantial. I have had mixed results buying reconditioned cartridges, but you know what your own have been doing in their spare time! However, it isn't quite just a matter of dumping new toner into a used cartridge:

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

Firstly the health/safety warning. Toner, because it's a very fine powder, is (a) carcinogenic, and (b) explosive. However, provided you don't make clouds of the stuff, you should be OK. It can't be *that* harmful, as some photocopiers take 'loose' toner, and some printers have separate toner/drum/waste toner units.

I've fixed mechanical problems on the SX and CX cartridges. I also once moved a good drum from an empty cartridge to an almost-new cartridge with a scored drum (don't ask...).

There are 2 things you need to do to refill one - empty out the waste toner tank and (obviously) add some new toner.

The SX cartridge is easy to dismantle. Unclip a little triangular plate on the side, pull out 4 plastic pegs, and the case comes off. The plastic bung for filling the toner tank is obvious. To empty the waste toner, you have to take the cartridge apart, remove a plate (2 screws) and empty the toner into something. I worked inside a plastic bag last time I opened one of these cartridges.

These printers use a combined toner and developer. The toner mix must be magnetic for the printer to work at all.

I've seen bottles of loose toner for some photocopiers. I have not idea which brands would be suitable (if any), but I might experiment sometime.

As for inspection/testing:

Well, the main test is probably drum sensitivity (but this won't change unless you are swaping drums). Now, if you get that wrong, all that happens is that the image is too light or too dark. There are some little plastic clips on the side of the cartridge that operate microswitches in the printer. And there are only 3 settings!. Believe it or not, I've found some remanufactured cartridges that work better when these blocks have been moved - in other words, the drum sensitivity wasn't checked properly.

Everything else should be mechanical inspection - condition of bearings/gears, leaks, primary corona, etc. Nothing that's impossible to do at home. Of course it's rather different if you're selling remanufactured cartridges - in that case you need to be sure the parts will last another 4000 pages or whatever. But if you're fixing up your own printer, and don't care if you have to fiddle with something else in 1000 pages time, then there's no real problem.

About the worse that can happen to the printer is that the cartridge dumps toner all over the insides. I've had that happen -

once. And it wasn't from a cartridge that I'd had in bits. It was from a remanufactured cartridge. That, together with the incident where a CX cartridge had had the door assembly incorrectly assembled, which caused damage to the transfer corona assembly, convinced me to avoid remanufactured cartridges that I'd not rebuilt myself, or at least checked.

You do need to avoid mixing waste toner (which will probably have a higher concentration of developer) with the new toner. Empty out the waste toner tank, but don't add the contents to the new toner. But if the toner you are adding is similar (or better still the same) as the original stuff, there is no problem from the residual toner in the cartridge.

Plenty of printers (Ricoh engine?) use 'loose' toner + drum/belt as separate parts. In those, you do add new toner on top of the old, and it all mixes up. Now, why should Canon printers be so different?

Cleaning laser printer optical path

As noted below, the optics are delicate and easily damaged. Use an air bulb to first blow off any loose dust/toner. Then use isopropyl alcohol and a cotton swab or lens tissue to *gently* clean the exposed surfaces. DO NOT disassemble any optics components - the alignment may be critical.

(From: David H. (textool@aol.com).)

It's always a good idea to clean the entire optical path from the laser (diode) forward. Most of this is inside the scanner module and there may also be a long external mirror.

With time these surfaces become coated with a film of toner/dirt and the laser beam reaching the drum gets weaker and diffused. Print quality suffers and later "beam detect" or "scanner failure" errors will occur, which may be intermittent at first, but eventually they will shut the printer down completely.

So open up the scanner module and gently clean all the prisms, mirrors and lenses. I say gently because the mirrors are front coated and the lenses may be plastic which can be scratched by aggressive cleaning with cotton swabs. Clean the external mirror if there is one. There is also a beam detection sensor which will have it's own small lens or prism which must be cleaned. Good luck.

In my experience dirty optics has been the they most common failure in 4+ year old laser printers with Canon engines.

Laser printer drum damaged by extended exposure to light?

(From: DenFrodo (denfrodo@aol.com).)

Yes, with extended exposure. I remanufacture toner cartridges for a time. Long term exposure to light will effect the photoconductive layer. We even cover areas of some (scratched) after-market drums and exposed them to sunlight to see how it effected them. It takes extended exposure to show an effect. No, the printer will not detect the problem and the printer will probably print dark for the basic 'positive' image (a dark area is exposed to light) laser printer. A scanner or copier might print light (reflective light of the 'white' surface exposes the surface of the drum. Good Luck.

Repeating images on laser printer

This likely means a faint ghost of the main printout at a distance equal to the circumference of one of the rollers or photosensitive drum.

Depending on where the problem originates, this could be a bad wiper (cleaning) blade, faulty corona, or incomplete fusing.

- If the distance between successive images is equal to the circumference of the photosensitive drum, it is a wiper blade, erase lamp, or corona problem.

  A residual latent image or residual toner is sticking to the drum and not being properly cleared.

- If the distance between successive images is equal to the circumference of one of the fuser rollers, then the fusing may not be complete due to damaged rollers or an incorrect temperature setting.

It is easy to determine where the problem is located: Interrupt a printout in mid-stride (where part of the paper is between the toner/developer and fuser. If the un-fused image has ghosting, it is a fault in the area of the drum. Also see the section: Previous copy doesn't erase from drum.

Black evenly spaced lines on laser printer or copier

(From: Edward Klotz (eklotz@www.flash.net).)

90% of the time it is the toner cartridge (or drum), If it is still exactly the same condition with the new cartridge, here is one exception: The fuser assembly has a rubber roller, I had one with an indentation in one spot, allowing toner to pack in the indentation & actually transfer a small character impression onto the fuser roller and then transfer it to the paper several times on each sheet. The fuser is very easy to remove(2 screws at the back). I temporarily worked the indent out of the soft rubber, but eventually replaced the fuser assembly.

(From: Dave Lee (leedj@uwec.edu).)

According to "Image Defects, Repetitive image defect ruler in LJ4", the cause would me the "Primary Charging Roller", is 1.5 inches or 38 mm around. Start with that, swap with another printer is possible, or order one, try Parts Now, Inc, 800/886-6688 or The Printer Works, 800/235-6116 or Global Printer Service, 800/588-3554.

Optics disassembly?

> "I would like to remove the mirror in order to clean it well. It mounts on a plastic bar that runs the width of the printer. The bar mounts by screws (2) at either end. I am worried that I will need some kind of aligning jig to get it back properly."

The short answer is: DON'T. Some aspects of the alignment are impossible to adjust/correct/reinstall without factory jigs and test equipment. The best you can hope for at home is trial-and-error. Most of the optics is probably solidly glued in place anyhow so disassembly is difficult or impossible - but it doesn't move much either! The long mirror itself is probably less critical than the rest but there is no real need to disturb it.

To clean the optics, use (low pressure) compressed air, alcohol and lens tissue, or as a last resort, alcohol and cotton swabs (Q-tips). However, some lens and mirror coatings may be easily damaged - test in a corner first.

(From: Pete (PTCull@lbl.gov).)

You are correct in being worried. Alignment marks closest to the muffin fan side of the engine should be noted before removal of the Beam-to-Drum Assembly. Better yet, just blow the mirror clean with a filtered compressed air source, leaving the mirror mounted.

Unless the mirror is very contaminated, I really wonder if you'll see the improvement you believe you might? Some of these mirrors have very soft surfaces and only should be touched with lens cleaner or cotton swabs.

If you still choose to remove the mirror from the engine, check to see if the two extreme sides of the page seem even when referenced to the top edge, using the "Engine Test print".

HP LaserJet FAQ

If your problem is with an HP LaserJet, before reading further, check the following three sources of information:

- The "HP LaserJet Information" document at this site is a comprehensive collection of common problems and solutions as well as a listing of error codes and likely causes.

- The Printer Works has a very complete listing of HP LaserJet error codes and possible remedies as well as some other model specific laser printer information. There are exploded diagrams for most Canon engines there as well!

- All Laser Services also has an error code listing along with some repair info. (Mostly HP but includes other printers using the same print engine as well as a few totally different printers.)

- Also see the section: Frank's repair notes: HP-IIP, HP-IIIP, Apple Personal Laser Writer.

Guide to disassembly and reassembly of HP LaserJet II and III

(From: Alexandre Souza (taito@terra.com.br).)

I used to fix lots and lots of HP II and HP III here in Brazil. So, with time, I developed a "checklist" for HP II and III repairing, that is safe enough to keep the printer working for years (4 years and NO defects whatsoever) and customers were happy. I'll include things not necessary for Americans (Brazil is HOT. Hotter than USA!) because friends all over the world may need this info.

What you need: Isopropyl alcohol, toner sucker, good screwdrivers, cotton, cotton swabs, screw picker (that little handy tool to pick/put screws in tight places), some rags - and lots of space!

I'll take the HP III as an example, The HP II is equal, with very minor differences. Please apologize me for any incorrections, since I'm telling everything from memory.

1. Be prepared to do a complete tear-down of the printer. Dismantle it to the last screw. This is a day-long work, so better you are prepared to do it. If you let for the following day, you WILL forget where the assemblies go, and will make your job a trip to hell.

2. Take the body cover entirely off. You will take total 6 screws, one of them in the back of the printer. You take it off pivoting it on your direction. It is a clumsy process, don't know why HP didn't made it easier.

3. Take the front "shield" off. The "front shield" is a big sheet of metal that covers the entire front of the printer. 5 or 6 screws, 2 ol the sides, 2 on the front, 1 or 2 on the top.

4. Take the Power Supply off. You need to unscrew 2 screws on the front of the printer, and one on the back of the power module, besides the main motor. Also, disconnect the cable of the motor from the power module.

5. Look at the solenoids of the power module. It is very common to have the solenoids' felts inside it became a messy glue. Take the metal flap off (take care with the coil) and clean everything that seems messy. Take 2 or 3 small squares of electrical tape, and put in the nucleus of the solenoid. Do it on both, replace flap. Don't forget the coil! Check the solder of the power module.

6. Now is time to take the ozone filter support out. This is a black plastic piece with 2 screws - one on the top, and another near the motor. Clean everything with compressed air and a rag. Be sure the filter is unobstructed. Better if you CHANGE the filter, but these are impossible to be found in Brazil. So you clean it. Or you will have some messy ex-gears. You have been warned.

7. Take the fuser out - it has 4 screws on the corners. Take care of it, there is a big and expensive lamp inside, and you don't want to buy a new one, eh? We will not disassembly the fuser module if not needed. But if you open the cover, pick the cleaning pad out and see black lines on the fuser roller, it is time for a cleaning!!! Dismantling the fuser is a complicated matter, but here we go: First of all, study how every piece fits its place. You should begin the dismantling by the right side, taking great care with the lamp. Take off the plastic pieces at the sides of the fuser, take the lamp out, so you are free to work. Store the lamp in a quiet place (no one should even touch it he he he) and don'ts touch the glass with your fingers - do it by the ceramic sides, or the wires. Clean the lamp with cotton embedded in isopropyl alcohol and set aside. Take off the locks of the gear on the right side of the fuser roller, there is an equal lock on the left. Take off the fuser roller, and PLEASE don'ts scratch it. You will see 2 thermistors on the fuser assembly, covered with yellow plastic. Clean it with cotton swabs and alcohol. If they are damaged (plastic is broken, missing a piece, has a hole, etc) CHANGE IT. If the surface of these thermistors isn't smooth, it WILL mark the surface of the fuser roller and WILL DAMAGE it. And this is not a cheap part. Everything clean, assembly it again, doing backwards what you did to unassembly. Remember this is a GOOD time to change the fuser roller.

8. Take off the AC module, where almost all the CX engine problems are located :o) This is the aluminum "tower" besides the fuser assembly, and where the AC cable comes in. Dismantle everything, change the little little little heat accumulator (yep, it is so little that should be called "heat accumulator") from the black TRIAC besides the mains power connector, and put a good heatsink with heat paste there. Also, clean THOROUGHLY the upper fan assembly, because when it fails, it can make things hotter. Hot enough to melt the fuser gears. :o) Remember: ERROR 50 = TRIAC open. A TIC 226 fits the bill on place. Of course there are other causes for error 50. But I've never seen that in Brazil.

9. Time to go to paper path! Take the 4 screws that locks the registration assembly in place. The registration assembly is the module where you have the big green handle. Clean everything and note if the "L" of the front is straight. If it doesn't make a 90 degrees angle, fix it. Also, change the separation pad. It is the culprit of 99% of the pickup paper problems. What? You live in Brazil and cannot buy new separation pads? So clean the black mess that was a long time before a hard rubber, and put some kind of rubber or cork on it. Also, take about 10 cm of isolating tape and cover the lower half of the "separation pad" you did. The printer will not give ONE pickup error for YEARS. BTW, I never had one return of this method. When you put the registration assembly back, don'ts forget the small yellowish piece on the front roller is assembled pointing the frontal part of the printer!!! This is very important!

10. Take the pickup roller out and clean it thoroughly. Use turpentine to make it softer, it will last years! Of course, if you have a replacement unit, better to use that.

11. Using a cotton swab, alcohol and LOTS OF PATIENCE, clean the corona wire. Be careful as you can, not to break the diagonal wires that surround it.

12. Do a GOOD cleanup on the inside of the printer. Use compressed air (with a dehumidifier) and don'ts throw air in the scanner assembly. Better never mess with that. Only open the scanner assembly if you HAVE a problem with

it. Hope you never have.

13. Of course you already took the toner cart off, eh? Well, you have a black metal plate, with instructions of putting a cart there. Slide that plate to right, and move it up. You will see a very nice and delicate frontal mirror. Use only cotton and alcohol to clean that, and after only cotton to polish it. Make it clean, and close the lid. Of course, you don'ts want to let it exposed. A nick on this mirror, and there goes your print quality away.

14. You have 2 contacts on the left part of the printer cover. They touch the fuser assembly below. Do a continuity test there, you should find some ohms, but continuity. If you don'ts find it, you have a broken "erasing lamp" inside the printer cover. 2 screws keep you far from them, better change it now

15. Close the printer cover, turn the printer upside down, take out the plastic pan on the bottom of it, take the metal pan, clean everything including the lower fan. Of course, a lower fan broken, is a laser printer broken. NEVER, I said NEVER run the printer with the lower and upper fan disconnected, OK? Do you remember what I said? You have been warned 2.0 :o)

Well, this completes my "HP Refurbishing method". To reassemble it, you do the following:

- Bottom aluminum pan
- Bottom plastic pan
- Turn the printer up
- Registration assembly
- Pickup Roller
- AC Power module
- Ozone Filter Support (the black plastic thing)
- Fuser Assembly
- DC Module (don'ts forget the main motor cable!!!)
- Frontal shield
- Top cover (don'ts forget the cable for the front panel)

And so you have a healthy HP III. It will last for YEARS if you did it right. don'ts forget to put a fresh new cart of toner and it will last forever. Of course, you want to clean everything externally too.

The common disclaimers apply here. Do it at your own risk. I've fixed some 500 HP LaserJet IIs and IIIs, and never had a problem, return or anything doing that. Your mileage may vary. Greetings for Brazilian friends, and for all around the world that uses that guide. :o)

Guide to disassembly and reassembly of HP LaserJet 4

(From: Alexandre Souza (taito@terra.com.br).)

I fell in love with this printer but this puppy got some Coke in her fuser and messed things a little. So I was obligated to do a complete disassembly of it, to clean up the mess and change a gear. So, here we go:

1. Open the right lateral cover, pick it out.

2. Take the top cover out, 2 screws on the back, one on the top, beside the little green brush. You have 2 plastic locks on front, be careful with them

3. One plastic lock on top, and you take the left panel out

4. On the back of the printer, take the big panel out - you have the plastic hinge besides the parallel and serial connectors (best done than said) and one small "lock" on the right pin of the door (the power supply side). Take the lock out, and slide the plastic door out the printer.

5. 2 more plastic locks, and you take the small front panel (where you put cartridges) out. The only remaining panel is the MP tray, that I didn't needed to take out.

6. Take the formatter door out. You have a small plastic pin on the middle of the hinge of it, push it and slide the door out.

7. Take the formatter out. You will have 2 screws on the left, behind the formatter door hinge, one or 2 screws on the top, one in the right.

8. You are seeing the main motor. 4 exposed screws, and it is out. Take GREAT care with a hole below the left screws, if you don'ts close it (and open before using the printer) one of the left screws ALWAYS falls by this hole on the power supply. And you don'ts want it, want you?

9. Behind the motor board, you will find 2 screws, it frees the main gear unit. This is the most fantastic thing I've ever seen - 2 screws and all the gears, inside a module, come out. I LOVE HP! :oD

10. Behind the printer, take 2 screws on the base of the fuser assembly, take it out, push up and back the fuser assembly.

11. 2 screws on the printer connectors, let you take out the cooler fan on top of it. It also has a small plastic lock on the left side of it

12. Take the black ventilation colum out. This is divided in 2 parts. Take care. Take the ventilation grid on the bottom of it, and clean it thoroughly.

13. 2 plastic locks on the BACK of the assembly that transports the paper to the top of the printer (sorry, don't know the HP name) and it is free.

To disassemble the fuser:

1. take the FRONT plastic part out. Note there are 4 plastic locks on the front, and another one on the lower right, besides a gear.

2. Unconnect a lug terminal on the bottom of it. Take GREAT care, this is the wire that comes from the lamp.

3. Free all the wires from their locks, and take the two screws of the frontal thermistor (the bigger one) on the top of the fuser. Also, unconnect the small 2 wires with a connector on lower left.

4. Unscrew the RIGHT plastic part, freeing the lamp, and with greatest care of all, unscrew the LEFT plastic part. TAKE CARE with the wires and the lamp. One wrong movement and the lamp is gone.

5. Take the lamp out, now you can play it safe with the fuser.

6. Take the right top and bottom gears - they are free.

7. Take the fuser gear. You have a small lock you have to take out.

8. Take the same lock in the left side

9. Take out the metal cover of the fuser - you have 2 small locks between the plastic back with the green sticker (that has 2 coils that go to this cover), just pull it back and here comes your metal cover. Clean the thermistors!!! don'ts forget to change it if they are scratched, dented or damaged!!!

10. Unscrew the fuser roller bushings from the main fuser module

11. Find a way to make the lower rubber roller stay far from the fuser roller, and pick it out of the module. So you can pick out the black rubber roller too

12. Clean everything with isopropyl alcohol

13. Reassembly everything in reverse order.

This is my method of "Refurbishing" the HP4+. Note I have one with 400,000 pages printed and NO problems. The gear I changed was INTACT (as the others on the main gear module) with only 2 broken teeth caused by the roller, that was completely locked!!! It was SO Glued with coke that a small gear on the fuser, after unassembling, was completely unable to move, before taking it out with great force, and cleaning with alcohol. After that, it was free as a bird. Go figure...

Just a little fun: This one cost US$30. :o) Spent more US$40 to fix. The parts were more expensive than the printer itself he he he :o)

Testing the erase lamps on an HP LaserJets

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

There's a very quick test for the erase lamps in these printers (SX engine). Open the cover, and swing it right open. There's a plastic post that comes down from the cover at the back left with 2 contacts in it. It goes into a slot on the left side of the fuser when the printer is closed.

Check for continuity between the 2 contacts in the cover. I have no idea what the right resistance would be, but it's less than 1k. If it's open-circuit then most likely one of the lamps is burnt out. There are 5 of them, in series.

If the lamps are good and there are still erase lamp problems, then remove the fuser, take the cover off the left side of it (1 screw on top) and unscrew the PCB under it. Check the 2SD1414 power transistor Q331 on this board (it's the erase lamp driver). If that doesn't do it, check the components around it. R335 (1.8 Ohm) is the current sense resistor in Q331's emitter circuit, L331 is a filter choke in series with the lamp supply, and Q331 is a current sense transistor that removes the base drive from Q331 if the thing overcurrents.

I suppose it could be a problem with the cable back to the DC controller or even the DC controller itself, but that's unlikely.

If you've still not found the problem, though, post again and I'll think again.

HP LaserJet error code 51

> "On self-test, pulls in paper, pauses, indicates "51 err." Then pulls paper through mechanism while "02 warming up" is displayed. Nothing prints, except for 2 horizontal black bars about an inch apart with grey in between them, about 1/3 from top of page. Since we stole this fair and square, and since we have a number of good (but _not_ laser printer) techs around, I'm wondering where we might dig. The book simply says error 51 means we should call HP service."

(Note: In the discussion below, the specific cable and parts IDs may not match your model.)

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

It's called a 'beam detect error'. Let me explain what that means:

The laser beam is reflected off a spinning hexagonal (I think) mirror, and scanned across the drum. At one end of the scan the laser is turned on, and the reflected beam hits a fixed mirror (not the drum) and is reflected down an optical fiber to a photodiode on the DC controller board. The electronics on that board detects the pulse from that photodiode and provides a sync signal for the data sent to the laser

So the fault can be the laser, the scanner motor, assorted optical bits, the photodiode, or bits on the DC controller board. I think we can eliminate the motor for the moment, as that tends to give Error 52s.

Look at the PrinterWorks Web site (http://www.printerworks.com/) for exploded diagrams. Also read the section: SAFETY since you will be inside the printer near high voltage and possible exposure to laser light.

The official fix is to replace the scanner, the cables (electrical and fiber optic) between the scanner and the DC controller, and then the DC controller until the fault goes away. But you can often fix things

Start by pulling the casing. Over the paper tray there's a flat black box. Start be reseating the 2 cables (one under the flap) that go to this unit.

If you have an IR detector (as used for testing remote controls) then undo the screw on the scanner - not the fixing screws that hold the scanner in place - remove the grey optical fiber, and hold the sensor over the channel that the fiber fitted in to. Do not look up this channel - it can output laser light. Turn on, and try to print a test page - which will fail.

If you get IR light out of the scanner unit:

Reconnect the fiber at that end, remove the base of the printer, and arrange some way to prop it upright with the interlock switch pressed in. Unplug the fiber from J201 (a DNP-like connector) on the DC controller board. Put your IR sensor on the end of that and test again. No IR light now, time to replace the fiber.

Reconnect the fiber to J201 and hook a logic probe or 'scope to TP208 on the DC controller. This is the output of the photodiode amplifier. Do you get pulses here? If not, check the photodiode and the transistors Q202, Q204, Q208. If you do, then, alas the problem is most likely in a custom chip, and it's time to replace the DC controller.

If you get no light from the scanner, then it's time to inspect it:

Carefully trim back the moulded clips that hold the cover on the scanner and open it up. Clean the optics with a soft brush or lens tissue. The mirrors are front-silvered of course. There's a little shutter in the laser beam, opened when a toner cartridge is locked in place - is this opening correctly when you close the printer? If not, find out why not.

Unplug the cable from the laser PCB, power up the printer and try a test page. Does the scanner motor rotate? If not, we'll debug that.

The last possibility is that the laser isn't coming on for some reason. Debugging that is going to be interesting (read Sam's laser diode notes next :-), and I'll do the same) and I'll try to talk you through that when I know it's necessary. (Note: Sam's laser diode notes -- Diode Laser chapter of Sam's Laser FAQ.)

(From: Tom Dunn (dunnt@cco.caltech.edu).)

Error code 51 indicates loss of laser beam for over 2 seconds. Check -5 V, also make sure there is no interlock mechanism damage, and +5 V at J451-1 on Laser Drive PCA. You may need new laser unit. Good hunting.

(From: John Holcepl (john_holcepl@nls.net).)

This is a very common error on a HP Series II. An error code 51 is loss of beam detect. The cause is a bad cable between the DC Controller and the laser/scanner assy. P/N RG1-0908-000CN. Sometimes just reseating the cable will make this error go away but it will come back eventually.

(From: Eric Liber (liberes@westinghouse.com).)

Here is the description of the possible 51 errors:

51 ERROR (Loss of Beam Detect)

- 2686 Only:
    1. Bad laser unit or improper laser power setting.
    2. Replace Laser Diode Assembly.
    3. Replace Scanner Assembly.
- II, III Only:
    1. Replace Cable, Laser/Scanner to DC Controller cable (P/N RG1-0908-000).
- II, IID, III, IIID Only:
    1. Inspect the Fiber Optics Cable for cuts or kinks.
    2. Replace Laser/Scanner Assembly.
    3. Replace DC Controller.
- IIISi/4Si Only:
    1. Visually check or replace toner cartridge.
    2. Inspect Fiber-Optic Cable between Laser/Scanning Assembly and DC Controller.

3. Reseat connectors J002 on the DC Controller and J601 on the Laser Drive PCA.

4. Replace Laser/Scanning assembly.

HP LaserJet I fuser swapping and other tidbits

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

What you need to do (if you're going to remove the whole assembly) is to remove the (brown) cover that's flat on the printer chassis just behind the 'tower' at the front that contains the interlock switch and AC control boards (where you removed the fuser heater wires from). Under that cover there's a little 4-way connector that links the fuser thermistor back to the engine control PCB (DC controller). Unplug that.

Then you can remove the 4 screws that hold the fuser in place, lift it up a bit, and free the heater wiring from the channel in the baseplate. The whole fuser then comes out.

These fusers can be stripped and rebuilt - I've done it. If the old one still heats up, keep it for the heater lamp that's in it - that lamp does fail, and it's not that hard to replace. It's a quartz-halogen bulb, so you shouldn't touch the 'glass'. The safest place to store it is in the old fuser.

These printers are that bad. I've had one stripped down to individual components (even dismantled the optical assembly), and have it running now. But the SX engine (LJ2, etc) are a lot easier to dismantle into modules (and in some cases harder to replace individual components on...)

HP LJ Series II bad bearing noise and other comments

> "Got one that started making unpleasant noises about two weeks ago. It is in a church office environment, so they have to turn it off unless they need it for a short while. I took part of the cover off and decided it wasn't the top fan or the small motor on the right side. The sound comes from the right rear at the grilles at the bottom of the machine. It sounds like a bad bearing or something rubbing a fan."

(From: Ralph Wade Phillips (ralphp@techie.com).)

Bad lower fan. Part number RH7-1056. I'd check at http://www.pcservice.com and register and order XX-RH7-1056 (it's under $20) and just replace that fan.

I'd also consider replacing the upper fan (go look for it with the search engine - it's about the same $ for the generic 3rd party version) since a failure there will ALSO cost you the fuser gears, thereby costing a fuser assembly.

As to removing the bottom cover - Eh? Put the top back on, flip it over, and remove those screws you see around the rim. Remove all cartridges also. Slip the metal cover off, and viola - There she is!

Big warning - Do NOT run the machine with the lower fan disconnected. This is known to damage the DC controller board (at least a $60 part, EXCHANGE - over $300 purchase!), and can cause massive problems later down the road ... Take a look at http://www.printerworks.com and look (and print, if possible!) their exploded parts diagrams. Yes, books are available, but will outrun the $150 the church is paying for it (worth it, though, with as many LJ2/LJ3/QMS/LWII and other SX-based printers out there, IMAO.)

(From: Al Savage (asavage@iname.com).) Probably the most-commonly-replaced part is the lower fan on the 33440A. Yes, it's very noisy when bad, right up until it becomes extremely quiet .

Well, buying 10 year old hardware and then wanting to depend on it not breaking isn't very realistic. As reliable as the LJII/III is, they DO break, especially lower fans, the 14T fuser gear, paper pickup roller, pickup photosensor, AC power supply, registration assy. It's just that they'll commonly print half a million pages in the process, and many contemporary printers aren't designed for a service life a third as long.

To replace the lower fan, have a vacuum cleaner with a brush handy (or an air compressor). Remove toner cartridge/drum unit. Close lid, remove all cables (power, data), flip printer upside down. On a LJII, you're looking at steel square pan; on a LJIII, you're looking at a large plastic tray and you have to remove four Phillips-head screws to get it off first.

On both models: remove any optional memory card(s) by first removing the access hatch for them on the left side. This hatch is the one *without* the 1/4" hole in it. Remove any circuit board you find under there: they just pull straight out.

On the back of the printer, remove any optional I/O card (HP JetDirect, Appletalk, etc) that may be installed next to the normal Centronics data port. This isn't always *necessary* but when it isn't it just makes things easier. Once again, just remove two screws and pull on the I/O card.

Now you can remove the lower pan. Nine Phillips head screws later, lift the front edge of the pan, wiggle it to get it off over the Centronics port cable clips.

Vacuum the pan out -- it will be filled with dust bunnies -- and any dust you see collected on the mainboard. You can now see the lower fan. It's a squirrel cage design. Remove the short wire harness and the four screws to remove it. Note the position of the small bracket under two of the screws, as you will need to put that bracket back!

Reassemble in reverse order. One screw on the lower pan does NOT go in the left rear corner, but that's only a problem is you have the upper plastic off as well. You can't put it in wrong if the upper half is still assembled.

The fan is about $20 wholesale, often close to $40 retail. Do NOT attempt to disassemble and clean it. I've tried several times, and no matter what I try it will either still be noisy, or will fail again within months.

HP LaserJet II just dies and no sign of power after a short while

(From: Larry Sabo (sabo@storm.ca).)

> "I have an HP LaserJet II that will just die after a short time. There are no power lights, not even an error message. If I leave it for a short time it will come back on after a power cycle. It is totally random."

Check the daughter board in the PSU at fault. On mine it had deteriorated solder connections on *both* ends of the connecting pins. Remove it, resolder the pins on the daughter board, then remount it. It's worked like a charm ever since.

HP LaserJet II with dark bands on first page

(Problem and solution from: Ken Eckert (eckert@sfu.ca).)

I have a LJ II that has the following problem:

> "The problem is a dark horizontal band starting at line 1, about 1/2" wide, indistinct edges. Repeats down the page at same length as the optical drum circumference. Problem is present only on page 1 of a print job. All other pages are clean. When the engine is stopped at the beginning of the print process a large

> amount of toner is present on the OPC in a band. Band gets darker and larger the more time between successive print jobs is incurred.
>
> Swapping cartridges has no effect."

The problem turned out to be the chassis wiring harness from the DCA controller to the HV module. There was a bad connection between the HV module and the chassis connector only when the module was inserted. I ended up extracting and soldering all the crimped pins in the connector. I suspect that it was probably the HV reset line that was the problem.

HP LaserJet II output jam

> "I found a junked HP Laserjet II which initially jammed pulling in the paper. I have fixed that. It still jams on the output, though. It prints nicely, so it seems worth fixing. If I open the back tray, the sheet exits 90% before stopping with the "paper jam" error. With that tray closed, I get the accordion paper jam in the fuser area. I do not detect any rotation of the upper rollers to feed the paper out of the top. When opened, I can roll them by hand easily. I see no obvious gear wear or broken teeth. I also see deep scratches in the grey fuser, which is probably unrelated. The toner does not have any fusing problem that I see in a band down the page."

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

I think you've got 2 problems here - the false paper jam with the tray open, and a problem with the drive to the top rollers.

Let's look a them in that order.

There's only one paper sensor in the SX engine that I know about, and that's part of the fuser. On the PCB at the left side of the fuser there's a slotted opto-switch with a lever that detects paper in the fuser. There's also a single transistor on said PCB that buffers/amplifies the output from the opto-switch, Q332, I think. This sensor must change state one way (to indicate paper has got to the fuser) shortly after the registration clutch operates and then change state the other way when the paper has got out of the fuser.

You might start by reseating the cable at J206 of the DC controller board (just in case it's bad connections) and then look at the sensor (mechanically and electrically) on the fuser PCB.

Silly question: If the paper tray switches (on the DC controller board) aren't operating properly, could the printer think it was feeding a shorter piece of paper than it actually has, and then give a paper jam error? It's always possible... Alas I don't know the coding for these 3 switches (SW201-SW203)

The other problem is almost certainly mechanical. Look at the gears on the right hand side of the fuser (stripped teeth do occur here) and in the top cover of the printer. Shouldn't be too hard to find where the drive has failed. I suppose you could remove the outer casing and AC block, re-insert the fuser and close the cover, and look at things while turning the machine by hand.

HP LaserJet IIp won't go past 'warm up'

> "I have an HP IIP that goes through the "05 Self Test" mode but hangs when it gets to "02 Warm Up." The only thing I ever hear run is the fan. I am not getting any error codes otherwise. If I try to send a print job to it in this state, it seems to take it and the On Line indicators light up, but it won't print. Based on what I've read in the FAQ and in the archives, I'm guessing it is the DC Controller. I re-seated the connections

> going to the DC controller PCB and the power supply and everything else visually looks good. I do not have a service manual for this unit.
>
> Can someone tell me how to test the DC controller to see if it is defective or maybe shed a little light on what may be causing the unit not to make it to the "ready" mode?"

Any number of simple faults can result in the warmup sequence not completing. Check these first before suspecting a blown power supply or controller.

It may indeed be as simple as a burned out bulb or broken door interlock.

(From: Dave Lee (leedj@uwec.edu).)

Here is what I found in my notes concerning your very same problem, Hope it helps......

New "Service Today" from Parts Now, volume IV, number 1, issued in Feb 95 is devoted to the "LX" engine units, IIP/IIP Plus/IIIP Series, the Cannon LBP-4, Apple Personal LaserWriter. Lots of good stuff, error 50's, error 41's, fuser upgrades, "moaning", other squeaks etc.

Here is what it says:

> If hung on "02 Warming Up", trouble may be caused by cables on the door wear and tear. Also look at DC Cnt PCA, dual I/O, formatter PCA. Now also look at the solenoid for the MP pickup roller assembly. This can cause the 'hung 02 Warming Up' error if an open occurs in either the solenoid cable, or solenoid coil. To check, remove the formatter PCA in order to access the DC Controller PCA. Locate J209 on the DC Controller; pins 1 & 2 are the solenoid. Measure across the top of these pins, the correct reading is 200 ohms +- 10%. Replace the paper path door cable assembly, Part #RG1-1608-000 if the solenoid has high resistance.

(From: Jeff Churchvara (jeffc@pond.com).)

Experience would have diagnosed this one in about 10 seconds. I just didn't know what I was looking at.

I started reading the FAQ and figured the worst. At first, I did not have the service manual to go over this code. When I finally did get a copy, I started checking the voltages and did not have +24 V at the DC Controller PCA.

All of what I was reading said to defeat the door interlock. At first, this didn't make sense to me because the bar that should be attached to the door was instead, laying on top of the switch and wasn't even moving when the door opened. I didn't know enough not to look any further.

Once I realized the bar should've been attached to the door, I started looking for it's correct mounting. The screw holding the bar must have loosened up and over time it broke the mounting nut right out of the door.

I ended up resetting the nut (threaded sleeve) by adding a screw from the outside. Then I pinched it in place with a second screw when I re-anchored the bar. This made the bar pull away when the door opened and then correctly contact the interlock switch when the door closed.

I forgot the basics of troubleshooting when I posted this one and was making it more difficult than it actually was.

Thanks to all of you who responded and kept me looking in the right direction.

Totally blank printout on laser printer or copier

(From: Ed Paolo (edpaolo@intac.com).)

Check to see if the image of the printout to be, is on the image drum. If it is there and isn't being transfered to the paper then something like the high voltage corona wire or hight voltage supply isn't charging the paper.

(From: FAXFIXR (justdfax@cdepot.net).)

There are two corona wires, the charge corona and the transfer corona. The charge corona is the one you should look at. It is located in the toner cartridge so the easiest way to check is try another cartridge, even one that is out (or almost) of toner. If you don't have another, then you can check yours. If you look at the cartridge in it's operating position, there is a black mylar plastic film that covers a slit on top from end to end. The mylar covers the corona wire but allows you to insert the little green tool, found inside the copier, to wipe the corona. If the tool is there, stick the pad into the slot and wipe it back and forth. If you hear a slight screeching sound (like a violin) then the corona is there. If it's not there, then the cartridge must be replaced.

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

(The following was written for HP LaserJet III but it is generally applicable to other laser printers and photocopiers.)

For starters, try a new toner cartridge. I've found these can cause all sorts of problems...

Now, blank pages are due to one or more of :

1. The drum is not getting exposed by the laser
2. The EHT power supply isn't transferring toner onto the drum
3. The EHT power supply isn't transferring toner from the drum to the page.

Start it printing a test page (the 'engine test' switch on the DC controller is useful for this). When the paper is still going through the printer, turn it off, open the lid and pull back the cover over the drum in the cartridge. Is there a 'latent image' on the drum? If so, check the EHT power supply and transfer corona assemblies.

Check that you plugged the cables into the scanner properly. They don't always make good contact. This will normally cause a 'beam detect' problem - I forget what the error is for that (51? 52?). It's possible that there's an O/C in the cable, of course.

If you have an IR detector (of the type used for testing remote controls), unplug the optical fibre from the DC controller and point the end at the IR detector. Again print a test page. If the laser and scanner are working, you'll get some IR (laser light, so take care) out of the end of the fibre.

There is a mechanical shutter in front of the laser in the scanner that's opened by a lever under the scanner when the cover is closed with a toner cartridge in place. The idea is to prevent any laser light getting out if the printer is run with the cover open/no cartridge. Is this working correctly. Did you get the scanner correctly on top of it.

Bearing replacement on HP LaserJet II to fix error code 41

(From: Andreas Mohr (a.mohr@mailto.de).)

My (donated) Laserjet II series printed black horizontal lines after about the third sheet. It then occasionally spit out "error 41".

Solution:

The ball bearings of the scanner unit were defective (now I know that my printer was MUCH louder than other HP 2s). That caused the scanner unit to get "out of sync" and print black lines and occasionally spit out "error 41".

I just replaced the ball bearings and everything was fine again.

As far as I know, no Laserjet error codes service page mentions this yet. (They only say that "the scanner unit may be defective", but not HOW that may be.)

HP LaserJet series II - error code 50 Service and clicking

(From: Peter Strezev (jup001@airmail.net).)

I had a LaserJet series II with exactly the same symptoms: 50 SERVICE and that very clicking sound. I fixed that printer last week after quite a bit of troubleshooting.

First: the clicking sound comes from a mechanical relay in the PSU, which controls, together with an SCR solid-state relay, the sequence in which power is applied to the heating lamp in the fuser. The sound itself is not a problem, it is a symptom. You probably have a bad thermistor in the fuser assembly, or the signal path from the thermistor to the control board is corrupted.

If you are good with electronic troubleshooting, try the following:

- Remove the fuser assembly from the printer. Locate a 7-pin connector on the left side of the assembly (I am assuming the same orientation, in which it was while inside the printer). Turn the fuser upside down, so that the connector is on the top. Using an ohmmeter, measure the resistance between pins 3 and 4, counting from the one closest to you. The meter should read a few hundred KOhms (if you take off the plastic cover, which covers the thermistor and thermoswitch, you could access the thermistor and try to heat it with a soldering iron. The resistance should come down to a few K Ohms or less if the thermistor is OK).

- If you got correct readings, measure the resistance between the corresponding pins in the socket, where the connector goes to when the fuser is installed. It should be quite high, about a M ohm. In my case, I found only 30 Ohms, and this was the source of the problem. What it turned out to be, the little cable underneath the printer, which carries a bunch of sensor signals from the fuser to the control board. Two wires responsible for the thermistor data turned out to be shorted by an excessively tight cable tie. It might not be the same in your case, but who knows...

(From: Mark Wolfe (markw@wwa.com).)

Just to speed things up a little, override the printer open switch, and remove the plastic cover from the right end of the fuser to get at the power connector for the bulb. Turn the thing on, and read this connector, should see about 115 VAC, if you don't, check Q101 in the Power Supply. The problem you had sounded like a rarity, as it's usually the halogen light in the fuser, or Q101 in the power supply. Yours was the sensors going back to control Q101. Anyway, if you ever have one of the power supplies opened, it looks as if HP intended this triac to fail with it's whimpy heat sink. Hope this helps.

I had the same thing happen to me on a IID, check the connections on the fuser. I swapped fusers with my III, and both printers worked, swapped them back and both printers worked. The power connector on the right end of the fuser seemed a bit loose, could've had a bad connection. Anyway, IID is still going, and this was in august when I did this.

(From: Chris Holmes (holmesc@sedgehill.lewisham.sch.uk).)

I dont know if Error code 50 is the same as Service 50 on the HP Laserjet II but if it is you are in luck.

I once had this and spent about an hour and a half stripping cleaning and reassembling it, and it worked! When I got back to civilisation I checked the manual. The official HP action for Service 50 is - switch off for 10 Mins!

Still i'm sure the clean did it good.

(From: Frank Reid (reid@indiana.edu))

A fuser-heating fault in HP Laserjet II or III (or the Apple equivalent) causes a capacitor on the dc controller board to charge. Discharge takes 10 to 30 minutes. If you repair the problem and restart the machine before the capacitor discharges, the error indication remains.

(From: Stuart Elflett (stuarte@OntheNet.com.au).)

Does the 50 error now stay on constantly, e.g. if you turn the machine on after a 30 minute wait, does it still say 50 error without doing its self test?? If so, I'd head towards the D.C. Controller. If the bulb in the fuser comes straight on, and the delivery rollers don't turn a little before hand, I'd be looking at the AC Supply. Is your fan spinning?? A stalled fan can often result in a 50 error. Is the fuser heating up?? If you're technically minded, you could remove the fuser and check the bulb for continuity.

Parts are commonly available almost world wide now.... you could check my links page for some sites that provide parts.... there's plenty more out there that aren't on my list..... try a web search for Laser Printer Parts....... They're not too expensive, as long as you get exchange parts where possible!! A manual would be a good purchase if you intend doing the work yourself, however they are still relatively expensive compared to parts!!

(From: David Gardner (gardneda@www.gc.cc.fl.us).)

Error 50 is called a fuser error, which it is, but I have found that it can also be caused by a bad High Voltage power supply or by a bad cable that runs from the power supply to the fuser.

Notes on HP LaserJet II error code 50

(From: ROO7L@aol.com.)

When confronted with a code 50 - after checking lamp, lower fan operation, thermal cutoff, wire connections etc. I always, as a precaution against call-backs, 1. remove solder from wire ends at thermistor, clean and resolder with silver solder, 2. replace 1k ohm resistor under pin connector (thermal protector board on end of fusing unit), 3. replace Q101 (triac on power supply board) and add more heat sink, 4. replace D155 on dc control board. 5. restake all wire end connectors with stake type wire connections. All of these are prone to happen and you can cut them off at the pass by taking care of these common offenders while you have the machine open. The voice of experience, I hate call backs!

HP LaserJet II - Top of the line printing shifting in multipage printing

(From: M K Ramadoss.)

Problem: In multipage printing, the first page will print fine. But, the top line of the second and subsequent pages will be shifted about 1/2".

Cause: There is a solenoid on the right side of the printer which stops the toothed gear. You can see this if you open the printer cover exposing the inside of the printer. On the solenoid there is a thin piece of foam which becomes sticky with age and temperature inside the printer. When the second and subsequent pages are printed, the solenoid the metal flap sticks to the solenoid and hence the timing of the feeding of paper is messed up and hence the shifting of printing.

Fix: This is very simple. In the hardware section of your store you will find thin felt squares or rounds with self-adhesive back normally used on the bottoms of lamps etc to prevent them from sliding as well as scratching polished surface of table etc. All you need is one such piece (about 1/2" round) which is stuck on the solenoid side of the solenoid. Thin felt is preferred. (Cost of a sheet of felt rounds/squares at Walmart is less than $1.00. All you need is one round).

HP LaserJet II bad bearing sounds

This also applies to many other laser printers using the Canon SX or similar print engine.

> "Developed frequency-changing whine of bad bearings. Not really sure whether a fan motor or main motor."

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

A service manual probably wouldn't be a lot of help. The SX printers (HP LJII, Apple Laserwriter 2, etc.) are very modular, and AFAIK, the official way to repair them is to replace the defective module. Of course it's possible to repair them at a much lower level than that, which is what I do to my pair.

There are 3 motors:

1. Lower fan. A tangential blower in the lower case next to the DC controller (Engine controller) PCB. This runs all the time that the printer is turned on. (Maybe the cover needs to be closed - I can't remember which 24 V line it runs from)

2. Upper fan. This sits on top of the AC block in the rear right corner (near where the mains cable plugs in). It runs when the machine is printing, and drops back to a slower speed when the machine is idle.

3. Main motor. This is a stepper motor that drives all the mechanics in the printer through a gear train. Needless to say it only turns when the machine is actually printing.

By finding out when the noise occurs, it's possible to figure out what is causing it.

Firstly the good news. I have never had a main motor bearing fail. They're ball races anyway (Yes, you can strip the motor down and rebuild it). I've never had noise from the gear train either.

Now the bad news. Fan failure is common. The bearings are bronze bushes, and they fail. Sometimes lubrication helps a lot, sometimes things are just too far gone.

Lower fan. Remove the toner cartridge and paper tray. Turn the printer upside-down and remove the screws that hold the base cover on. Remove the cover. The fan is obvious, and is held down by 4 screws (there's a bracket at one side that comes off as well), and it plugs into the smaller of the PCBs in the machine. Remove it. You can then unscrew the motor from the fan and slide the motor + blades out. Then pull the blades off the motor, remove the circlip, and pull the motor apart. Examine the shafts and bearings. If they're not too badly worn, a drop of oil (3-in-1 or similar) will probably cure the fault. Otherwise you need a new fan - parts are impossible to obtain.

Upper fan. Remove the paper tray and toner cartridge. Undo the screws and remove the outer casing. Remove the 2 screws and lift out the fan duct + ozone filter (on top of the AC block). The fan is under it and is held down by 3 more screws and a 2-pin plug on the upper (fuser protection) PCB in the AC block. There are at least 3 different upper fans in use, so I can't give directions for dismantling them. But in general, the motor can be unscrewed from the side of the fan, and the bearing on the other side pulled out. Inspect them as above, and try a drop of oil.

Editor's note: If you buy a replacement for this, it will likely be a 24 VDC muffin style fan (like in your PC, except that is 12 VDC). HP or Apple will likely charge you $70 or more for this part!

(From: Frank Reid (reid@indiana.edu).)

If the upper fan fails, the fuser assembly will overheat and do about $200 damage. Cleaning the bronze bushing often solves the problem.

An obscure and obnoxious squeak sometimes comes from the anti-static brush on the end of the upper fuser roller (end opposite drive gear). A bit of high-temperature grease on the nearby felt pad will fix it.

HP LaserJet II fuser overheating

(From: Glenn Allen (pclogic@xtra.co.nz).)

I had this problem on my HP LJII. I traced it to D155 shorted on the Fixing Heater Saftey PCB , this is in the same casing as the AC Power Assembly where the power cord plugs in. There was some sort of corrosion there.

I replaced it with a IN4148 diode as it is only a signal diode.

HP LaserJet II triac replacement

(From: John (jneff@uidaho.edu).)

We have been replacing these with a SK10466 (800 V, 8 A, Vgt 2 V, Igt 50 mA).

(From: dhickey@knox.edu).

If it is in the AC Powersupply, try a NTE 56006.

Also check for 2 open resistors.

HP LaserJet Series II intermittent

> "My new (to me) HP Laserjet Series II printer seems to have a power supply problem, although its previous owner said his supplier/servicer suggested the problem was 'probably due to a fryed mainboard' and promptly sold him a new printer. Lucky me. :-)

It works fine for a while, then starts to cycle between "12 Printer Open" and "00 Ready" before the fan in the power supply area drops in speed at the same time. I notice that the lamp on my desk flickers occasionally, even when the printer shows "00 Ready". Tapping the cover at any time immediately brings on the "12 Printer Open" message and fan speed drop-off. The cycle eventually ends with a "67 Service" message."

(From: Larry Sabo (lsabo@freenet.carleton.ca).)

The cause of the problem was an intermittent connection in the DC power supply, where the daughter board is attached to the pcb with a right-angle connector. I got so tired of removing and reassembling the power supply, I just jammed an empty plastic scotch tape role to hold it in position, and it has worked like a charm ever since.

HP LaserJet IIP printer error code 12

(From: Michael (action@netdoor.com).)

Your problem is likely to be the "Density Control PCB" that if you had the top cover off the unit, it would be a little board with a lot of wires (mainly purple, I think) going to it. It is in the front on the top.

About $40. Not saying that's it for sure, but I've seen it three times in the last 4 months.

(From: Frank Reid (reid@indiana.edu).)

I agree, but it could also be the assembly of photoelectric sensors and their wiring harness (about $25). Before replacing components, clean the sensors with compressed air and re-seat their connectors on the DC Controller board.

(From: Greg Smith (n6nyx@cox.net).)

Check the 10 uF electrolytic capacitor on the Density Control PCA board to clear Error 12 Open or No EP.

The capacitor on my printer went open-circuit big time! It started off with an intermittent error message. Percussive maintenance brings it back for a while, then it dies for good! The capacitor is only rated at about 16 V. I put in a 10 microfarad, 50 volt unit to replace it and still had plenty of room to clear obstructions after I bent it over a bit!

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

I am not sure how the printer detects that the cover is closed - there are 2 obvious ways : from the +24 V interlock switch or from the toner cartridge microswitches. Since, I believe, it'll claim the cover is closed even without a toner cartridge in place, I think it's the former.

OK, things to check:

Firstly, there should be a little peg on the cover (on the right hand side under the edge) that goes into a slot on a metal housing on the LV power supply module. This presses a microswitch inside that housing. This peg often breaks off.

If that's not it, then take off the bottom cover from the printer and stand the printer on one side. It's safe to power it up like this. Connect a voltmeter between the 2 outside pins (1 and 14) on J212 (a long 14 pin socket on the DC controller board). Power up. If you don't get 24 V here, you have a LV power supply problem.

Now connect the meter between pins 2 and 13 on the same connector. If you don't get 24 V now, then the problem is almost certainly the microswitch in the LV power supply, or the peg that operates it, or something like that. You can probably fix that by taking out the LV power supply, taking it apart and examining the switch and its connections.

If you do get 24 V there, then assuming the printer uses the +24 V sensing as the method of detecting when the cover is one, the problem is possibly R817, R818 or C760 on the DC controller board. If it's not those, then it's IC218, a custom microcontroller.

As I said, it _might_ use the toner cartridge switches to detect when the cover is closed. Take off the upper casing, the frame round the front, and the LV power supply module. On the side of the power supply there's a PCB with the paper sensors, the clutch solenoids, and the cartridge switches on it. Check the latter (SW301 and SW302) and the spring leaf that operates them.

HP LaserJet IIP with 12 Open or no EP error

> "I have tried to reseat the EP-L cartridge and opened and closed the fuser door many times, but can't seem to get this printer to work."

(From: Erik Welander (erikwelander@hotmail.com).)

I have written a detailed description of how to repair the "Error 12 OPEN or no EP-L" problem of the Lasejet IIP that seem to be very common on this printer (cost of approximately $1 for the capacitor). This, and some general maintenance advice can be found at: [HP Laserjet Maintenance and Repair].

(From: Terry (tmredding@worldnet.att.net).)

Sometimes the spring tabs on the left side of the printer that are the sensor for the cartridge get bent or are dirty. Also you get this error if the fan is not working.

(From: Dave Lee (leedj@uwec.edu).)

Most times I find that its the Density PCA that causes the problem. Sometimes its just dirt/dust in the two sensors on the right side above the toner cartridge, blow these out and give it a try. Density Board is avail through most laser parts houses, these are the ones I use:

- Global Printer Services, Phone: 800-588-3554
- Parts Now, Inc., Phone: 800-886-6688
- The Printer Works, Phone: 800-235-6116

HP LaserJet IID Error 13

(From: John H. Meyer (John_Meyer@compuserve.com).)

(I finally found the cause of the problem described below: One of the voltage outputs on the main power supply was blown. Had the power supply refurbished and everything works perfectly.)

> "LaserJet IID gives Error 13 message immediately upon warmup. (This is paper jam message.) The paper path, however, is totally clear. I've taken things apart and cleaned the exit sensor and paper path. Unit is quite clean. I've downloaded information on Error 13 and have tried everything except replacing DC controller card ($200-$400 part). I took the unit to two different repair places. One tried swapping out the fuser assembly -- that didn't help, and that was all they were willing to do for their free diagnosis.

MicroAge charge me $$ for a few hours troubleshooting and tried swapping out the main motor. No help. They also claim to have electrically checked the exit sensor. They said that the only thing left was to replace the DC controller card, but they didn't have one to swap in, so I'd have to pay up-front for the card.

I didn't do this. Instead, I took the unit back home and pulled the DC controller card. I tested all the discrete parts (simple diode tests on the transistors), and they all test OK. Two questions:

1. Does anyone have other suggestions of things to try?

2. Does anyone have a recommendation on where else to get a DC controller card for less money?"

(From: Dave Lee (leedj@uwec.edu).)

Had almost the same problem about a year ago, problem was the AC Power Module, just needed reseating. ACPM is located in right rear corner, just under ozone filter and upper cooling fan. Fuser assembly must also be removed to get to one of the 4 screws that hold the ACPM to frame. Remove the ACPM and then put back in place, thats all I had to do. Has been working since Feb 1995.

But another thought about this, are you sure that something isn't jammed where paper from botton tray comes up just in front of the registration assembly. If you remove the reg. assembly, there is a clear plastic guide that is held in place by 2 screws. Remove this and check to see if maybe something is jammed by that sensor.

As far as a good price on DC Controller board, I would call Parts Now, Inc. at 1-800-886-6688 or The Printer Works, 1-800-235-6116. I know that Parts Now sells either repaired or used or exchanged boards, probably a LOT less than what you were quoted.

(From: John Meyer (john.meyer@worldnet.att.net).)

Thanks for very complete reply. Your message sparks a lightbulb. When I first took the cover off when this problems initially surfaced, I took the power unit apart from the top (took of the little fan, and then started disassembling it). When I put it back together, things worked. I then put the top main cover back on, and things didn't work again. Nothing has worked since. However, I never took the whole assembly out and therefore never got to the connector. I'll try this and let you know what happens.

I don't use the bottom tray because the bottom paper path is prone to jamming, and has been for years. However, it is possible that someone (I have a four year old boy) may have jammed something in there. I have looked for such a jam and haven't seen it, but based on your input, I will try again.

(From: Dave Lee (leedj@uwec.edu).)

As far as the jamming from bottom tray goes, 2 areas to look at:

1. Remove the registration unit, its the first assembly inside the printer. Open cover, its the part with the hinged assembly with a small green handle. (Not the fuser, this is right inside the printer). Remove both paprer trays, registration assembly is held in by 4 screws. Under that is clear plastic guide held in by 2 screws. Remove this guide, and you should be able to inspect path from bottom tray for an obstruction. Also check the clear plastic guide, something may be caught in the guide.

2. Paper pickup roller for bottom tray may be glazed or very dirty. Clean with damp rag (water will work) although some "Fedron" cleaner is best but hard to find.

Do this after you get the error 13 fixed so you don't compound the problem.

HP LaserJet IIP and LaserJet series 2 error code 52

> "I have a HP LaserJet IIP, which does not print, but displays Error Code 52. Don, a man who is willing to help me fix mine, has a HP LaserJet series 2 that works. How similar are theses two machines? Is there any chance that one can swap parts to find the problem?"

(From: srob@iprolink.co.nz and Michael Schuster (schuster@panix.com).)

Totally different. Different cases, electronics, toner cartridge and system.

(From: Lewis King (echo@infogo.com).)

Error code 52 is 'Scanner Malfunction' and there have been posts on the USENET newsgroup sci.electronics.repair that indicate that this is fairly common and is usually the cable leading to the scanner mechanism. These printers, and the CX before them, use insulation displacement connectors. Quite often the connection gets flaky and pressing down on the wires where they enter the connector will fix a problem (worked on my Xante Accel-a-writer when it was telling me I needed a new DC controller board).

The part you need is the scanner motor... I can't remember the part number, but it is the same as the scanner motor for a IIP+ and a IIIP. The scanner motor has three screws holding it in, in the box where the laser attaches to the side. As you pull off the scanner you will notice a square microprocessor on it's board. the bottom side of that board will probably have a dark spot where that processor got too hot. I fixed about 50 of them that way.

I will find out what the error code means and get back to you.

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

That sounds like the classic scanner motor failure on these printers. It's a very common fault, alas.

The 'Official' repair is to replace the scanner assembly (the entire unit - the black plastic box - on top of the printer), and if that fails to cure it, then change the DC controller board. But you can normally fix it a lot cheaper than that.

Here's how (I believe) the unit should work:

There's a frequency generator (FG) coil on the motor PCB, just like the one in a VCR. The signal is fed down the cable to J203 on the DC controller and then converted to a TTL signal by IC202A (LM393 comparator). It enters the gate array (IC206) and comes out again when it is fed to a TC9142 chip (IC203) which compares it to a reference clock also from the gate array. The error output from the PPL is conditioned by IC201b (LM358) and fed back to the scanner motor. There is feeds the control input of the TA7259 (IC401) chip which drives the motor windings.

First check that the cables are connected to J203 and J401 (inside the scanner unit). The most common fault is that IC401 has failed and probably burnt out R401 (8R2) with it. Fortunately, this chip is not custom - in the UK it's available from (e.g.) Grandata, so a VCR spares place might have one.

If you've still not got it working, get back to me, and I'll talk you through the test points on the PLL on the DC controller board. Hopefully the gate array is still good, since I've not found a source of those.

Oh yes, how to dismantle the scanner to replace the chip.

Firstly remove the outer casing from the printer. Then unplug the 2 cables on the scanner unit - one on J451 (on the laser PCB) and one on J401 (under the little flap on top). Undo the clamp screw in the back right corner, swing up the clamp and remove the beam detect fibre cable. Then remove the 4 screws and lift out the scanner unit.

Now, *carefully* cut back the melted-over studs and lift off the top cover. Keep dust to a minimum (obviously). Remove the circlip on the scanner motor spindle on the bottom of the unit. Remove the rotor and hexagonal mirror, taking care to note where all the washers go. Remove the small screws and lift out the PCB.

(From: Flemming (flemming.gottsche@get2net.dk).)

Where the scanner cannot maintain proper speed. Replace electrolytic capacitors on scanner board. All capacitors are 10 uF/16 V. Also replace the current measurement shunt resistor (R301) on scanner board. It has a value of about 1 Ohm. All these parts are in the black plastic box below processor.

HP LaserJet II scanner information

(From: Jon Fick (JFick@pcilightingcontrols.com).)

The following Web site has some helpful hints about scanner chip/board replacement, and also has a scanned datasheet for the chip for those that want to substitute flatpack/dippack types.

- PIC Circuits.

HP LaserJet IIP error code 51

> "I have here a HP Laserjet IIP which gives errocode 51. The manual says something about a beam-detection. Do you guys 'n girls think this is to repair for relatively little money?

(From: Osceola Electronics (osceola@netonecom.net).)

On my IIP+, I had to take it all apart. I had to remove the main board and open the main cover to the laser area and clean the fiber-optic pickup and lens.

HP IID error code 50

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

A problem on the DC controller (in particular C210) can cause intermittent ERROR 50's

Mechanical failures of the fuser will not cause ERROR 50 (AFIAK). After all, the fuser temperature is maintained even when the mechanism is not turning. A broken gear in the fuser will cause paper jams, but not much more.

If you've got the machine in bits on the bench, and you are *sure* the fuser is not overheated, try shorting C211 on the DC controller board momentarily with the power off to clear the error.

HP LaserJet IIP+ error code 50

"My owners manual tells me that if this error persists after a 15 minute power interruption then service is required. Is it feasible for me to perform this service myself? What is the risk factor that my printer will be FUBAR if I attemp this?"

(From: Don Hickey (dhickey@knox.knox.edu).)

It could be one out of a number of items that are actually bad. Most likely it is the fuser assembly. However it could also be the Ac Power Supply, Dc Controller or the cable going from the fuser to the dcc. Most of the time the lamp on the fuser burns out or one of the thermal switches.

(From: (Frank Reid (reid@indiana.edu).)

Test for continuity through the large terminals on the fuser. That will tell you if the lamp and thermostat are good. If they are, then the problem is in the AC power supply (cubical box under the upper fan). Remove the printer case, observe the fuser lamp upon power-on. If it lights immediately and then goes off with an audible click, the triac in the power supply is shorted. ECG 5620 is a replacement. Be careful desoldering the plated- through holes.

HP LaserJet IIP - 52 error

"The problem with the machine is as follows:

1. I bought the printer used from friends a year ago. They sold it because the printer would crash when they sent it a large print job. I do that very rarely, and thus this happened very infrequently. I would just shut off the power and then turn it back on and it would print the same job just fine.

2. In December the printer would go through the initial diagnostic routine, but when the first print job came it would at first sound fine, but then make a longish whining noise and then display the error message "Printer Error 52" (I looked that up in the Users' Manual: "This error message indicates a scanner malfunction.") I reset the printer, and then it would work fine.

3. The problem as described in 2) gradually occurred more frequently: I would have to reset the printer several times for it to print. After it started to print it would work fine until I turned the printer off for some time.

4. Finally even after letting the machine warm up for hours it would not print at all, even though it went through the diagnostics on power-up.

5. Model Number of the laser printer is: HP33471A, manufactured: April 1990 Serial Number: 3049J01EOB

(From: Charles Kyle (kyle@citynet.net).)

I have repaired a lot of the HP IIP printers with error 52. It has always been the scanner motor assembly. The assembly can be repaired by replacing the motor driver IC and possibly a burnt resistor or by ordering the scanner motor assembly.

Laser Impact carries the scanner motor assembly for the HP IIP. The part # is RG1-1771-000. it is easy to replace and costs about $60. Their phone number is (800)879-5882.

"I have a HP Laserjet IIP printer that no longer works and I need some help diagnosing. The printer does not print any text pages but instead gives an error 52 on the LCD screen. The owners manual says that an error 52 is a scanner malfunction. However the authorized service center said that this error was a memory error. The cost of having them fix the printer is more than the printers worth."

(From: Rich (richcar@flash.net).)

The service center gave you the wrong info. It is a bad scanner motor or a bad dc controller. I have found, that on a lot of laser printers for this error and others, that if you re-seat all connections internally, to all PCB's, the problem will go away. (About 50% of the time) If this doesn't work you can check the voltages on the dc controller itself. The dc controller is the PCB under the formatter, (If you were looking down on top of the printer) and directly above the scanner assembly.

```
 J212 on the dc controller
------------------------------------------------
 Pin 1: Gnd (blue)
 Pin 2: Gnd (blue)
 Pin 3: +24 * (red)
 Pin 4: +24 * (red)
 Pin 5: Gnd (blue)
 Pin 6: +12 (orange)
 Pin 7: Gnd (blue)
 Pin 8: +5 (brown)
 Pin 9: Data signal (yellow) (shouldn't matter)
```

* Paper path door closed or pwr supply interlock defeated

These are the voltages the dc controller uses. (From the pwr supply) The scanner assembly. is the most expensive part and on exchange you can get one for about $150-200. But don't quote me on that. Contact Printer Works or PC Service Source to find out. I don't have their numbers but you should be able to get them from the 800 directory. 800-555-1212 >

HP Laserjet IIP error 52 - chip replacement

(From: Jon Fick (fickpci@aol.com).)

I was finally able to fix the printer by replacing the chip on the scanning motor board rather than replacing the whole board. That's a $10 fix rather than a $80 fix!

The surface-mount chip and an associated surface-mount resistor apparently run hot in this application, and over time, darken the back of the printed circuit board.

- The resistor color bands indicate that it is 1 ohm. It measured 0.8 ohm so I left it in place. I was able to obtain some data sheets for the chip. Although the data sheet diagram is written in an oriental language it appears that the resistor could indeed be a low value in that location so I didn't change it.

- The chip part number is HA13456AMP. It is a surface mount device, a quad package. It's leads are meant to be soldered, not plugged. With Solderwick and a small iron the old chip came off easily. Be careful of the heat, though, because it appears that the surface of the board can become slightly delaminated. I also used a stereo microscope so I could be exacting as I applied the heat.

I covered the scanner rotor before attempting anything because I didn't want to have to clean the mirrors afterwards.

I also have the same chip in a different package that might actually be more robust. It is the HA13456A, a long DIP package with triple-width ground tabs in the middle of each side. It is electrically equivalent from what I can tell and might be a good substitute if the flat pack fails early.

The printer came right up, and self test immediately printed two pages!

The chip came from: B & D Enterprises International, PO Box 460, Main & Liberty Streets, Russell, Pennsylvania, 16345.

Their worldwide number, as well as tech support (really helpful) is: 814-757-8300 (800-458-6053 in the USA).

Their 24-hour fax number is: 814-757-5400

VISA, MASTERCARD, AMERICAN EXPRESS are accepted worldwide.

Each chip was $7.55. They have a $15 minimum order, so I ordered two, partly to make the minimum order, and partly to have a spare.

Laserjet IIP PS board

(From: Brian Mathews (icontech@volcano.net).)

I have repaired many of these power supplies and I usually replace the triac, two resistors (22 and 150 ohms?) and the eight pin DIP (usually marked SHARP).

HP LaserJet III problems

> "This LaserJet III has me stumped. It has a persistent error 50. I tried everything in the service manual, but to no avail. If anyone has an idea how to fix this, it would be most welcome"

(From: Ted Szypulski (szypulsk@esslink.com).)

Sounds like an open fuser lamp, like mine was. I have an LJ4. HP would only sell a rebuilt fuser assembly. My cost was $150.00. The fuser assembly on the 4 comes out the rear real easy. There are two captive screws to loosen and then it just unplugs. I removed mine and took it to another LJ4 just to be sure that was the problem before buying a new one. My testing with an ohm meter also proved the fuser lamp was open.

I hope the LJ3 is similar and this is of some help.

Smudged vertical line on HP Laserjet III

(From: Dan Bourque (danbou@nbnet.nb.ca).)

The common problem with these printers is that the fuser drum gets scratched by the heat sensors of the fuser assembly which gets dirty with toner. Take a look at the drum of the fuser if the protective coating was scratched to the metal. If this is the case then the fuser needs to be replaced (around $80.00 for refurbished). If the protective coating is not scratched to the metal then the fuser can be removed and disassembled to clean the heat sensors. Use alcohol and Q-tips to clean.

To print a test page hit the On_Line button to put it off-line and then press test button for about 5 seconds.

Shifted print on HP LaserJet III

> "The LaserJet III in my office has acquired the annoying habit of shifting its printed output about half an inch down on the paper. This sometimes cuts off the page numbers. It typically will never happen on the first few pages. Once shifted, it stays that way, until I turn it off. I'm kind of clueless, the manual doesn't mention anything like this."

(From: Frank Reid (reid@indiana.edu).)

Replace the pickup roller. Clean the transfer rollers with naphtha or mineral spirits. If that doesn't work, replace the transfer assembly (set of metal and rubber rollers after pickup roller; removable by 4 black screws). Inspect the solenoids on the DC power supply: The rubber pads sometimes become sticky and hold onto the armatures, thus messing-up the timing. If that happens, scrape the old pad off, clean the armature and core with solvent, and replace the pad. I use squares of double-sided foam tape and then use naphtha to remove the glue from the outer side. If you remove the old pads but don't replace them, the printer will be more noisy, and permanent magnetism in the solenoid cores may affect timing.

(From: Joop van der Velden (joopv@solair1.inter.NL.net).)

Two possibilities: a mechanical problem with the paper transport, or a escape sequence reprogramming the printer paper format(ting)

Try to print some test pages from the printer itself (no pc connected) If that gives the same problem, try cleaning the paper path and transport an paper separation mechanism.

(From: Randy McVittie (rmcvittie@octrf.on.ca).)

I thought it might have been the pick-up roller, at least that is what the manual was pointing me towards, but other people's 2 cents worth said to look at the solenoids SL301 and SL302 on the Paper Control PCA.

There is a piece of foam tape on the core of these solenoids, and it had become kind of sticky, preventing the solenoid from snapping back when power was removed. Then I had severe paper jam problems I guess you need some amount of spacing here. So I put a few layers o of electrical tape in the same spot and now I had great registration. 3 layers of tape was my magic number, your mileage may vary.

This area was not even mentioned as a source of problem in paper registration troubleshooting chart in the HP manual.

HP LaserJet III powers on but appears dead

> "When I flip the power switch on, I can hear it power up, but the none of the lights comes on and the LED panel is also dead."

(From: David J. Pittella (ddc_pitt@ix.netcom.com).)

Since you say the unit 'powers up', I assume you hear the engine power up (fan, drive motor, etc). Assuming this is a Lajerjet III (not IIIp or IIIsi, etc.), you can do an engine test by removing a small cover on the bottom of the right side, removing this cover will expose a metal plate with a hole in it. The hole exposes a switch on the DC controller which will print simple line test pattern. This will at least confirm that the engine is working.

The front panel LCD display and status LED's are driven by the formatter board. The formatter gets its +5 power from the DC controller via (2) screws that secure the formatter to the CD controller. If you remove the bottom plastics and bottom pan, the formatter is the large main board. The DC controller is the smaller board with several connectors attached to it.

I am also making the assumption that the cable leading from the formatter to the front panel is attached at both ends?

You may also want to remove any options, (memory, optional I/O) as one of these options could be preventing the formatter from initializing and possibly lead to a blank display. BUT, the best guess here is that the formatter is not getting power - check those screws between the DC controller and formatter!

HP LaserJet III cold fuser

(From: Flemming (flemming.gottsche@get2net.dk).)

Where the fuser is cold and the relay trips, check Q153 for leakage (C-B) which results in current leaving the base and charging C158. When C158 is charged to about 3.3 V, Q153 is turned on and the relay trips.

The relay that is tripping is RL101, which actally is located on another PWB than the transistor. This relay has a very distinct sound, which has been mentioned over and over again in postings to various news-groups. Both PCBs are placed in the rear right corner of the HP LJIII.

HP LaserJet III paper jam

> "I have two LaserJet IIIs that complain about a paper jam on power up, right after the self test (i.e. before I've even had a chance to send anything to the printer)."

(From: Terry (tmredding@worldnet.att.net).)

The most likely cause of this problem is the exit sensor arm or photointerrupter or the dc controller board. Standing in front of the printer with the top cover up it will be in the far left lower corner.

(From: Wong Sy Ming (siming@singnet.com.sg).)

HP LaserJet III paper feed problem

My LJIII wouldn't feed paper past the registration assembly. Sounds like a mechanical problem right? No, it was not mechanical but rather it was electronic problems. At first I replaced the two drive transistors on the solenoid board thinking that one of them burned out but that didn't solve the problem.

Then, the whole thing came apart as I traced the connections for one of the solenoids back to the DC controller board. Guess what? One of the PCB traces near the 78324 IC (large square one) was corroded away. I quickly soldered a wire across it and now it works perfectly! Now I wonder what could have caused that...?

HP LaserJet III error 50

"My HP Laserjet III is giving a "50 Service" error. So something is wrong with the fuser. But the lamp is not burned out. Also, the fuser roller is pretty clean.

When I turn on the printer, the light in the fuser comes on for a second. Then there's a click from the power supply (or around there), and the light goes off.

The 05 Self Test message comes up.

Then Warming up (takes a while).

Then, both online and page feed lights go out and "50 Service" appears.

The power supply and fan are working and the ozone filter is clear."

(From: Geir Knutsvik (geirk@netpower.no).)

What about the fuser? Does it make heat? I have in some cases have faulty opto electronics for sensing paper and drawers result in Error 50.

In worst case it cold be the main pcb ...expensive... check dc controller.

(From: Mark Wolfe (markw@wwa.com).)

5 bucks says it's Q101 in the power supply (crosses to NTE 5620). I've seen quite a few where this was the problem. Check the power connector at the right end of the fuser, it's under a plastic cover. There should be about 115 VAC there during the warm up, you'll have to stick something in the cover open switch to get it to power up. If there is 115 VAC, it's the lamp in the fuser. If there isn't 115, it's save to say it's Q101 which is the triac that supplies the fuser. Get a new heatsink with the new triac. Cost here with tax to fix the problem is $7.07 + my labor. :)

(From: Terry (tmredding@worldnet.att.net).)

This error can be caused by missing 24 v, bad Thermistor, Fuser Bulb or Thermoprotector. Replacing the fusing assembly is quite easy by removing the 4 silver screws that secure it.

Notes on HP LaserJet III error code 50

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

[Error 50, SX Engine]

Remove the fuser (4 screws hidden down holes - it helps to remove the plastic cover from the left hand side (1 screw).) At the right hand side there's a 2 pin plug that goes into the AC block. Test for continuity between the 2 pins on the fuser. If it's open, then it's either the fuser lamp or the overheating-protection thermal switch that's open. It's pretty easy to trace the connections and test them separately if you can figure out how to dismantle the fuser (I can talk you through it).

If the fuser is OK, then remove the outer plastic casing, and the AC block under the upper fan [at the right rear of the printer. Remove the two screws securing the black plastic ozone filter housing, pull that housing straight up and off. Three vertical screws secure the base, plus one horizontal one on the outside rear. Then pull the AC block straight up. The fuser must be removed prior to removing the AC block].

Most of the time the thing that fails is the Triac, Q101 on the lower board in the AC block. This means the fuser can't heat up.

Here are a few notes on what goes on in the AC block (totally unofficial, BTW).

Lower board:

R101, L101, C101, C102, C103 form a mains filter. The output of that goes to CB1 (circuit breaker) with VZ1 connected across the output of that lot as a spike suppressor. The output of that goes to the 2-pin plug (J104) and thence to the DC power supply. Watch out for J104 if you run an AC block out of the printer as it carries live mains.

The fuser control circuit on the lower board isn't complex either. The live side of the mains (output of CB1) goes to T101 (current sense transformer) primary. The other side of the primary goes to the contacts of RL101 (fuser protection relay). There's a snubber SQ101 across the relay contacts. The other side of the relay contacts goes to one pin of J103 and thence to the fuser lamp. The other pin of J103 (and thus the other side of the fuser lamp) is returned to the neutral side of the mains via the triac Q101. This is triggered by SSR101. Oh, there are a couple of resistors (R102 and R103) in the triac gate circuit, and suppression components L102 and SQ102.

There's a 10 pin connector between the lower board and the upper board. The pinout seems to be:

```
Pins 1,2    T101 current sense transformer secondary
Pins 3,4    RL101 relay coil
Pins 5,6    Solid State relay (SSR101) input (6 +ve)
Pin 7       Fan control
Pin 8       Fuser drive from the DC controller
Pin 9       Ground
Pin 10      +24 V (input)
```

The last 4 pins are connected to the 4 pins of J101 which is connected to the DC controller. Shouldn't be hard to trace those.

Upper board:

This virtually never fails, so I'll simplify the description by missing out resistors, etc. You can trace the signal flow from this description anyway.

The fan control is trivial - the fan control input drives Q159 with the fan as the collector load.

The fuser control signal is AC coupled (C157) to Q157. The output of that is rectified/smoothed (D157/C156) and drives Q156. The collector load of Q156 is SSR101 on the lower board.

There's also a protection circuit, which works as follows. Normally Q153 is on which turns on Q152 and Q151. This turns off Q155 which has the protection relay as its collector load.

If the fuser control circuit fails so that Q156 stays on too long (which would cause the fuser to overheat), then C153 is discharged by D155 and the collector of Q156. This turns off Q153, Q152, Q151 and turns on Q155, energizing the protection relay and turning off the fuser.

If the fuser takes too much current then the output of the sense transformer T101 becomes large enough to trip the comparator IC151 (LM393). This turns on Q154 which discharges C153. The rest of the circuit operates as above.

(From: Jon Martin (jon.martin@unisys.com).)

There is a partial Schematic of the AC power supply at: Fuser Controller RG1-1438.

The fuser thermistor comes in on pin 4 or J206. There's an 18k resistor (R237) to +5 V, and a 4.3K resistor to ground via SW205 (which is open when the base cover is on the printer -- the idea is to shut the fuser down if you power up the printer when dismantled). Then there's a 3.3K resistor in series (R747). And then a 4.7 uF cap (C210) to ground to smooth the signal out a bit. Finally we get the AN0 input on the main microcontroller IC218.

The fuser drive signal comes out on port PD2. This is buffered by IC219e ('04) and IC211e ('07) before going to pin 2 of J208 and then to the AC block.

There is one more bit of circuitry to consider -- the overheat shutdown. If the fuser overheats (or the machine things it has), then a signal comes out on port PD3. This turns on Q210 (2SC1815) which charges C211 (100 uF) via R749 (330 ohms). There's a 4.7M resistor (R748) in parallel with C211, which gives a time constant of many *minutes*. That's why to have to leave the printer off if the fuser seems to have overheated. Anyway, the voltage across C211 is monitored by the AN3 input on the microcontroller

So, what to check? C210 is a favorite, it goes leaky. If that's not it, check (with the printer assembled and therefore SW205 open -- you have to solder wires onto the points so you can look at the signals) the following

1. The voltage across C210 (should be around 2 V I think). If wrong, check the fuser thermistor and connections, the R's and C's between it and the microcontroller, etc

2. The voltage across C210. If it's more than 0 V, then switch off, discharge C210 (short the leads together), try again. If it rises again, find out if Q210 is being turned on (Check the base voltage -- it's an emitter follower). If so, then either the microcontroller is faulty, or there's a problem you should have spotted in (1) :-). Check Q210, the R's and C's, etc.

3. Any pulses at the input to IC219e (pin 11 of IC219). If not, then again, suspect the microcontroller if you've got this far. If you do have a signal there, check it again at the output (pin 10) of IC219e, then the input of IC211e (pin 11) and the output of IC211e (pin 10 -- this should be a 24 V level signal, not TTL). If you get a signal at the output of IC211e, then make sure it gets to the AC block. If it does, then the fuser should work.

If the microcontroller is faulty then as far as I know, the only place to get a replacement is off another DC controller board.

Paper jams on HP LaserJet IIIP

> "More and more I get HP Laserjet IIIP printers here with all the same problem: 13 Paper jam. Every time I look at the driving-mechanism and move it with my hand, but it all seems to work fine. I suspect there's a common cause to all this. I think it's got something to do with the electromagnet in the tray, but I'm not sure."

(From: Frank Reid (reid@indiana.edu).)

If the paper is getting crunched accordion-style, the 'drum-drive clutch' is probably broken. It's a couple of small white gears inside the right-side cover of the machine. The plastic tends to crack in a ring, separating the gear from the shaft.

To confirm, mark the green drum in the toner cartridge: If it doesn't turn, then the clutch is surely at fault. Apple "Personal Laser Writer" and some other brands use the same print-engine.

If the machine won't pick up paper at all but the pickup rollers are good, look for a bent piece of metal preventing movement of the bar that raises the stack of paper just prior to pickup.

A third possibility is stripped plastic gears on the fuser assembly.

(From: Lars Arvidsson (arvid@plea.se).)

My guess is the paper intake rubber reel, you see it if you pull out the paper tray. It gets old and dry, and it needs to be sticky to get a grip on the sheet. It gets worse at dry weather, cold and dry. Try to clean it with alcohol, then coat it with some balsam turpentine (don't know if this is the right translation, it's a liquid used for diluting artist oil paint).

Allow it to be absorbed for a few hours, then wipe of the excess. The reel is sticky again...or just replace it - but that's no fun. ;-)

(From: Rick Norton (RKNORTON@worldnet.att.net).)

I repaired an HPII with a similar problem using automotive belt dressing on the rubber pickup surfaces. Spray a small amount on a rag and wipe on surface. Allow to dry for 15 minutes. The printer has been working for 3 years without a problem.

(From: Dr. John Betts (Dr@browser.demon.co.uk).)

Don't ignore a more mundane cause - that paper is stuck inside the fuser, particularly if someone has used inferior grade labels.

HP LaserJet IIIP power up problems

> "I have a HP Laser Jet IIIp, The problem is when it is switched on, the printer can do one of two things; the panel lights up and displays 05 Self Test and then switches off after around 3 Seconds, and other times nothing happens at all."

(From: Pete (PTCull@lbl.gov).)

If you have a voltmeter, J212 on the DC Controller is a good place to start checking. Blue wires are earth/ground, brown is +5 VDC, orange is +12VDC, and the red wires have +24VDC.

However, it sounds like a nice time for known good spares or another known good LX engine to borrow known good assemblies from.

HP LaserJet IIIP - error code 52

> "I have inherited a dead HP LaserJet IIIP printer and would like to hear your thoughts on its chances.
>
> The machine goes through its warm up routine OK but if I do an internal font printout or print from a PC then it sits quitely for about ten seconds, then raises in pitch for a second and simultaneously displays: 52 ERROR.

> The manual states that this error is a 'scanner fault'.
>
> I have dismantled the unit down to the laser and rotating mirror but can see no obvious faults. Perhaps the motor that drives the mirror is burnt out or the laser is dead??
>
> HP have quoted me a repair price equivalent to a new Oki!!!

(From: Frank Reid (reid@indiana.edu).)

That symptom can often be cured by re-seating the cables between the laser assembly and the dc controller (smaller board under bottom cover). Also check the optical fiber running from the laser scanner housing to the dc controller: Sometimes it goes bad or the end gets dirty. If you can shine a flashlight through it, it's probably ok.

(From: Ralph Wade Phillips (ralphp@prysm.net).)

About 50% dead laser and 50% bad DC controllers (photoreceptor dies, or interface chip it drives is dead ... gives SAME error!)

Without a spare printer for parts, it'll cost you about a new printer for parts ... sigh.

(From: John Fiskio-Lasseter (johnl@yin.earlham.edu).)

Not necessarily. There are a number of places where you can simply buy the parts themselves, often refurbed - even a DC controller and laser assembly together would be cheaper than getting another printer.

Adam, at a guess, I'd say that you really are looking at a failed laser/scanner assembly. Of the possible causes, that's the part that gets the most wear and tear, and the most likely to fail under normal operating conditions.

A few places to try for parts:

- Hewlett-Packard: Part # ID: 1-916-783-0804, Sales: (800) 227-8164.
- The Printer Works: 1-800-235-6116. (These people have the coolest catalog in the business!)
- Laser Impact: 1-800-777-4323.

Both PW and LI will do repair, parts sales, and exchange parts sales, and you may find them a good bit cheaper than Hewlett-Packard.

Also note that the engine parts from all other HP LaserJet II's and III's are interchangeable with yours. So are the engine parts (except the DC controller) from the Apple LaserWriter II printers. Other printers based on the same Canon SX engine are: QMS 410, Brother HL-8e, and several others that I can't remember off the top of my head.

(From: Steve Pepin (steve.pepin@mogur.com).)

You may not need to dump the printer or even pay for a new scanner assembly. I had exactly the same problem with mine and it turned out to be only the cable that attaches the scanner assembly to the main PCB. It's only a $28 part and you can possibly simply repair the one you have. I don't know how mine failed, but that is what our local HP service center replaced.

(From: Frank Reid (reid@indiana.edu).)

Correct! I repair at least 100 of those things per year. The connections fail far more often than the $canner. The problem can usually be solved by removing and re-seating the connectors on both ends of the cables that connect the scanner and laser to the 'dc controller' board (smaller board under bottom cover).

(From: TAltmeyer (taltmeyer@aol.com).)

Sometimes the driver-IC for the mirror motor is defect. It's a circuit from Hitachi HA1XXXX, i can't remember the number exactly. A half year ago i had such a printer with error 52 and i replaced the chip and all was fine.

The chip is a little bit difficult to get but if your're encouraged enough you can get it (after a lot of telephone talking) from your local hitachi distributor. It's much cheaper than a complete unit :).). The scannerunit itself was made by Canon (as the complete printerdrive is made by Canon)

HPLaser Jet IIIsi - 'User Maintenance' message?

> "What cause a working HPIIIsi coming up with 'User Maintenance' message in the lcd window. If you pop up the cover and reclose, the message goes away and printer keeps on printing fine."

(From: Jim Hunt (jhuntjr@b-c-i.com).)

I believe this is the message you get after printing 200,000 (I might be wrong) copies which is a reminder to replace the fuser unit. This comes in a kit with new pickup rollers and several other pieces. It is pretty easy to replace

HP LaserJet 4 - intermittent error code 50

(From: Brian Mathews (icontech@volcano.net).)

I have seen this problem quite a few times and I check the fuser lamp to find it was manufactured by USHIO. After replacement with a Toshiba lamp (not an endorsement, just what the supplier sends) the problem is gone. I haven't ever had this problem and not found that brand of heat lamp in the fuser......

HP LaserJet 5L grabbing more than one sheet of paper

(From: Shaun Harwood (shaun.harwood@virgin.net).)

I'm a field engineer and deal with quite a lot of printers. What is quite a common cause for this problem is damp paper or using the printer in a damp room. Try a brand new ream (direct from store) and try using in a warm room and see if the problem goes away. I've been having this problem a lot lately as the weather has turned a bit - most of my customers store the paper in store rooms and it gets a bit damp. Incidentally HP printers in particular seem to be suffering from this quite a bit. >

HP LaserJet 5 SIMM codes

(From: David B. Gustavson (dbg@SCIzzL.com).)

Here are the empirically determined SIMM codes for the HP LJ5: (o for open circuit, g for grounded jumper)

```
 Pin 70 69 68 67
------------------------------------------
```

```
o  o  o  o  treated as an empty slot
o  o  o  g  53.00.02 error
o  o  g  o  53.00.02 error
o  o  g  g  53.00.02 error
o  g  o  o  53.14.03 error
o  g  o  g  16 Meg RAM
o  g  g  o  2 Meg RAM (=LJ5 70ns)
o  g  g  g  4 Meg RAM
g  o  o  o  53.14.03 error
g  o  o  g  16 Meg RAM
g  o  g  o  53.14.03 error
g  o  g  g  4 Meg RAM (=LJ4 80ns)
g  g  o  o  53.14.03 error
g  g  o  g  16 Meg RAM
g  g  g  o  53.14.03 error
g  g  g  g  4 Meg RAM
```

Since there are several codes that have the same RAM size, it's possible that they correspond to different RAM speeds or other differences that might matter. I connected my $129 16MB 70ns 32-bit-wide 72 pin SIMM in the g o o g pattern, and so far it seems to work OK.

If anyone has more info, such as speed or other characteristics that ought to match the ambiguous codes, I'd be very interested. Some of these codes correspond to the RAM/ROM PostScript SIMM, but those seem to be driven from a logic array and might have more complex behavior. In particular, no static code was interpreted as such a PS SIMM, but that might be because it already found one in another slot.

With a duplexer, the LJ5M barely functioned with the original 6MB RAM, had to run it at 300 dpi or it would just not bother to duplex. Borrowing 4M from my old LJ4M raised it to 10M, which raised the performance ENORMOUSLY. 16M raises it to 22M, which is surely major overkill, but for $129+tax at Fry's, why go for less.

So far the software on my Mac is refusing to control the duplexing features, e.g. the "which edge is the binding edge" choices are always disabled, but turning it on at the printer works (unselectively). But maybe this is due to some beta printing environment stuff I'm using.

HP LaserJet random behavior - no ground

Aside from surge supressors not being effective (to the extent that they ever are) without a proper safety/earth ground, here is another example of possible symptoms:

(From: Leif Gastgivar (lgastgiv@technis.syh.fi).)

I bought a new HP Laserjet 5L printer and I just plugged the printer into the socket. After a time the printer started to print out pages by its own. I checked out the manual but I couldn't find out the problem. But after a wile I find out, that the printer wasn't connected to the ground. After I fixed the problem, it will have been working properly.

Determining if HP LaserJet partial print problems are scanning or logic

This would apply if, for example, an HP-LJ3 prints only left side of the page.

If the boundary is sharp and constant, logic is likely but not always.

If the boundary is fuzzy and/or ragged, blockage in the optical path is more likely - a label or Post-It(tm) note that escaped, or even a wad of dust or other debris.

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

Does the printer have an 'Engine Test' switch (a button on the DC controller PCB on the LaserJet 2, and one on the side of the LaserJet 1)?

This will cause it to print a test page (of vertical lines normally) even if the formatter board (the thing that translates the incoming data into a bit stream to send to the laser) is defective.

If you can find such a button (it's hidden on the side of the lower cover on the Laserjet 2), press it and see what happens. If you only get half a page, then the fault is almost certainly optical (Check for defective mirrors, etc as mentioned earlier in this thread). If you get an entire page of lines, then the fault is in the formatter board. I have no info at all on any formatters other than the Apple Laserwriter 2NT one, alas

(From: Ralph Wade Phillips (ralphp@gcstation.net).)

On one side of the bottom, there's a cover that can be removed after removing one screw. After that, the button is visible through a hole.

Only push this AFTER it warms up all the way - it's ignored until the engine is ready!

LaserJet IIID and others: paper not picked up correctly

> "The printer will print perfectly on both sides if the paper is fed into the sheet feeder. If the paper is fed from either of the paper cassettes, the paper not picked up from the cassette. There is a mark on the paper where it appears the roller has been rubbing on the paper."

(From: Al Savage (asavage@iname.com).)

Piece of cake. Replace the pickup rollers. You can clean them, but it won't last.

Now, the bad news: it's not real easy. Or, like most things, it's really easy once you've done it a couple of dozen times.

The rollers themselves are about $5 these days, and have been redesigned to eliminate one problem they used to have: you can't put them on backwards anymore!

LaserJet IIID: remove all exterior plastic: three screws up top accessed after opening the lid. One screw horizontally near AC power cord receptacle. Release nasty catch of top lid from side plastic at just above AC receptacle. Try hard not to break top lid while doing this. :)

Now you can access two screws retaining front edge of side panels to front panel. Remove two vertical screws holding left side panel to rear of printer chassis, near fuser.

Unhook front panel operator panel cable, remove front panel assy.

Remove six small screws retaining front chassis subframe to (scanner, HVPS, DC PS), plus about five larger screws holding power envelope feeder subframe to front.

Remove DCPS on right front of chassis: remove three vertical large screws (two in front, one at right rear). Disconnect main motor harness from DCPS. Disconnect gray fibre optic cable from black clip at left front edge of DCPS, or it will be damaged, and you'll add another large batch of screws to remove/replace! Then remove DCPS by grasping firmly and pulling straight up. This takes considerable force, as there are connectors at the bottom that you are separating.

I recommend removing the registration assy prior to removing the paper pickup assy, but it can be done without. To remove the registration assembly, remove four vertical screws (three black, one chrome, most likely on III series) from reg assy, which is the part with the green "handle" just inside the paper path, as you look straight down into the printer. The left rear (shiny) screw will likely have a short ground wire under it on a III. With the DCPS out, the reg assy will just lift straight out. Note carefully the bronze ground lug at the left front of the reg. assy. It must be rotated forward at reassembly or the forward black roller (small diameter, 9" long) on the reg assy won't be grounded, and you'll get all kinds of odd print quality problems. Look at it now, BEFORE removing the reg assy, to see how it's supposed to look.

Using long #2 Phillips, remove two small screws retaining the pickup assy (the shaft with the grey PU roller on it, plus the black or white spring clutch on the right end of the shaft) black plastic bearing blocks. Lift up PU assy, slide 2" to right (the reason you had to remove the DCPS), then swing left end rearward to where the reg assy used to be, and remove.

To replace the PU roll: remove E clip on left end of shaft, slide off all the washers, spacers, etc, noting the order carefully. Roll just falls off!

On reassembly, don't forget to reconnect the main motor's wire harness to the DSPS. One of my common problems.

If you're going to do the lower PU roll, do it now, prior to reassembling the top half. Remove the lower side plastic panels -- one horizontal screw in back for each side.

After removing the sides, remove the E clip on the left side of the lower pickup assy, then remove the bronze shaft bushing. Don't lose it.

On the right side, remove the three small horizontal screws on the clutch plate, disconnect the clutch's harness from the chassis harness and harness hold-down clip, then rotate the clutch plate and slide the lower PU assy out the right side.

Replacing the PU roll is identical to doing the top one at this point.

Now you know why I charge 1.5 hours to do top & bottom rolls. Plus, I pull the lower pan and vacuum it out, Fedron the reg assy, and replace upper/lower fans if needed.

The IIID is the best laser printer HP ever made, barring the Si series. Well worth the effort and expense, even if you have to replace the fuser too. I like them a lot.

Done right, a proper PM of a IID or IIID involves removing the upper unit from the lower to properly clean the skewed feed roller, but that's another 30 minutes, plus cleaning the refeed assy. You can "kinda" clean that lower feed roller (not the PU roller) if you have small hands and a long Q-tip, but it really isn't a good job.

PS: oh, yeah. I wrote this all from memory, and I haven't done one in a couple of weeks, so I just *might* have overlooked something. But the major steps are there. Keep track of the various screws, they're not all interchangeable.

Laserwriter LS

> "I have a Personal Laserwriter LS; am getting 'fuser assembly malfunction' error. Does anyone have

> experience w/this, know the likelihood that I need to replace the entire fuser assembly, or how I can find out? Also, is there a place to get a used assembly, and is it difficult to make the repair myself? Stores charge $200 parts and labor for the replacement, and this printer's not worth that investment."

(From: Frank Reid (reid@indiana.edu).)

The fuser lamp often fails in that model. The replacement is Apple part number 890-0427. I think it costs roughly $25.

Apple technical information

The following Web site provides links and a search capability for Apple computer products including Apple printers:

- AppleCare Tech Info Library.

Apple Lserwriter I/O

> "I just picked up an Apple Laserwriter II NTX which appears to be working. The problem is I need to find out what this thing has for I/O, and what the dip switch settings are. It appears to have a 50 pin centronics connector, along with a DB25, an appletalk port and one other port."

(From: Erik Johansson (erijo105@student.liu.se).)

The ports are a Phonenet Appletalk connector, a 50 pin centronics-like scsi connector (to connect a font cache hard disk), 25 pin female D-sub serial connector (wired as a DTE so the cable should be the same as when connecting to computers, not a computer and a modem) and a RS-422 8 pin miniDIN connector (also for serial communication).

The jumper settings:

```
 Switch1 Switch2           Function
---------------------------------------------------------
   Up      Up     8 pin AppleTalk (Serial Port Disabled)

  Down     Up     25 pin RS-232 and 8 pin RS-422
                  Serial Ports 1200 baud

   Up     Down    25 pin RS-232 and 8 pin RS-422 *
                  Serial Ports 9600 baud

  Down    Down    25 pin RS-232 serial port 9600 baud;**
                  pin RS-422 serial port 0 baud

 Switch3 Switch4   Function
-----------------------------------------
  Up       Up     PostScript Batch
  Down     Up     Diablo 630
  Down    Down    HP LaserJet
  Up      Down    PostScript Interactive

 Switch5 Switch6   Function
----------------------------------------
  Down    Down    No Handshake
```

```
Up      Up      ON/XOFF
Down    Up      Etx/Ack
Up      Down    DSR
```

Apple LaserWriter and LaserWriter Plus paper jams

(From: Ralph Wade Phillips" (ralphp@techie.com).)

I suggest that you cruise on over to The Printer Works and check out the blowup parts list for the LaserWriter and LaserWriter Plus mechanical (Canon CX engine - also LaserJet, LaserJet 500, LaserJet Plus, and several, SEVERAL other printers). That will make the text easier to follow. (Use the search facility for the printer model - that will include the "Parts Identification Diagrams".)

To repair the MOST common problem with consistent jams at the paper INLET, you have to strip the printer down to where you can remove the Registration Shutter Assembly. Due to how the LaserWriter I/O board is connected, you'll have to remove the I/O board (the big one with the Plus ROMS on it), and the case it's in (Note: DISCONNECT the board from the computer's wiring harness, do NOT try to remove it from the case. The case should come off also - leave it mounted there.) After that, you can see the registration shutter mounting screws, along with the wiring harness for the shutter solenoid AND for the cartridge installed/sensitivity microswitches. Remove the shutter assembly. You'll have to either dismantle it and clean the solenoid out, quite possibly having to replace the rubber bumpers, or you'll have to replace it.

I have left out the most obvious steps of removing the upper housing and several other steps - they should be obvious from the parts diagrams for the printer.

Apple LaserWriter prints double/repeated images

The characteristic is faint repeated printing a couple of inches down the page as well as from the previous page.

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

- Try a new toner cartridge. I _think_ there's a problem that will cause this.

  (The wiper blade which is inside the toner cartridge on these printers may be warped/defective --- sam).

- The preconditioning lamps are not coming on (more likely).

On a Laserwriter 2 series (the most common one IMHO):

With the top cover open, look for 2 ping contacts in a little white pillar attached to the cover on the left-hand side. When the cover it closed, it makes contact with 2 similar contacts on the PCB on the left side of the fuser. Check for continuity (but not 0 resistance) between the 2 contacts _on the cover_. If it tests O/C, remove the toner cartridge (you did that, right?), then the little metal plate (grey metal, held on by 1 screw) behind it, then undo the 2 terminal screws under this, undo 2 more screws on the large grey metal assembly, and remove it. Inside this are 5 bulbs in series, one of which has probably blown. You can get replacements from the PrinterWorks

If those bulbs are OK, then check the power transistor on the PCB on the left end of the fuser.

Apple LaserWriter IIg runaway scanner never stops

(From: Dave Lee (leedj@uwec.edu).)

A good possibility is the cable from the scanner to the DC controller. It might just need to be re-seated. Might need replacing.

Apple Laserwriter IINT error codes

> "Where can I find the meaning of the flashing error codes on a Laserwriter II NT printer? It is flashing both the paper jam and the paper out light. The fuser doesn't heat up."

(From: Ralph Wade Phillips (ralphp@gcstation.net).)

It means that the fuser isn't getting to proper heat. This might be a blown fuser, might be a bad AC Input Block, might be a bad DC controller.

Before I fought TOO hard, I would pull the fuser assembly and check the 115 VAC inputs for continuity. If you don't have any, then I'd say you most likely have an open fuser lamp, and it will need to be replaced.

If you have continuity, I'd change out the AC Input Block, and work from there.

The DC controller being dead is rare, but it *can* cause the same symptoms.

(From: Mark Wolfe (markw@wwa.com).)

Do what the other guy said, but instead of replacing the AC Power Block, check the triac at Q101 inside the ac power block. Common failure on this engine. When you do fix it, put a good heat sink on the thing.

Apple Laserwriter IINT 'clicks' with intermittent fuser error

> "I have a LaserWriter IINT with an intermittent fuser error. When the printer is switched on, sometimes it cycles normally and works fine; but sometimes, the startup cycle sound is followed by a soft click, and a few moments later the green light gives way to double blinking red. I have attached a voltmeter to the fuser lamp contacts; when the soft click is heard, no voltage reaches the fuser."

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

The click is almost certainly the fuser protection relay dropping out. This relay is located in the AC input block assembly at one end of the fuser, under the main cooling fan.

This relay is on the lower board in that module, and is driven by the protection circuit (a few transistors, not hard to trace out if needed) on the upper board. It operates if the fuser drive signal from the DC controller is active for too long at a time - it prevents the fuser from overheating if one of the CPUs on the DC controller goes crazy

OK, things to check:

1. Look for dry joints on both boards in the AC input block. They are *very* common here.

2. Check the thermistor in the fuser. Clean it, check for dry joints, check that it is pressing against the fuser roller.

3. Reseat all the connectors on the DC controller board associated with the fuser and AC input block.

4. If that doesn't cure it, you'll need to hang a scope off the fuser drive signal (one of the 4 wires from the DC controller to the AC block - the other 3 are ground, +24 V and fan speed control) and see if the fault is in the DC controller (Signal does stick high) or the AC block.

Diagnosing a blank vertical strip problem on Apple Laserwriter IINT

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

There aren't many (if any) electronics faults that can cause this, thankfully...

First press the test button on the side of the bottom casing round the back. Does the test printout also have this strip missing? If not, then you've got a very strange problem with the formatter board, and I'll have to think again...

Secondly, take out the cartridge and shake it, and put it back in. If that doesn't help, then try a new toner cartridge.

If you've still got problems, then the most likely problem is something in the beam. SX engines (which you have, and CX engines and...) print black where the drum is discharged by the laser [1]. Start by removing the toner cartridge. There's a black metal strip in the top cover above the toner cartridge. By fiddling with it you can move it slightly, exposing a front-silvered mirror. Inspect that for bits of paper, etc. Clean it _very_ carefully.

Next area to look at is the laser scanner itself. If you know what you are doing, take off the outer casing (screws round the outside, some under the lip that the lid closes onto, and 2 on a metal bracket at the left side of the fuser) and look at the scanner block. This is the black thing mounted over the paper tray. Unplug the cables (one to the laser PCB itself, one to the scanner motor under the little flap on top), undo the small screw to release the optical fiber, and undo the 4 screws that hold the scanner in place. Lift it out. Look at the slot on the front edge for any paper, etc. I don't know if I recommend you opening the scanner (Canon DO NOT, but I've done it), but you can carefully trim back the heat-moulded studs and open the cover. Look for debris inside. Handle it with great care, of course.

(From: Ken Eckert (eckert@sfu.ca).)

One problem that gives this printout is loose screws on a plate in the top cover above the toner cartridge. The screw(s) fall out and get stuck in the toner shutter window that that the laser goes through. I've had a couple like that, I made it a habit to tighten those screws whenever I work on one of these Canon engines.

Upgrading Apple LaserWriter to LaserWriter Plus

It may be possible to upgrade your Apple LaserWriter if you have a partially dead LaserWriter Plus.

(From: Ralph Wade Phillips" (ralphp@techie.com).)

There are two ways. One is to swap the eight or sixteen ROMS from the Plus into the same sockets on the LaserWriter, !AND! to swap the programming shunt assembly (a set of four jumpers in a 16 or 24 pin DIP socket), placing it in the exact SAME place. The easier way, if you have both printers, would be to remove the upper cage and swap THAT. This will mess up the page count, however, that's not such a big deal nowadays (not on a CX engine - after all, does it REALLY matter on a '88 Dodge Aries K that it's got 213K miles or 127K miles? ...)

Toner All Over Paper on Various Brother Laser Printers

(From: Robert Wilson (rfwilson@intergate.ca).)

Both my 300 dpi Brother 641 (sold as the 630 in the USA), and my friend's 600 dpi version of the same printer, had a problem where toner ended up all over the page. What a mess.

The problem was that there is a long thin spring that is rotated at one end, and propels the used toner (scraped off the drum) back to the point where toner enters from the toner container. It acts like an Archemedes' Screw, gradually transporting used toner back again for reuse. It also transports fibers of paper that have been scraped off, and therein lies the problem. Brother stupidly "closed" the end of the long spring (its last coil is bent to be in contact with the coil before). The result is that paper fibers (once they reach the end of the spring), get caught in the closed end of the spring and cannot get out.

The fibers build up until they jam the end of the spring and it can no longer rotate. The drive mechanism doesn't know this, and keeps rotating the spring until it breaks (usually right at the driven end).

The solution is to disassemble the printer drum (not all that hard, but not for the faint of heart!), remove the spring (it's about 15 inches long), and bend the end so it engages into the drive gear again. Then, eliminate the original problem by opening the last coil at the far end, so fibers can get out.

Resetting "REPL.DRUM" error on Sharp JX-9460

This will probably work for other laser printers as well though the details may vary. Use at your own risk!

(From Owen Solberg (osolberg@infinex.com).)

If your Sharp JX-9460 laser printer has decided it is time to give you the "REPL.DRUM" message on the LCD screen, but the print quality is still fine, then all you need to do is fool the page counter to think a new drum has been put in. Here's how:

1. Open the cover and remove the photo-drum.

2. Look down into the area under where the drum was. On the right hand side, you will see two circular metal contacts. You will also see two "slots" on the far right side. These slots mesh with plastic tabs on the drum cartridge.

3. At this point you will need two paper clips. Use the first one (unbent) to insert into the FORWARD-MOST slot. You don't have to push it very far. You will hear a click and the LCD panel will probably go from saying "COVER OPEN" to saying "REPL.DRUM." Keep holding the paper clip in the slot while you:

4. Touch the 2 ends of another paper clip BRIEFLY to the two circular metal contacts. (you will have to unbend the paper clip a little.) It will spark a little. Don't worry, it is only 4 volts. But I wouldn't hold it there for too long.

Anyway, the theory behind this is that the new cartridge comes with a fuse in it which is blown by the 4 volts the first time you insert the cartridge. That is what resets the counter. Better than spending $190 on a new drum, right?

TI MicroLaser Plus laser printer reports 'Main Motor Err'

> "I have a Texas Instruments Microlaser Plus laser printer which after I turn it on, reports that the self-test passed but then displays an error on the LCD: 'Main Motor Err'.

> This laser printer uses the Sharp JX9500 engine and I was able to find out how to get it into diagnostics mode. I selected "Test Print" and it returned "Service (C2) 01". The stepper motor appeared to be working correctly along with the fuser lamp."

(From: All Laser Service (laser@ix.netcom.com).)

The lubricant used on the gear train tends to gum up and the motor strains to the point that you receive a main motor error. Take the complete gear train apart and clean it. You will need to disassemble all the gears and clean both the gears and the axles. Also take a look at the developer and drum cartridges as they are driven by this gear train. If they are jammed this will also cause your problem.

Fuser problem/printer parts

(From: Robert Blackshaw (blckshaw@clark.net).)

> "I have a ti-microlaser printer that worked great until a gear in the fuser assembly cracked. This gear drives the rollers in the fuser. If anyone can tell me if there is a place to get used parts or a kit of the common parts that fail in the fuser etc. it would be a great help. Also looking for any other info on this printer such as: schematic, user manual, and part numbers for the photoconductor unit, developer unit and toner cartridges."

Try The Printer Works at http://www.printerworks.com.

I fixed an HP Laserwriter II (same engine as the NT) with exactly the same problem, a $0.49 gear on the fuser assembly. On top of it all their catalogs are like service manuals with exploded diagrams of everything.

Swapping fuser parts

> "I have a couple of Scrap Brother HL-8 Laser printers.
>
> Both have defects in the Toner Fixing unit (Fuser roller?). Which is the unit that melts the toner onto the paper.
>
> One unit has VERY BAD scratches on the Toner fix roller itself, which causes a bad streak on pages.
>
> On the other unit the heating element on the Toner fixer has blown. The big question is can I take the heater from one, and place it in the roller of the other? Anyone done this? A new roller unit will cost me 90 quid, so a couple of hours to actually do it is worthwhile, as a working laser printer will be the result."

(From: JStev55598 (jstev55598@aol.com).)

No problem if you are careful when swapping over the fuser lamp you will have a working printer which is a darn site cheaper than a re-con unit. One thing to bare in mind is what made the lamp fail in the first place. Although it has usually got to the end of it's natural life sometimes a failure in the temperature sensor or a power supply fault can cause the lamp to overheat.

When turning it on for the first time after replacing the lamp check that it switches on and off after it's initial warm up . You can sometimes see the lamp when it is on through a vent in the side of the printer by the end of the fuser roller.

Panasonic KX-P4410 CHNG DRUM error code 027

(From: David Moisan (dmoisan@shore.net).)

The drum sensor on my 5400 is an opto-interrupter that sits over an opaque flag that's connected to a bucket inside the waste-toner compartment on the drum. When the bucket is full, the flag blocks the sensor and causes the CHNG DRUM indication.

Carefully drill a hole to get the toner out and BE CAREFUL OF THE DRUM SURFACE. I killed mine doing this. What sucks is that when this happened I was getting the indication and I only had 4400 pages on it (it's a 6000 page life span, supposedly).

when you're done, power up the printer while depressing ENTER. The display should tell you "DRUM COUNTER RESET" or something like that. Another fun thing I really love about the printer is how the developer mechanism--the magnetic drum that picks up toner--is permanently mounted in the printer. Lots of fun if the scraper is removing toner in one spot and you can't clean it. :((A slip of paper *somewhat* works.) I only found this out after tearing my printer down *completely* and removing every last bit of old toner.

After 3 years, I'm *not* happy with my printer any longer. Though it's had a new drum, it has *never* worked the same since it was changed out. White streaks on the output where there's not enough toner. And smeared characters where there's *too* much toner. *sigh*

It goes against our dogma here to say this, but I am very tempted to throw my printer out the window. (And I say this as a Panasonic owner who loves his 27-inch TV.) It's not repairable, I'm tired of tearing down the printer for a fault I can't possibly fix. And I'm tired of blowing another $70 on a drum that will die before I know it. Not when I can get a new printer for about the same price, 600 DPI and at least 12,000 pages before I have to spend big bucks on a drum. Like Curly Sue, when it was good it was very very good but when it's bad....

Panasonic 4420 laser printer error code E31 and other comments

(From: Al Savage (asavage@iname.com).)

E31 is the most common reason for a 4420 to fail.

The manual says that 'fusing unit failed to reach x degrees in 90 seconds' or words to that effect. Makes you think of fuser problems, right? Bulb, thermal fuse, thermistor? Well, only about 1 out of 10 times.

The problem is solder blown off two pins in the AC power supply, located on the front left side of the printer (after removing plastic cover) as you face the front. Easy fix, if you're moderately handy.

E31 and dirty feed rollers (and paper pickup roller) are about the only things that fail on a 4420. Well, you do need to replace the developer and drum every so often, and they're pretty expensive, but they're long-lived, too. Much lower cost-per-page than any HP product.

I happen to think the 4420 was Panasonic's best-made laser printer. The 4450 is over twice as fast, at 11 pages/minute, but you can't really run laser label through it. And it's MUCH harder to service.

Copy counter fuses

> "I have a Panasonic KX-P4420 laser printer. It locked up with a message about 36K service.
>
> I issued the incantation to reset this message. It now works again, but the display is flashing 'Change DEV' and 'Change Drum'. This makes it more difficult to use the menu system. I'd like to turn them off.
>
> From the dealer's explanation, I gather that there are fuses in both the developer and the drum. When you install a new one, the machine senses the fuse, resets the counter then blows the fuse. If this is true, I should be able to bridge the fuses with another and reset the counters. Maybe even a resistor will do it. Or maybe even a reset switch somewhere?
>
> Can anyone tell me how to reset the error messages for the developer and the drum? I'm willing to disassemble the thing to do this."

(From: Jeff Roberts (jroberts@axionet.com).)

- To turn off change drum message turn machine on while depressing "<" key
- To turn off change dev message turn on machine while depressing "^" key

(From: Mark Wilson (mawilson@worldnet.att.net).)

There must be something additional to that. I tried it on my 4420 and it did not work. Can anyone shed additional light on this??

(From: Jeff Wilkinson (laser@ix.netcom.com).)

The fuse on the drum unit burns out when you first install it. This momentarily shorts the input to a counter IC and resets the counter. I would be very careful about shorting it with a piece of wire, even though the circuit is current limited it is just not a safe practice. Of course you could always replace the drum! The same is true for the developer unit. The developer and drum unit should have been replaced at both 18K and 36K pages as they have reached there useful life expectancy. E-mail me if you want more info, I believe I have the value of the fuse required here someplace.

(From: Mark Wilson (mawilson@worldnet.att.net).)

I believe there is a module with a microfuse, similar to the one on the toner cartridge. If this is so, you have to replace the microfuse (preferred) or short it with a piece of wire (not recommended). The fuse burns out after so many pages, triggering the drum message. When the drum is replaced, it has a new (intact) fuse.

Laser Printer info

> "Is there any info available on the net on how Laser Printers work, & how to fix them? I've worked on a few, & am learning the hard way, but could use all the help I can get."

(From: Robert Blackshaw (blckshaw@clark.net).)

Lotsa luck! I have an HP LaserJet 500+, an Apple Lasewriter Plus, and a Xante AcceleWriter which were DOA and which all now see active duty. The only piece of information that I have that is very useful is the HP Printer Service Manual P/N 02686-90920 that I got *after* solving the LaserWriter Plus' problems.

I went through Border's Books and other computer book shops looking for anything covering laser printer internals with no luck at all. It's your brain and logic, and luck.

One thing that will cause you grief on the older CX engine based printers are those *insulation displacement* connectors they used. Occasional no contact problems are usually solved by pressing the wires into the plug.

Strange running time meter/copy counter

> "I have disassembled (read: cannibalized for parts) an old Cannon laser printer a few months back. I found a mysterious part in it. Perhaps somebody can enlighten me as to what it was thrown in for...
>
> It looks just like a standard fuse, as found in power supplies. The usually-glass part is made of white plastic. There is a window on one side, made of a clear material(glass, plastic?) And there is a scale next to the window, 0 to 10.
>
> In the window is some substance that looks like mercury from end to end, but there is a "break" somewhere in the middle (around 3 or 4 on the scale)."

(From: Tony Duell (ard@p850ug1.demon.co.uk).).

The substance is mercury, AFAIK, and in the 'gap' there's a small amount of some electrolyte. Passing current (very low current) through the device electroplates mercury from one column to the other, thus making the gap appear to move along the tube.

It can be used in 2 ways - if a constant current is passed through it, it records the total time that the unit has been in use. That is the more normal way to use it.

However, in the CX, it's fed with a short pulse of current at the start of each page. Thus, a small amount of mercury is transferred for each page printed, and the device does, indeed, operate as a page counter.

Laser Printer prints heavy on one line about 2 inches from bottom

> "What could be causing my Brother HL8e laser printer to smear/or blur one line of text about 1-2" from the bottom of the page. At this point, 90% of the page has already fed through the printer with no problem. Can't see any botched labels or other obstructions. It doesn't always do it, but at least 50% of the time if there is text at that point on the page, there will be a heavier print on that line. I don't know if you would call it blurring, it's kind of like it's printing twice double at that point. Is it the rollers? Which rollers should I replace?"

(From: Frank Reid (reid@indiana.edu).)

If changing the toner cartridge doesn't fix it, the lower (rubber) fuser roller may be bad. Those (at least in HP printers) sometimes don't pinch the paper tightly enough during fusing, causing smears.

The fuser has a teflon-coated hollow metal roller with a heat lamp inside, and another roller which pinches the paper against the hot roller during fusing. The lower roller is made of high-temperature silicone rubber. Those sometimes go bad as described above, but if you have replaced the whole fuser assembly recently, it probably isn't the problem.

Look for any rollers between the pickup roller and the fuser, and clean them with naphtha or mineral spirits. If there is a black roller with foam-like surface, that one is electrically conductive and is part of the mechanism that places electrical charge on the paper. Clean it with alcohol and do not get fingerprints on it. Clean everything in the paper path: If there is a corona wire (instead of the conductive roller), clean it with a Q-tip dipped in alcohol.

Image tilted/skewed/crooked on old IBM laser printer

> "I have an ancient IBM Laserprinter E P/N 1039229 that has an aggravating problem: the printer prints fine except that the image is skewed on the page. There are no problems with the image itself other than the fact that it is a little crooked. I suspect that the take up wheel (D-shaped with rubber coating) is the culprit because the paper does not jam. Anyone have any experience with this? I don't want to replace the wrong part!"

Bad rubber is a very likely possibility. There are rubber restorer chemicals - don't know how well they would work. Sanding the top layer may help. Replacement would be best if you can locate parts.

Fuser Roller collects toner on laser printer

> "I have an AST TurboLaser/PS (also known as an DEC LN03, a Brother, etc, etc.). When I bought it someone had let a ring of melted toner collect on the fuser roller until it had burnt through the coating and ruined the roller. So I replaced it and ran a few thousand copies through the printer. Now I notice that the roller is beginning to collect a bit of toner again. Just how does someone clean that roller without pulling the coating off? I tried the usual wiping with a paper towel and that removed some of it but there is still a hint of it left and a few more copies begins to let it accumulate again."

(From: FAXFIXR (justdfax@cdepot.net).)

I would bet the "picker fingers" or "separation claws" are in need of replacing. They are the claw type pieces that ride on the roller and prevent paper from sticking to the roller. The end that rides on the roller will build up a coating of toner and crud and will wear a groove thru the teflon coating of the roller. Once the teflon coating is gone, toner builds up in the groove and shows up on each page as a faint line.

HP original laser printer 2686A: bargain or boat anchor?

> "This printer is (i'm told) supposed to print a test page full of assorted characters yet only prints multiple parallel lines. Also, i'm unsure of the proper hookup to Win95, parallel or serial interface. To clarify, I bought this thing used from someone who 'knew nothing about it' and the HP web site volunteers little information."

(From: Gerald Chafee (GChafee@worldnet.att.net>).)

If I remember right the original Laserjet has a "test switch" located towards the back that only tests the print engine and is supposed to only print parallel lines. I think that you can take the printer off-line from the front panel and get some sort of printout by holding down a self-test switch on the front or a combination of switches. Somewhere I have a service manual for this unit and I will try to look it up.

BTW, the LJ I's were invariably a serial port only printer which made them a pain to interface. They do give a good print for such old technology, but you only have 1 or 2 resident fonts and I believe there was no graphics capability. You had to use cartridges to get any other fonts.

(From: Mike B. (osiris@avana.net).)

It's printing correctly. If I remember, there are two ways of testing this thing. You are hitting the 'test print' button on the side. This is the parallel lines test. There is another test button on the front panel that when hit, causes the cascading alphanumeric printing sequence.

With Win95, you should be able to use the HP Laserjet driver with no problems. Since you have Model #2686A, I think the 'A' stands for parallel connection. In that case, just connect it like any other parallel printer, and make sure that you have the proper Win95 drivers.

Why doesn't the HP site help much? :-). They just want to sell you one of their new, whiz-bang models :0

This printer is a great workhorse. I believe you will still find lots of support for it from other places. There is a place called Laser Connection that supports/services these printers.

Okidata printer that's streaking

(From: Dan Fraser (dmfraser@rogers.wave.ca).)

These printers need a new drum every 4-5 toner refills. They are designed that way to fool you into buying them as the toner is cheap. Then they get you later at drum time. The drum is a consumable and does NOT last the life of the printer. Resign yourself to a new drum every 4-5 toners or so. That's the system.

(From: Chris Laudan (chris.laudan@zetnet.co.uk).)

Yup, agree with this. The cleaner unit has a fine clear plastic strip that removes old toner from a roller, in time this develops fine kinks or scratches which let old toner stay on roller, hence streaks. If this strip is OK and machine says need new cleaner unit, you *can* carefully empty cleaner unit and carry on, but you must be careful not to damage strip doing this. Best to replace unit as above,

First page smudges on OKI OL400

> "Sounds like my second hand (sorry, previously owned) OKI OL400 has a problem with the fuser roller, too. Up till now I've just printed two first page copies of everything I needed 'clean'.
>
> Please does anyone know if the fuser roller is an integral part of the OKI OL400/800 Image Drum Cartridge replacement kit? If not, any ideas on the part number, please?"

(From: Al Savage (asavage@iname.com).)

Note that an OL400 is nothing like an OL400e. Almost no parts interchange including the drum/developer assemblies.

(From: Brian Hughes (bkhughes@gisco.net).)

The problem you're both describing is caused by the "wiper blade" in the drum cartridge, not the fuser! OKI doesn't sell the part and says when you have this problem you must replace the entire image drum assembly $$$$

The cure is really quite simple: I remove the entire drum cartridge and place it on newspaper under subdued lighting (you don't want to "shock" the drum). The corona wire assembly can be recognized by the sliding blue knob on top; I release the left side with a small screwdriver tip and remove it. After removing the two screws I have just uncovered, I lift the blade free. Gently wiping the accumulated toner off the blade allows me to see the rubber better. If I see that the blade has "curl", I can then weight it down on my bench for a while to reverse the curl before I reassemble it. Sometimes all it takes is the cleaning. I have done this with my own "preowned" OL400, and now enjoy like-new printing.

The one that stumps me is where to find a fuser lamp, OKI will only sell the fuser assembly (major part!).

DISCLAIMER: Due to the possible health hazards of toner dust, I have only told you what I have done...it is your choice, and your responsibility to take precautions should you disassemble your printer.

(From: George Hurley (ghurley@voicenet.com).)

That smudge on the first page is your OL400 telling you that your image drum is getting old - they're about $240 from Staples, or $180 rebuilt. HOWEVER, the actual cause of the smudge is the failure of the toner wiper blade inside the image drum assembly. This acts like a windshield wiper and scrapes excess toner off the drum. When it hardens with age, it stops working as well as it should. This blade can be replaced at fairly low cost - I bought one for $25 and suspect that I overpaid, and it took about ten minutes to replace the old one. You'll eventually need a new drum assembly, but this repair should squeeze another 10-15,000 pages out of the drum.

I forget who I bought the blade from, but LaserImpact should have one. You can reach them at 1-888-809-4155 - if you ask for tech support, they can probably give you instructions on how to do it.

Resetting 'Replace Drum' message on OKI OL400

The following may apply if the printer produces quality output but insists on the error message. Of course, if the printouts are faded, etc., it may indeed be time for proper maintenance.

(From: Jason Kuetemann (jason.tracey@sympatico.ca).)

Press the 'RECOVER/RESET' button while turning the printer ON. This will reset the counter.

(From: Steve TR I have this model, too. Don't fall for that drum error. It only goes by a page count and the drum will continue to yield quality images for at least another 200-500 pages! Also, you can hold down the MENU 1 key to get into a service menu where you can reset the drum count and total page count for the printer.

Laser printer test equipment

At least one company offers a device specifically for testing of laser printers. This is obviously not going to be something you will want if you deal with 1 laser printer every few months. However, where dozens of printers a week are involved, check out: http://www.LaserWizard.com/.

Frank's repair notes: HP-IIP, HP-IIIP, Apple Personal Laser Writer

(From: Frank Reid (reid@indiana.edu).)

All of these use the same Canon print-engine.

- Paper jam: Paper is crunched accordion-style near the toner cartridge, does not reach output rollers:

  The toner-cartridge drum is not rotating due to a failed "drum-drive assembly." You can mark the periphery of the light-sensitive drum to confirm that it is not rotating.

  Remove the top and right covers of the printer. The drum-drive assembly is a white plastic gear/clutch attached to the gear that drives the toner cartridge. Inspect for cracks, replace if necessary. OEM part # RG1-1777- 100, Apple Part # 890-0609. You must partially dismount the entire gear assembly to replace the drum-drive assembly, however, sometimes the new clutch can be slipped onto the old shaft (which does not wear out): Not all shafts are identical.

- Paper jams or gets wrinkled as it exits the top of the machine; works OK if the selector is set for front delivery:

  The upper output-rollers deteriorate (perhaps due to ozone) and become mushy: Replace the roller (Apple "face-down delivery assy." part # 971- 0043 does not fit HP machines, but you can remove the roller and replace that only.)

- Paper jam: Paper does not progress past pickup rollers:

  Inspect the pickup-rollers. If the gray rubber is smooth and shiny on the tips of the cams, replace the rollers. Replace obviously-worn rollers as part of preventive maintenance during other repairs.

- Paper jam: Paper will not feed from front of machine:

  When paper feeding begins, a mechanism lifts the paper stack so that the pickup rollers can grab the top sheet. Inspect the lifting mechanism: Sometimes parts at the sides become bent, preventing it from working.

- 50 Service:

  The fuser lamp often burns out because the seals fail and let air into the lamp (resulting in opaque purple/yellow deposits inside the quartz tube). Replacement is easy, requiring minimal disassembly of the fuser. Rarely, the lamp-control circuit in the power supply fails.

- 51 Service:

  The laser-scanner motor commonly fails. Replacement is simple but getting at the scanner requires removing several layers of sheet-metal and circuit boards, the black plastic cover of the scanner housing, and the plastic lens: That may take an hour on your first attempt, 15 minutes with experience. Typically, the IC which drives the scanner motor overheats and visibly discolors the circuit board. HP-IIP, -IIIP and APLW all use the same scanner.

  Normally, you can hear the scanner motor running; it whines like a tiny jet-engine starting, a few seconds before the machine begins to feed paper.

- "Door open" or "No EP" indication, although door is closed and toner cartridge is installed:

  Inspect photoelectric sensors, clean with compressed air. If problem persists, re-seat the appropriate connectors on the dc controller board, or replace the entire sensor harness. Failure of the circuit board that holds the contrast control can also cause this indication.

- Groaning sound while feeding paper:

  Replace the separation pad (~1x5cm bar with cork-like surface). No tools required.

- Prints are mostly black, characters barely visible:

The high-voltage terminal on the toner cartridge is making bad contact. Placing washers under the two mounting-points of the (white plastic) high- voltage insulator on the cartridge will often extend the terminal enough for good contact.

- Printer equipped with optional bottom paper-tray delivers one page followed by a blank page, then halts unless door is opened and closed. Possible "41 Service" message (misleading! - means laser-scanner error):

  The detachable paper-feeder contains two solenoids. Under the armature of each is a rectangular black foam pad. If the pads become sticky (as in the HP-II), the paper-feed timing is disturbed. Remove the solenoids, replace the pads. I use double-sided foam tape, then use naphtha to thoroughly remove any glue from the upper surface.

  I never encountered this problem until November 1995, then saw several cases in rapid succession: The entire lot of HPIIP-type printers may be reaching an age where this failure is common, so I now inspect the solenoids for stickiness as part of the preventive maintenance of any printer I repair.

  Also inspect for broken solder connections on the pins which connect the paper to the printer.

- Paper stops just prior toner cartridge:

  (From: Edward Klotz (eklotz@www.flash.net).)

  The worn D-roller assembly can be replaced in about 15 minutes. May as well replace the separation pad also (5 more minutes, fixed at least 6 with new D-roller assemblys from LASER impact out of Texas - about $28 last time I purchased). Also ozone filters are available, very inexpensive (may save a repair down the road).

Tony's entry into laser printer repair

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

You may be interested to know how I got into laser printer repair. It's a long story, but here goes...

I was given a non-working Canon LBP8A1. I pulled the case and started fiddling about and discovered a PAL on the formatter board with a stuck output. The cure was obvious -- replace the PAL.

Alas Canon didn't like that solution. No parts were available, and no manuals. At about this time I discovered that the original printer for a computer that I happen to love - the PERQ - was a CX-VDO -- the same printer without the formatter. And I managed to obtain the PERQ interface board, admittedly non-working.

So I totally dismantled the printer in the hope that I could figure it all out. I had a pile of screws, gears, lenses, mirrors, bearings, etc. And PCBs covered in unidentifiable chips.

A lot of work with data books (and questions to newsgroups) identified most of the chips. A lot of hacking about got me enough of the pinout of the CX DC controller connector to guess roughly what was going on.

Then I had some luck. The guy who'd given me the PERQ card remembered that the CX-VDO had a ribbon cable from that connector to the outside world. And Bob Davis, who had obtained all sorts of stuff when PERQ Systems folded, dismantled his personal machine and ohmed out cables, etc.

Slowly it all went back together. I figured out how to align the scanner unit using the IR detector I use for testing remote controls. I figured out how to test (and repair - there was a defective chip and a shorted capacitor) the main PSU. And I worked out how the status LEDs were connected.

I made up what I thought were the right cables, put it all together and fired it up. The test page was fine. I was getting there. Put the PERQ card together, plugged it all it. It sort-of worked. The page was black apart from a 16 pixel strip at the left. But Bob had been helpful and had sent me info on the operation of this card. I was my fault. I'd missed out a jumper which connected a clock to the data FIFO. After that it worked fine.

I now believe that these printers *can* be repaired at home, no matter what Canon say. And if Canon won't help people, then somebody else should...

Repairing plastic paper feed strip in Canon PC10, etc. or CX laserprinters

(From: Curtiss Priest (BMSLIB@MIT.EDU).)

Serach at: Google Groups for the subject heading: "Repairing plastic paper feed strip in Canon PC10, etc. or CX laserprinters".

- Back to Printer/Copier/Fax Repair FAQ Table of Contents.

Photocopiers

Note: also see the chapter on Laser Printers as the operation and problems of the two types of equipment are very similar.

Warnings about vacuuming copier toner

> "I know there are special vacuum cleaners for use in picking up toner in laser printers. What is the problem with using a cheap ordinary vacuum cleaner? Is there a fire hazard? Thanks for any comments."

(From: (jollyrgr@mc.net).

If you vacuum toner with an ordinary vacuum, a static charge from the toner will build up in the vacuum and shock you. Toner works by static charge. Moving it, as in vacuuming, causes it to give up its charge to the vacuum. Without having a complete ground throughout the entire vacuum can cause charge to build up to quite a high potential. Be safe, use a toner vacuum.

Now if the paper does not get fused, the toner can be rubbed off. This toner, and any spilled toner still retains some charge. As it is moved though an ordinary vacuum, charge is transfered to the various parts of the vacuum. (Much in the same way charge is transfered to a person walking across a carpet in dry weather). When the charge builds up, it has to find a way to ground. In the case of the person walking across the room, the charge is discharged when they touch a metal object such as a light switch cover or door knob. In the case of the vacuum, its the vacuum that builds up the charge. When the person using the vacuum touches the charged portion, the charge is transfered to them (ZAP!!). If the person is holding the part of the vacuum that is getting charged, they get charged as well. Only now they get zapped when they touch something else. A friend of mine worked in a print shop at one time. He spilled a bottle of toner. Instead of getting the toner vacuum used on the copy machines, he used an ordinary shop vac. The metal pipe was attached to a rubber hose. As he vacuumed the toner it was he that got charged. It was when he touched the grounded portion of the vacuum as he was turning it of that he got shocked.

Toner vacuums have all their parts grounded (pipe, hose, canister, motor ect.). These parts are all connected by wires to the ground terminal on the power cord, shunting any built up charge immediately to ground. So it is not the conduction of the toner to the electrical ac line but from the charge the toner itself has.

(From: jlager@tir.com).

I don't know about any fire hazard, but I DO know what that stuff will do to an ordinary vacuum cleaner from lessons well learned! Toner/Developer is the finest stuff you may ever see, and will instantly clog all the pores of a regular vacuum bag. You'll go broke just buying bags. And... don't wash any of your clothes/rags with hot water that it has penetrated because it will make the stuff solidify. All my advice is based on repairing copiers over the years.

(From: Ed Wright (motogump@cris.com).)

The point here is that vacuuming toner, which is carbon black and latex, will create a static charge. Using a vacuum that is not intended for this purpose can cause the following. You can blow sensitive components on circuit boards, expecially bias boards on the developer units of the larger copiers and the transfer belt power packs of the smaller machines. Another worrisome possibility is an explosion. I have seen two old toner capable vacuums ignite the toner dust as it went through the vacuum. I admit this is a very rare phenomenon but I would think it would be even more likely in a vacuum not designed for sucking up toner. I would suggest reading on the side of your toner bottle. Most bottles caution about disposing of toner by incineration, the stuff is explosive if the air/fuel mixture is right. It probably wouldn't do much harm but I bet it would play hell with your office.

(From: Le Baron O. Ferguson" (ferguson@math.ucr.edu).)

Thanks for the response. I think I should state for everyone reading that I am now convinced that there IS a serious fire hazard. One person who responded (by email) has seen two of them "light up."

Comments on copy problems

(From: Copenhagen Cowboy (cowboy@fastlane.net).)

Copy problems can be hard to figure out, but given the evidence the copier gives you, you can now probably determine what to check.

Black or dark lines are mostly caused by dirty optics (not enought light getting to the Drum) Blank copies might be a broken corona wire, or even failed High Voltage board. Black copies can mean a bad exposure lamp (broken or burnt out) or failed exposure lamp thermal fuse. Black copies with even blacker images in them could be overtoned (too much toner in the developer unit) or bad drum ground (the drum cannot discharge {the voltages have nowhere to go, so they just stay on the drum). Bad drum grounds usually pull developer, and you get the grit on the copies.

General image quality problems - Clean the optics first!!

The office here has a Xerox 5310 (Rebadged-Sharp) and it's been getting progressively worse with respect to overall image quality. A new drum ($140) has helped but things go down the crapper too fast for comfort. (~90 thousand copies, 4th drum now.)

So, I cleaned the optics. That was it! 2 mirrors were CLOUDED with white dust. Geeeee, do ya think that could do it? ;-)

Light-path in each is going to differ but I'll give you this one as an example. The 5310 can enlarge and reduce and the table does NOT move, i.e., more hoopla under the glass :-)

```
 ddddddddddddddddddddddddddddddd                         LEV 1
 ======================================== glass          LEV 2
    [1    ]                      \2                      LEV 3
   A[  \  :                        \                     ..
    [     ]                          \B                  ..
                                     /                   ..
       4/          ()L             /3                    ..
    C /            ()            /                       ..
-----|  |--------------------------------------          LEV 4
     5\                          \6                      LEV 5
        \                          \D                    ..
                      [P]   .--.                         ..
                          /      \                       ..
                         |  DRUM |                       ..
```

Legend:

dddd - represents the paper document you are copying
A - Moving assembly that holds the exposure lamp and (1) first mirror.

B - Moving assembly containing 2 mirrors: (2) second mirror and (3) third mirror.

L - Movable assembly containing enlarge/reduce lens.

C - Movable assembly (covered by black sheet-metal cover that also covers the top of the Lens) containing (4) fourth and (5) fifth mirrors.

D - Fixed (6) sixth mirror that directs light onto the drum.
P - Erase lamp assembly.

Layers:

LEV 1 - External to the copier, look for whiteout and layers of smudges.

LEV 2 - Glass pane (see LEV 1)

LEV 3 - Scanning layer, exhaust fan to keep dust from settling... Does that for about 2 minutes and then starts accumulation of very fine dust on all mirrors. :-)

- Some assemblies are covered to 1) keep the stray light and 2) reduce dust accumulation - do NOT skip them in cleaning. *Especially* Assy C!

LEV 4 - Structural sheet-metal separates Scanner from drum/toner assembly below.

LEV 5 - Toner and Paper transport layer

See the document: Notes on the Troubleshooting and Repair of CD Players and CDROM Drives for appropriate chemicals and materials for cleaning mirrors (and lenses) In a pinch, a bit of my [clean] 100% cotton T-shirt works well - followed by a good blow with duster can and soft, [fake] camel-hair brush. The object is to have a mirror as clean as the minute it was made.

Apply a half dozen drops of non-detergent light oil onto the felt 'washers' on any movable assemblies' rods, if present. Might want to dampen a piece of cloth with oil and wipe the rods. This helps to prevent drips, etc.

I would remove the glass (LEV 2) completely from the machine and give it a good scrub from BOTH sides with the usual chemicals (ammonia-content is superior, IMO) for 2 reasons: 1) to keep ALL overspray from rest of machine and 2) to do a really GOOD job... not half-assed worried about overspray :-)

Don't skimp on corona wires... many machines include a plastic/felt wiper than prevents injury to the wires, USE IT. I keep a supply of scavenged wires for times when it goes 'TwhanNNnnnG' for the last time... :-|

Density control - some machines, the 5310 included, have a density adjustment under the front cover. This is in addition to the DARK-NORM-LIGHT control on the front panel. I find that after this cleaning, it can be turned back to somewhere near the middle. This cleaning is often needed if even *that* adjustment doesn't compensate for crappy copy :-)

After this cleaning, the copy will *overall* have whiter (read: less toner wasted) background... this will improve contrast and lead to greater toner cart life. We get them recharged, BTW, for ~$49 or so... New it's $120 from Office Depot. ARGHHHHHHHHHHHHHHHH....

Diagnosing 'blank copy' problems

> "I have just cleaned a Sharp SF 755 which was quite dirty but now will not copy at all! No error codes paper hot on exit, all seems well but the paper is blank."

(From: Bruce L. Miles (henry31@prodigy.net).)

Two things to try:

1. Peek inside and see if you can detect a latent image on the drum. If an image of your test document exists on the drum, then the main corona unit is working at least.

2. Perform a 'Skyshot Test'. Leave the cover off the glass and take a picture of, well, the sky. It is a good idea to cover the leading edge (left side) of the copy glass with a piece of paper so that the fuser doesn't try so hard to jam on a solid sheet of heavily tonered (blackened) paper.

If the skyshot print comes out white (it should be entirely black since the amount of light hitting the drum compared to reflection from actual copy is nil), and you DID have a latent image on the drum, the prime suspect would be the transfer corona - it is not receiving the high negative voltage needed to pull the positively charged toner off the drum and onto the paper. The culprit could be the corona wire being broken, the corona assembly not making a good connection into its high voltage socket, or even some weirdness going on with the high voltage power supply - i.e., supplying proper voltage to the main corona, but nothing to the transfer corona.

Copies too dark 1

> "I have an old Savin model 7010 copier that works just fine except it prints to dark. I have to keep the

> "lighter darker' control to max "lighter". I have replaced the (expensive) OPC cartridge and cleand all the wires and mirrors etc. It works best right before it runs out of toner, of which it uses up to fast. Any info will be appreciated!"

(From: Thierry Thdereck (thdereck@aol.com).)

There also other reason a copier is darker than it should:

- The lamp is old and has not enough light on the drum,
- You may also have wrong voltages (currents) which polarize the drum,
- The voltage on the toner developer may be incorrect ...

So you may have lot of work if you don't know the right setups before having good copies.

Copies too dark 2

> "Canon NP-2015s ... prints very dark, with "water stained" appearance. All controls full light gives a 'readable' copy with a dark grey background. I have been told everything from 'wrong toner' to moisture in the toner. The guy who brought it to me doesn't know. Before I vacuum out the toner & stick a $25 cartridge in it, could this be a bias problem?"

(From: Bernard Morey (bmorey@aardvark.apana.org.au).)

Have you tried cleaning the corona wires? There are generally two modules. Pull out and clean with cotton-swabs (Q-tips).

(From: Lionel Wagner (ck508@FreeNet.Carleton.CA).)

If your dark grey background is not uniform, you will have to vacuum out ALL the old toner, and thoroughly clean the roller that transfers it to the drum. Do not use abrasives, as the surface of the roller is very critical. If this restores even grey background, you can think of adjusting the bias voltage.

Copies too light

Aside from a misadjusted 'darkness' control, improper voltages, dirty corona wires, and worn drum, don't overlook the trivial: your paper may be incorrect or damp.

(From: Morton Lee Cohen ya484@@vtn1.victoria.tc.ca).)

I am a former copier tech. that worked on Konica copiers. To get good results from your copier, a periodical maintenance should be perform on the copier, every so many copies or once a year, depending on which event occurs first.

During a PM, the optics, corona wires, drum gets cleaned. The Fixing unit gets cleaned, and serviced. The Developer gets replaced. And adjustments are performed, if needed only.

The developer transports the toner to the charged area of the drum and developer gets weak over time. Developer is made up of iron filings.

Previous copy doesn't erase from drum

> "I recently purchased a Mita DC-111 copy machine, and I finally it to make copies, now I have on big problem. When I do more than one copy, the drum doesn't fully erase itself, thus leaving ghosted images on the remaining copies that are made. I don't know much about copiers, and I really just lucked into getting it to actually make copies. Any help would be appreciated.

(From: Jeff Roberts (jroberts@axionet.com).)

Make sure it is the drum that is not cleaning by measuring the distance between the origional image and the ghost image on the page. that distance will be the circumference of the drum if that is the cause. The drum assembly should come out as a unit. Take it out and make shure to quickly remove the drum from the unit and put it in a dark place so that it doesn't become light shocked. then look for a blade of some sort, it may be neoprene or rubber. it is usually on a actuater assembly that can push it out to make contact with the drum and then retract it back (possibly a solenoid/cam) this blade does the cleaning by scraping the excess off the drum. If it is hard or brittle it will have to be replaced but cleaning it with a 70% solution of rubbing alcohol may be enough. After cleaning it rub some toner along the edge to re-lubricate it and reassemble and try that. Also check that the drum unit is not clogged up, the waste toner goes somewhere and if it uses a sump and the sump is full then it will ghost no matter how clean the blade is.

(From: Vance Harlow (musk@aol.com).)

On copy machines and laser printers with long life drums (ones where toner can be refilled without replacing the whole drum assembly) the wiper blade will usually fail long before the drum does on machines that are not used frequently or used to print one or two copies at at time. If the service department is not aware of the problem, or the manufacturer doesn't supply the blade as a separate part, you'll usually end up getting stuck for a whole new drum assembly when all that's needed is a wiper blade (this is the rubber or plastic blade that bears on the image drum, not the felt wand, BTW).

Usually the clue will be that the first few copies are bad, but then quality improves. If that's what's happening, usually replacing just the wiper blade will cure it.

Since the blade costs only $10 or so, it can be worth giving it a try before replacing the drum assembly. This has worked on both my Canon 1010 copier and various OKI and GCC laser printers.

Finding the blade can take some doing - when I called the local Canon distributor, they couldn't give find a part number, even though I'd bought a couple years earlier and knew it existed as a replacement part. Luckily, one the the service techs was able to dig up the number. OK doesn't list them at all - they only sell the the whole assembly. But you can get the blades for most laser printers, and some copiers, from American Ribbon and Toner or Computer Friends. Since the drum assembly on the old Okis like the 400 and 800 series, and the GCC/Mac versions lists for $250 or so, one frequently runs into them with bad drums for $0-25. I've revived a half dozen of them simply by replacing the blade - knowing this trick is like having a free source of laser printers! the OKI blade pops right in with only minor disassembly; the Canon is a bit more trouble.

Computer Friends also has a teflon wax for reconditioning drums - they claim it will protect the coating, fill in small scratches and treble the life of a throw away drum, and vastly prolong the life of long life drums. I've tried it so far only on an old 1010 drum, with mixed results so far (worked great at first, but now copies are getting dirty - don't know if it's the wax acting up, the drum going despite the wax, or other problems. They also sell the Oki drums for about $40, and drums for many other printers but not copiers.

Copy quality degrades with use

(From: Lionel Wagner (ck508@FreeNet.Carleton.CA).)

If you are lucky, cleaning the optical path: mirror and lens will help. Cleaning the corona wires is a routine necessity. Use two Q-tips, one on top, the other on the bottom, of the fine wires and travel the length. Soak the Q-tips in lighter fluid, my favorite all-purpose cleaner.

Probably the photo-sensitive drum has aged. A sure sign of this is a difference in density between the first and last copy of a long (50 copy) print run. This is particularly noticeable after the copier has not been used for some time.

(From: BRADS TV (bradstv@aol.com).)

I have found that dirty mirrors and optics will cause smudging, dark copies and generally poor quality copies. Try cleaning these mirrors in the optical path. NOTE these mirrors are first surface or front silvered mirrors and they scratch easily. Also look carefully for the complete light path from the exposure lamp all the way to the drum, you will find several mirrors mounted at angles to direct the image to the drum . You are right in the fact that the drum can cause poor copies but cleaning first might be the first step. Brad

Copier error codes

Most modern copiers produce an error code of some sort when, you guessed it, they detect an error. However, there is no standardization. So, other than posting to sci.electronics.repair or checking this FAQ, how does one determine their meaning?

(From: Sid Ashen-Brenner (sashen@midusa.net).)

Affordable Photocopiers (http://www.photocopiers.com) may have a Service sheet for about $15.00 that would contain the codes for your copier. I got the one for my Mita DC 1255 from them. They also sell parts and supplies at a fairly reasonable rate.

Canon PC25 copier problems

> "The lamps goes on my Canon PC-25 but I get nothing but black copiers. I'm told the problem could be a broken corona wire. Where is the corona wire located? What does it look like? How do I determine if it's broken and how is it replaced? Thanks in advance."

(From: Lionel Wagner (ck508@FreeNet.Carleton.CA).)

I doubt the cause is a broken corona wire. If this were the case you would get white copies, instead of black. Check the bias lamps are coming on. They are a string of small lamps located 'downstream' from the transfer corona (located at the bottom of the drum).

> "I have an elderly Canon PC25 Copier, which still runs well apart from two problems.
>
> The first is an intermittent fault which makes it turn out blank paper, usually on switching on but occasionally during a run. I assume this is a faulty joint on a circuit board because opening the machine and slamming the top down usually cures it for the moment.
>
> The second is that the light/dark slider has to be at one end of its range to get satisfactory copies.
>
> Are these common faults on this model with a recognized cure? Although it is expensive to run, I seldom

> need enough copies to justify purchasing a new one."

(From: Lionel Wagner (ck508@FreeNet.Carleton.CA).)

You're right about the bad connection fixed by the vibration of closing the cover. Your exposure control is probably at darker than normal to compensate for aging of the photo-sensitive drum. Some compensation is possible by adjusting the high voltage or (I prefer) the toner wheel bias voltage. I'm assuming your corona wires are clean, of course.

The mysteries of developer

> "My owner's manual never mentions developer anywhere. This copier uses toner cartridges which mount above the dispenser and drop toner into a mechanism which distributes it to the drum. There is a white plastic bottle which catches excess toner and eventually fills up and needs replacing. They say to replace the bottle, but I just empty it, wipe it off and reinstall it. Only the toner cartridge and the bottle are mentioned in the useless owner's manual."

(Responses farom: Nate Morrison (nmorriso@plains.nodak.edu).)

Well, that's all they think you need to know. They want you to call the dealer if the copies are crappy.

The reason you should just toss the used toner bottle is the dust--it is messy and not good for your respiratory tract.

Some copiers use developer; others don't. How long it lasts before it runs out is basically in how the copier is engineered. Some gets carried away every time you make a copy. Pretty soon there isn't enough to carry toner to the drum anymore.

> "So, if my copier needs developer, how do I obtain it? Where does it go? I suspect that I purchase a bottle of these 'iron particles' and dump it into the slot where the toner drops into, but I don't want to do *anything* until I know the right thing to do."

If you need developer, you can get a kit from the local service shop. You'll pay plenty, to be sure, but not as much as if someone came out and did it for you. It might not be a bad idea to invest in a service manual - I got one for our Minolta for around $20.

> "Why is this rather simple maintenance procedure kept a secret from the owner? Is Mita trying to make money for their authorized repair outlets?"

Well, that's another of those reasons they want you to hire the serviceperson at a ludicrous rate. (the local place gets $99/hour!) You have it pegged.

Another reason is that they want to promote the idea that _their_ copier is service-free. Telling any prospective buyer that in 50,000 copies it will require professional service is NOT a selling point. :-) The copier is designed so you can change toner and paper and that's it. Anything else is always "see your authorized dealer" in the useless owner's manual.

Problems with Ricoh copier

> "Some time ago I got a big and heavy RICOH xerox copier and I have got a problem with it:
>
> The output of the device is very poor: Passages which should be black are only light grey. If the contrast is turned on to the maximum the whole sheet gets grey. The copies look as if there would be only a little bit

> of toner on the drum. In order to solve the problem I already checked the optics, the corona wires and voltages and I filled up the toner. My question now is whether it is possible that the drum is defect? What else could cause such a failure?
>
> Since the device is quite old (1988) spare parts are not easy to get, but the mechanics looks quite well so I do not want to loose the device."

(From: Copenhagen Cowboy (cowboy@fastlane.net).)

I am a Copier Repair Tech and have a few suggestions for you. First, what does a Blackout look like? What I mean is, make a copy with the lid up, and check to see how Black it is. Note to see if there is any "Grit" on the paper. Most likely if there is no Grit, and the Black area is Grey, then I would suggest changing the Developer (or you might even have a Developer Drive Problem [gears and stuff]). If there is a fine layer of Developer on the page, you probably have a Drum Grounding problem.

Toner sensors?

I took one of those apart and found something that looked like a piezo element with 3 wire connections to concentric rings. I looks to me like some sort of resonator but I have not attempted to analyze the circuit.

My wild guess would be that the frequency changes with low toner or something like that.

(From: Morton Lee Cohen (cx163@FreeNet.Carleton.CA).)

Probably the disks stir the toner for even dispersion, and break a photogate to tell the controller PCB that there is toner there. Some Cannon laser printers/photocopiers use magnetic sensing of the toner level. Most Okidatas use the photogate sensors with magnetic toner agitators.

Comments on copier cleanliness

Copiers are about the ickiest equipment to dismantle with all that black toner over everything!

(From: Morton Lee Cohen (cx163@FreeNet.Carleton.CA).)

There is toner over a lot of places in copiers, not so much due to customer problems, but due to lazy service technicians, trying to raise their average call per day ratios. Service Technicians often get calls to do Periodical maintenance on copiers late in the day and rush to leave an account at 5pm, so many overlook non-important parts of the copier to clean during a maintenance of a copier.

And as far as the toner sensor goes, lots of times toner cakes on the sensor and the copier never tells the customer that it needs toner, when the copies start getting light, that the copier starts pulling developer from the developer tray, and that it gets messy.

Not all copiers are created equal and not all service technicians are created equal, either also. Some will always be better than others. But the best policy is always to tell the truth. My telling the truth, you tell the customer where the problem exists.

Never lie, because if you lie, one always has the remember what they lied about. From the writers of Star Trek - The Next Generation. And I practice that in dealing with customers and myself.

Gray tinge on Xerox 5260 Copier

> "Earlier this year, I inherited a Xerox 5260 personal copier. It works well except all the copies have a grey tinge to them, even when the auto-exposure control is set to light. The grey background is visible over all the page, and gets noticably darker when the auto-exposure control is set to dark. Is it time to replace the copy cartridge?"

(From: Lionel Wagner (ck508@FreeNet.Carleton.CA).)

Your toner/developer wheel bias voltage may be wrong. When light strikes the photosensitive drum it does not completely discharge it. The toner/developer bias voltage must precisely match the residual charge or grey background will result.

Streaky copies

(From: Bernard Morey (bmorey@melbourne.DIALix.oz.au).)

Well, I discovered that streaky copies are caused by dirty corona wires (fixed easily, although 1 unit was held by a screw-in plate, rather than the usual pull-out method) and that dirty corona wires seems to be caused by excessive toner deposition (haven't figured that out yet).

(From: Lionel Wagner (ck508@FreeNet.Carleton.CA).)

If the streaks are white, in black areas, clean or replace the corona wires. If the streaks are narrow black and run the entire length of the page, replace the soft plastic wiper blade on the drum (and hope the drum is not scratched). Black smudges are related to the toner/developer purity. Replace both.

Toshiba parts

> "Can anyone tell me where to get old / deleted spares for Toshiba photocopier model No BD-3110, or where to get the following for the mentioned copier. TEC High Voltage Unit (HVT-T)..Model No AFT-375-A

(From: Filip M. Gieszczykiewicz (filipg@repairfaq.org).)

Greetings. Give URL: http://www.europa.com/~tait/copiers.htm a go. They have all the usual stuff (rollers, picker fingers, lamps, masters, etc) for many Copiers. My $200 order is in the mail. :-)

[dig dig]

Drat, they don't list prices for anything but toner for that one. Their number is 1-503-293-8071 but you might want to try something closer to home (than Portland, Oregon - 1/2 world away :-) because the shipping *will* kill you...

Canon PC20 cold fuser

> "I'm trying to repair a Canon PC20 copier, on which the main problem is a cold fuser.
>
> The fuser lamp has blown, but it looks as though it might have overheated before doing so : in two places the tube has expanded as though it got very hot while under compression from the spring endcaps. The

> 47R sacrificial resistor in the fuser lamp relay circuit (I think it's there to stop the control circuit holding the lamp on permanently) has also gone open circuit.
>
> What would cause the lamp to overheat ? The thermistor (which was coated in toner) appears to work : it measures about 300K at room temperature and falls a few 10K with finger heat, so it's not open circuit (though it might be incorrect). I'd like to check out the rest of the copier before buying spare lamps etc. - can anyone tell me what the thermistor should measure (hot & cold) so I can test the control circuit and fool the copier into working?"

The thermistor may be working. It sounds like a bad triac or whatever is used to actually switch power. Get a 300K pot as a sub for the thermistor during testing.

(From: Adrian Godwin (agodwin@piresearch.co.uk).)

I had a go with this : about 4K fools the control board that the roller is hot, and allows the rest of the cycle to run. However, this _doesn't_ cause the heater power to switch off - in fact, only turning the resistance almost to zero has any effect, and at this point it appears that the controller attempts to burn out the 47R resistor.

This might make sense, except that as far as I can see there's no way that the control board COULD turn off the heater power without burning this resistor : the fuser lamp is powered through a relay which is excited by the main 24 V supply via this 47R resistor. There's no way that I've seen so far that the controller can turn off the lamp other than to short out the relay (which burns the protective resistor). So I wonder if there's no control - just a monitor for the copier control board and an overtemperature safety circuit that disables the fuser lamp (and simultaneously disables themain motor control triac). This surprises me, as I have a Canon SX-based printer where the lamp power cycles (though not using a relay, as it's quiet).

(From the editor).

There must be a triac or other mechanism for cycling power to the lamp - its temperature must be tightly controlled regardless of line voltage fluctuations and ambient temperature. (--- sam)

Broken Sharp Copier

> "My Sharp copier is dead again, it's an old one. It is flashing "U1" which I think means internal lithium battery is dead, but it won't reset. Somebody emailed me the secret code once, but I have since

(From: FAXFIXR (justdfax@cdepot.net).)

The prefix is always CROP (clear, repeat, zero, pause) and the code for a U1 reset is 13 then press the copy button. So it would be C R O P 14

Resetting Sharp Z-25 copy count

This may be necessary if you run the copier past the recommended life of the drum but still get acceptable performance. You then need to trick the copier into thinking a new drum has been installed. Other copiers may require similar treatment as well.

(From: YonyMar (yonymar@aol.com).)

You need to reset the counter inside the copier. When you buy a new drum, it resets the counter, however it can only do this once. Unplug the copier and remove the drum and toner cartridge, at the back of the machine where the drum would slide in look for a small metal lever, push it in with your finger to reset the counter. The counter numbers are covered by a black plastic cover.

Sharp SF-71 copier will not reset

> "I have an old Sharp SF-781 copier which will not reset. The diagnostic code "H1" is flashing on the display and the copier will not reset to the operation condition, using the keyboard clear sequence.
>
> I have been able to reset the "H1" code before, but this time no luck."

(From: copymann@usa.net).

H-1 means an open thermal fuse on the upper fuser roller. Remove the cover on the fuser rollers and you will see a ceramic fuse located on the top plate. Check the fuse for continuity. If bad replace it with one with the same temperature rating, (or close to the same) Sometimes you can find them a radio shack. If not email me and I will send you one. If you order the fuse from sharp it is pretty expensive. If the fuse is good check the lamp in the upper fuser roller or the upper lamp triac. 99% of the time it is the fuse.

Sharp SF-7100 copier drum replacement

> "I have a Sharp SF-7100 copier. When I call about a replacement drum, people tell me it uses a Master. What is a Master? Can I install it myself. Does anyone have a service manual for this copier?"

(From: Lionel Wagner (ck508@FreeNet.Carleton.CA).)

The Master is the SURFACE of your photo-sensitive drum. In a brilliant design concept, Sharp allows you to easily replace a thin (in your case) cardboard sheet, that effectively gives you the performance of a new drum at a fraction of the cost. There is no wiper blade, residual toner is removed by polarity reversal and is re-absorbed in the developer. Cardboard Masters for your machine are in short supply. Let me know if you can find some. You may wish to upgrade to an aluminum backed Master used in model SF760, but they are much more expensive.

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General Problems

Panasonic 1124 power supply problem

The following, of course, also applies to many other printers and other electronic equipment, for that matter.

> "I have a Panasonic 1124 printer which keeps blowing the only 250V 3A fuse on board. The fuse burns as soon as the power is turned on.
>
> I unhooked the components which connect to the logic board - i.e., printhead and tractor feed.
>
> Is it possible that the problem is in the power supply? If it is, what can it be? (The bridge rectifier consists of four hefty diodes)."

(From: Bruce A Haugh (yrp456@freenet.mb.ca).)

With the power supply disconnected from the rest of the printer circuits, blows the fuse, the problem is with the power supply. I have a Raven PR-9101 (made by Panasonic) that has the exact same symptoms. Turns out that one of the secondaries on the power transformer has shorted. You'd need schematics to confirm voltages.

(From: Robert McCallum (simply@sk.sympatico.ca).)

I've fixed quite a few panasonic printers and yes 90% of the time when the machine is dead, it's one or more of the bridge diodes.

(From: Kerry Messana (messana@capital.net).)

It's fairly simple to diagnose where the problem is originating. If you unplug (if possible) the output cable from the power supply and it still blows the fuse then the power supply is at fault. As for what could be wrong, well, I am not familiar with the particular supply. If it is a linear supply a good place to start is the bridge circuit. If it is a switching supply you could also start there but there are more possibilities further on.

(From: John A. McCulloch (advp@notnow.com).)

Another very common problem with the whole Panasonic 11XX series of printers is the zener diode and pass transistor. When the diode shorts, the transistor blows, and I mean *blows*!

Cannon LBP-8 A1 Printer 40 and 22 errors

(From: GTRIST (gtrist@aol.com).)

The 40 and 22 errors normally refer to a problem with the cabling etc. Make sure that you have it cabled properly. Also, it can be a bit tricky changing from parallel to serial I/O. Make sure that it is indeed selected.

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Fax Machines and Scanners

Fax/scanner striping

> "One of my fax machines produces some black stripes in copy mode and on the documents received on another machine. Are these stripes caused by a malfunction of the optical diodes bar, some other electronic failure or by dirt?"

(From: Paul Grohe (grohe@galaxy.nsc.com).)

Probably by dirt or a paper shreds stuck in the optical path.

A common cause is Liquid Paper. Somebody makes a correction and sticks the not-yet-dry correction into the fax. Then the still-wet correction fluid makes a streak on the pickup window as it passes by. Subsequent faxes will now have streaks.

I had the same problem. It turned out that the ink from a faulty page stamp had dripped down onto the mirror.

Generally, the paper is moved and the optical path does not move. So if there is something blocking the optical path, it will show up as one continuous image, or stripe. The "blockage" can be a paper shred, ink, dust or even a loose wire.

The image is usually bounced off a long, wide mirror and then into the CCD pickup somewhere in the bottom of the machine. If anything is in this path, it will cause that problem.

Open er' up and just look around inside for dirt and loose debris. Then inspect the *ENTIRE* optical path. BUT DON"T REMOVE ANYTHING!!! You don't want to mess up any alignments.

If the fax is old, or is in heavy use, you'll probably find that it is in need of a good cleaning. Clean the mirror and blow out any dust or junk.

Also check the automatic paper cutter (if it has one) for paper shreds.

Brother Fax machine feed problems and cleaning

(From: (Al Savage) asavage@iname.com).)

I suggest you look carefully at the paper feed mechanism. Brother has a reputation with me for feeding the scanned documents poorly, resulting is overscanning the same area two or more times, which results in "stretched" text or graphics. If this seems to match your symptom, cleaning the feed rollers will probably cure this.

The downside is that a couple of the Brother fax machines that I've had to clean force you to do an unbelievable amount of teardown work to get to some of the feed rolls. Fortunately, I don't work on them anymore .

Brother IntelliFax 950M transmits black messy lines

> "I have a Brother IntelliFax 950M plain paper fax that transmits with black lines or dots. When making just a copy the prints are just as bad. The prints are tiny square dots that make up these lines. It looks like digital problems and not dust on the lens. I'm not very familiar with plain paper faxes. It looks like a scanning failure. I'm guessing at a scanner or some other circuit board. Receiving faxes are ok. Has any one had experience with the Brother Intellifax 950M? Also, Brother has a part called a NUC printed circuit board. Would this be some sort of scanner?

(From: MECHSHOT (mechshot@aol.com).)

This problem is a known fault because Brother assembled these units with what turned out to be defective scanners. They would fail after some time, typically withing 2 to 3 years. I know, we have 3 that failed and they were all built around the same time. The good news is Brother will supply the part (worth about $120) if you pay for the labor (usually around 55-85). Contact Brother Customer Service (the 800 number is in your owner's manual) and they will refer you to an authorized service center. Get a bunch (if possible) of different shops in your area, they charge different labor costs. You must supply your machine's serial number to see if it is eligible for this program.

Then customer service will make out work order, send it along with part to center of your choice.

All of the centers I spoke to were aware of this problem and were confident once fixed, the units were very good and reliable afterwards. Check local office equipment repair houses for more info too. Hope this helps.

Hewlet Packard LaserJet FAX (HP C1740A)

> "This machine is copying and sending fax with a line about 3 cm across straight down the paper. This is a thick black colour. Any ideas as to the cause? I have already checked that there is no paper jam or any block to the sensor.

(From: Robert Macy (robert.macy@engineers.com).)

I'm not familiar with the HP LaserJet FAX, but I assume the LJ scans in a page and then sends it, or copies it. Since the black stripe is unique to sending or copying a document (does not appear on incoming faxes), the problem is in the HP's acquisition system.

It can either be the illumination of the page over that small section (no light, looks black) or it can be a whole section of the linear CCD went out (the whole section is losing any charges built up, looks black) or it can be the memory where the image is shifted into (dead RAM section, looks black).

I don't know how the HP illuminates its pages. Is it a flourescent tube across the page, or a row of LED's? Knowing HP's penchant for reliability I would almost assume the engineers went after LEDs. And the section that lights up that 3cm width could have died. However, if it's illumination that died, usually the edges are "soft".

If it uses flourescent light (remember I said I'm not familiar with this scanner), then it sounds like the CCD, or memory, has gone funky on you.

If the memory where the image is stored has a section that died, then you could end up with such a stripe also. Even my ScanMan Plus by Logitech has occasionally put a black strip on the first 10% of the pixels. To solve that I have to do a full power OFF reset (not reboot, but full power OFF)

You can look for the illumination uniformity with your eyes. Just make sure there is no section that's darker by a noticeable amount (not necessarily black, but just a lot dimmer)

Put a sheet of white paper in the machine and put a scope on the output of the CCD & sync from the line reset. Make sure that the CCD is supplying active light information across its whole field of view. If not, you can go from there.

If the data coming out of the CCD looks good, then it's probably the memory holding that line. You can probably change the line storage RAM and fix it.

These are just guesses based upon how I perceive the HP LaserJet to work. Hope somebody that *knows* this unit jumps in with more specific help.

Paper sense problems with Brother Fax

> "I have a Brother 470 FAX machine that appears to have a broken micro-type switch that detects there is paper WITHIN the front feeder.
>
> Also sometime it jams paper at the rear. It looks like it cuts the paper off (the copy or document report) a little short and the roll of FAX paper pulls it back towards the roll. Thus when the roller advances the paper next time it gets jammed as it isn't in the feed slot?"

(From: "NO UTN" (utn@pi.net).)

My experience with brother fax:

There are 2 detectors at the output of my Brother Fax, do not know type but it uses a roll of thermal paper.

Detector 1 simply uses an IR LED and IR receiver to sense the paper.

Detector 2 is on the cutter, when cutting paper the motor turns by means of a worm-wheel a wheel that moves a handle that lets the cutter move. On the wheel is a detection switch, there is a ring on the wheel from which one part is taken away to be able to detect the home position. If cutting starts the wheel has to be turned in a maximum time, if not the wheel is turned back and cutting stops. The Fax gave and error message. Solution: put some oil at the motor and it works again.

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Miscellaneous Problems and Procedures

Cleaning the fuser roller

Of course, the stuff mentioned below is probably banned now.

(From: uiop@cyberramp.net).

When I worked servicing copiers for Canon, we took the roller out, the wiped it down with tri-chlor-ethane, which did a great job.

(From: Joseph Patrick (jpatrick@edge.net).)

The best way to clean a fuser is to use a very light coat of silicon oil. This is used on the heated fuser as well as the pressure roller.

The function of the fuser is to bind the ink to the paper through heat and pressure it should not accumulate any ink during normal use, it doesn't remove or collect toner normally, unless the surface is dirty or deteriorated. The teflon on the main fuser should be slightly shiny much like the surface on a Silverstone(tm) frying pan.

The item you were thinking of is the drum wiper blade which is a part of the drum assembly and is usually responsible for streaks / smudges that persist on the photo drum's surface and make permanent smudges on copies.

I learned of the silicon oil treatment from a 3M service rep. I was using alcohol in the copiers I serviced up to that time. He showed me the way to do it by wiping the fuser components with a non linty rag with a little oil on it until the rollers were completely clean then drying them with another cloth. The job naturally was done with the rollers fully dis-assembled but in his case could be done with minimum removal just so the rollers could be turned and reached without touching the drum assembly, the oil would kill it.

Streaks on laser printer output

(From: Bruce Tomlin (btomlin@crl.com).)

There is also a drum cleaner blade which cleans excess toner off of the drum between pages. On a regular copier, this would show as streaks or even a double image that only shows when you print more than one page at a time.

HP plotter communications problems

> "I'm repairing HP plotter 7550 and there are some chips that I suspect to be broken. They are related to serial communications (thats what is broken). The chips are labeled as 1820-3321 and 1820-3322. I suspected that they could be 1488 and 1489 but changing them did not fix the problem"

(From Paul Grohe (grohe@galaxy.nsc.com).)

Been there, dunnit...

The serial interface on the 7550's is...well...weird!

Without the proper cable, the interface will seem "dead" or unresponsive.

First, you need to use the *male* 25 pin connector, not the female one (which you may automatically assume).

It requires a specially wired serial cable (you can build it yourself). A standard modem cable with a F-F adapter will not work. There are a few handshake lines that need to be wired. Note that you will also need to get a *female* plug for the plotter end of your serial cable.

There are also some menu setups required.

HP has a diagram of the needed cable and menu setups on their FTP site. Get these two documents:

- ftp://ftp.hp.com/pub/plotters/support_doc/cable.txt
- ftp://ftp.hp.com/pub/plotters/support_doc/7550a.txt

Everything you need, short of RTFM, is in these files.

(These no longer exist. If anyone knows what happened to them or has the info, please send me mail via the Sci.Electronics.Repair FAQ Email Links Page. --- Sam.)

There are some other plotter docs at:

- HP Support.

The 7550 suffers from paper pickup rollers that dry/wear out and have trouble picking up the paper from the tray. If you look at the rollers, there is a flat portion. The edge of the "flat" part wears down and becomes rounded, causing it to no longer pick up paper. Try to keep the paper tray as full as possible. Overfilling the paper tray will cause it to pick up multiple sheets, and that can cause a real mess!!

Check the paper feed slot and pinch rollers for shredded paper.

Also, check and make sure the screw that holds the pen carousel together is tight. If this screw becomes loose, it will cause pen loading problems.

It's a "helluva" plotter when it works!

Okidata FAX machine - Printer Alarm 4

> "I am currently working on a Okidata fax machine Model Okifax 2100. The display reads: PRINTER ALARM 4[TEL], CONFIRM AND 'STOP'
>
> If anyone has seen this problem and would be kind enough to share the fix it would be greatly appreciated."

(From: Darrin Acreman (darrina@profax.com.au).)

In all Oki plain paper machines, 'Printer Alarm 4' is caused by the fuser section failing to reach the correct operating temperature. The most common cause is a blown thermal fuse in the fuser section.

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Unresolved Problems

Packard Bell laser printer - strange bug

(From: Jordin Kare (jtk@s1.gov).)

> "Just picked up a used Packard Bell laser printer with some problems and could use help...
>
> Print engine is not one I'm familiar with. It's an 8 ppm engine that uses separate drum and developer assemblies. The drum assembly is attached to the top section, which hinges upwards. The developer assembly is attached to the bottom section, and uses a replaceable cylindrical toner cartridge similar to that used in older Canon NP-series copiers. The whole developer assembly can also be removed.
>
> Paper tray mounts underneath unit, and paper follows an "S" shaped path through printer, stacking face-down on top. Front panel has a ~16 char. LCD display and typical button/LED set (ON LINE, Form feed, Menu, Test, Reset).
>
> (Sorry, don't have the model # to hand. Printer was built in late 1993.)
>
> Printer executes power on self test OK, warms up, and goes on line.
>
> Problem 1: Take it off line and push test, and the motor whirs briefly, then stops. The LCD display then reads: 'ERROR 74-M: MOTOR'. Reset has no effect; printer must be power cycled to get it to restart.
>
> Interesting variation: The top section is held down by two large catches at the right and left sides of the printer. The 'hooks' are released by a button on the top section. It's possible to get only the right-side hook to catch, leaving the left side 'loose' and raised by about 1/4 inch. In this condition, the printer will start up and work fine (except for problem 2 below) for many pages. Eventually, it will stop with ERROR 74-M

again. Pushing down the left side will cause an immediate ERROR 74-M.

I assume there's something binding or sticking a bit in the various rollers, such that the motor draws too much current or otherwise triggers an error when the top is latched down. Releasing the top on one edge reduces the pressure on the various rollers and thus the load on the motor. But I can't find any obvious points of sticking.

Problem 2: When the printer *does* work, with the cover popped, the leading edge of the page, down to the first line of print, is dark grey. The grey is faint on the first page or after a restart or long idle, but uniformly dark on all pages thereafter. It tends to be striped along the page (varying darkness as you move left-to-right; uniform as you move top-to-bottom). The grey disappears at the first line of text. There's also a slight "ghost"; text printed near the top of a page is repeated faintly further down the page, apparently displaced by one rotation of the drum.

This seems most likely due to a bad cleaning blade or clearing corona. Anyone have any suggestions other than replacing the drum assembly? Also, anyone recognize this print engine, so I can track down parts via sources other than Packard-Bell?"

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Service Information

Printer, copier, and fax Web sites

Unfortunately, these tend to come and go! The following include some with info, error codes, message boards, and links. Some make their moeny on parts and repair kits to beware of those that may be overpriced.

- Photocopiers.com - Supplies, Service and Maintenance
- Smarka - Copier/fax/printer buy, sell, info, tips, etc.
- FixYourOwnPrinter.Com
- Office Machine Buyer's Guide
- HP Laserjet Maintenance and Repair.
- HP LaserJet Printer Error Messages
- HP Parts Surfer
- Laser Wizard - Service courses
- Max Patch Ink - Inkjet tips and free utilities
- Parts Now
- Parts Now Print Engine Information
- Printer Works
- Fax Service Systems
- Bell Copiers
- Ames Supply
- All Laser
- Tips About Inkjet Printers And Refilling Cartridges
- Resources for Epson Inkjet Printers
- MacIntosh Printer Manuals

- Depot America - HP and Lexmark printer parts, technical info, and links

USENET newsgroups

In addition to the USENET newsgroup: sci.electronics.repair, there are a variety of computer related newsgroups including comp.periphs.printer, comp.laser-printers, and comp.sys.hp.hardware which are relevant to printer related problems. However, sci.electronics.repair is probably still best for hardware type print problems (not drivers or applications).

Copier forums

This is a newsgroup style bulletin board for copier selection, troubleshooting, repair and appears to be a good archive if you should need to find something not in this document - hard to believe, but possible :-). However, it is separate and distinct from any Usenet affiliation as far as I can tell.

- The Copier Network - Copier Service Forum.

HP LaserJet parts

(From: Dave Lee (leedj@uwec.edu).)

Dor HP Laser printers, try:

- Parts Now, Inc, 1-800-886-6688.
- The Printer Works, 1-800-235-6116.

Laser printer cartridge rebuild info

(From: terwes11 (terwes11@email.msn.com).)

I've been recycling cartridges for a few years now. Summit Laser Products (formerly Chenesko Products) has comprehensive product and technical information.

Although they are not aimed at hobbyists and do-it-yourselfers their emphasis on service is refreshing. Currently their minimum order is $60 with about 6%discount above $250. They can probably point the private consumer to stores which do handle single-unit sales.

Another distributor for the pro is Oasis Imaging (1-800-322-8992, New Hampshire for regional office).

Here are a couple of places who used to handle small orders. I haven't been in touch with in years, though:

Steven Michlin's LaserLand (orders 800-60-TONER) in Michigan Computer Friends (orders 800-547-3303) in Oregon had "starter kits"

Finally, RECHARGER Magazine intended for the remanufacturing industry only. Each issue is full of products and companies.

Printer parts

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

I've heard good things about a company called 'The PrinterWorks' for HP (and other Canon) laserprinter parts. They have a web page with an on-line catalog and search facility at:

- The Printer Works, 3481 Arden Road Hayward, CA 94545 USA. Phone: 1-800-225-6116.

All kinds of parts are available even down to that little brush stored inside your HP LaserJet Series II: The SX engine parts catalogue shows that the part on page 350 (feeder assembly) as part number RF1-1177-000. It costs $1.23 plus shipping. Or, that 27/21 tooth fuser driver gear (RS1-0287-000). It costs $1.10 in quantities of 1.

(From: Dave Lee (leedj@uwec.edu).)

- Parts Now, Inc., Madison, WI. Phone: 1-800-668-6688.

I have used them for the last 4-5 years for HP Laser and ink jet parts. They also do some Panasonic parts. Great tech support, good prices, same day shipping, etc. They have treated me very well. Also, service information on a variety of printers.

(From: Paul Strider (pstrider@phys.ufl.edu).)

- PC Service Source, 2350 Valley View Lane, Dallas, TX 75234. Phone: 1-800-727-2787 Fax: 1-972-406-9081.

(From: George Hurley (ghurley@voicenet.com).)

- LaserImpact. Phone: 1-888-809-4155.

They'll even fax or mail you a diagram of printer subassemblies so you can identify the exact part you need.

(From: Dave Noseworthy (davenos@pesl.com).)

- Katum Corporation.

Katum is a business machine (i.e., copier/fax/page printer, etc.) part supplier to office equipment dealers. If they won't sell direct to you, I'm sure they'll indicate a local dealer.

(From: SargW1 (sargw1@aol.com).)

- Laser Products Co., 1010 E. 18th St., Kansas City, MO 64116. Phone: 1-816-421-7830.

(From: Sid Ashen-Brenner (sashen@midusa.net).)

- Affordable Photocopy, Inc.

You may be able to get a Service Sheet with the error codes (among other information). They also sell parts & supplies.

HP DeskJet Parts

(From: Jeff (jkinc@erols.com).)

Try this link for HP and other printer parts:

- Parts Now, Inc..

They have a free tech line. Much better than HP.

LaserJet II: Where is the fuse?

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

There are 3 fuses/breakers to my knowledge:

The mains circuit breaker is in the AC block (right hand side of the fuser). It's hidden by the fan duct, but that's quite easy to remove if you have the casing off. The breaker is a little rectangular object with a button on top, on the lower PCB. Press down the button and try again.

The Low Voltage PSU contains the other 2 fuses. One is in the mains side, and is a normal 20mm cartridge fuse. If you remove the casing and the bracket round the front of the printer (6 screws), you can see this fuse on the PSU PCB. This fuse is a listed spare part at 'the Printerworks', which is strange, since the only time it should fail is if there's something majorly wrong with the PSU, and no other PSU spares are available.

The other fuse is a thermal one, clamped to the heatsink in the top right corner of the PSU PCB (looking at it from the component side). This one protects the 24 V pass transistor that on the same heatsink. I've never had to replace this one, so I don't know what the rating is.

If all the fuses are good, then you need to do some more troubleshooting. Firstly, check for mains at the 2-wire connector to the LV PSU. If that's missing, then you need to remove the mains input block (easy, once you've removed the fuser), and sort it out. It's _very_ simple, and should pose no problems.

If mains is present at the input to the LV PSU, check its outputs. Remove the base cover, and sit the printer on the right hand side. The LV PSU output is on the 14 pin connector in the middle of the engine control (DC controller) PCB. The front 2 pins are ground, the next 2 are +5 V, and the rearmost one is +24 V. If they're missing, you have a PSU problem.

Good luck in that case - Canon flatly refused to supply me with any spares for the PSU. They claimed that it would be dangerous to repair it. Quite why it's more dangerous than any other SMPS that I've worked on remains to be seen.

LaserJet III: Where is the fuse?

> "I am looking for the fuse of an HP LJ III. I shorted an exposed wire to ground at the fuser unit with my screwdriver. It was exposed because someone broke the cover of the fuser unit. Now the printer gets no power, the front display does not light, the fan does not come on. I looked for the fuse in all obvious places to no avail. Any hint is appreciated.

(From: Patrick Mulvey (pmulvey@li.net).)

A number of the fuses that are in the laserjets are hard to spot. There is a small component on the boards that is a small black disk. You will have to follow the wiring from the fuser back to the board and look for this small component (fuse).

I have on one occasion lost power to the paper feed motors installing a card access device (defective harness shorted the motor to ground), and found the "fuse" after looking everywhere. Looks like a disk cap but leads are on opposite side of the disk and its mounted parallel to the PCB. Hope this helps...

Copier and laser printer manuals

(From: Gerald Chafee (GChafee@worldnet.att.net).)

I have had good luck purchasing manuals from a company called "Wright-Moore Corp, P.O. Box, 66019, Indianapolis, IN. 46266-6019. I have bought a ton of Toshiba parts and manuals for less than a quarter what any Toshiba repair parts distributor quotes and I know that they are a distributor for Mita. The only possible problem is that they want to deal with someone that has a business license (read resale or Tax ID certificate). If you know someone that will let you use their name and / or address, Wright-Moore doesn't care if it is copier or laser printer connected. They do have an 800 number which I don't have in front of me but is listed with 800 directory assistance.

Canon information

Canon has a faxback service at 1-800-526-4345. Quite a bit of technical information is apparently available for their printers.

Epson printer switch settings

(From: Kim (103114.1526@compuserve.com).) Some info can be found at:

- Epsom DIP Switch Settings.

Hewlett Packard information

HP actually has a fair amount of printer maintenance and troubleshooting information on-line but no schematics:

- HP Support.
- HP parts info.
- HP Parts Surfer (Includes exploded diagrams with parts numbers).

Printer schematics?

> "Working "on my own" Okidata microline 590. Need a print of mother PCB and regulator PCB. A copy of the schematic will save time and let this OLD TV tech enjoy life.... Thanks"

(From: Joe Wagg (jwagg@fs.cei.net).)

Good luck. Even the Okidata service manuals don't have schematics. The easiest and most cost effective way I know to fix these printers is to send the board off to be repaired. I'm not sure about the price, but the logic board for that model is probably around $100, assuming you send yours in to be repaired. This way you get a known good board with a guarantee. I suggest using Laser Impact, address below. Hope this helps.

(From: Uncle Monster (unclemon@bellsouth.net).)

Try "Ted Dasher & Associates" (http://www.dasher.com), 1-800-638-4833. Ted sells refurbished HP equipment out of Birmingham, AL, He may sell you the parts, info or a trashed printer with the parts you need.

References

Here is the start of a list....

1. Maintain and Repair Your Computer Printer and Save a Bundle
   Stephen J, Bigelow
   Wincrest/TAB Books, a division of McGraw-Hill, 1992
   ISBN 0-8306-2563-2, ISBN 0-8306-3507-6 (paperback).

2. Easy Laser Printer Maintenance and Repair
   Bigelow et. al.
   Windcrest Publishing
   ISBN: 0070359768

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-- end V2.66 --

Notes on the Troubleshooting and Repair of Small Gasoline Engines and Rotary Lawn Mowers

Version 2.18a

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

DISCLAIMER

Improper use, testing, or repair of gasoline powered equipment can result in explosion, fire, injuries including loss of limbs or worse, as well as total destruction of your spouse's prized flower bed.

We will not be responsible for damage to equipment or property, your ego, or personal injury or worse that may result from the use of this material.

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Introduction

Can you see above the weeds?

Most problems with gasoline powered rotary lawn mowers as well as other small engines have simple and inexpensive solutions. For example:

* A mower that is hard to start, runs roughly, or dies at the first opportunity may just need a new spark plug or to have its carburetor cleaned.

* A mower that won't start after its blade hits an obstruction may just need one or two 25 cent locking keys replaced.

This document addresses some of the most common ailments and provides detailed instructions for their diagnosis and cure. In addition, it provides detailed maintenance guidelines to prolong the life and happiness of your lawn mower(s) and other yard equipment.

For electric lawn mower and other electric yard tool problems, refer to the document: Notes on the Troubleshooting and Repair of Small Household Appliances and Power Tools which includes chapters on basic electrical theory (relax, no rocket science) and electric motor testing and repair information.

We will deal with problems the weekend gardener is likely to run into (sometimes, literally!) as well as semi-detailed overhaul instructions. One or more of the books listed in the section: References can be used to supplement this document and can provide much more detailed troubleshooting and repair procedures.

Even if you don't know the difference between a carburetor and a crankshaft, you may still be able to do some of your own work. (Hint: if you drop one of these on your foot, the crankshaft will hurt a lot more!) We begin with an introduction to small engine technology and have more-or-less separate chapters on basic maintenance, intermediate troubleshooting and repairs, and more extensive overhaul procedures.

I welcome comments, additions, hints, corrections, funny or other stories, etc. As the title implies, it is oriented toward the gasoline engine powered rotary lawn mower. However, much of the general information applies to a wide range of yard and shop equipment powered by small 2 and 4 stroke gasoline engines.

SAFETY

Despite all the dire warnings (don't forget that the lawyers need to make a living!) it is possible to use, store, maintain, and repair gasoline powered equipment safely. Mostly, the necessary precautions are just common sense - for example, don't smoke around gasoline (well, don't smoke at all but that is not a part of the charter of this document!).

The following represent the basic precautions to take when performing maintenance or service procedures on gasoline powered equipment and dealing with gasoline in general:

* NEVER work on a gasoline powered engine indoors unless it has been totally drained of gas and given time for the residue to evaporate. Gasoline, in particular, is extremely explosive. It is not the liquid but the vapors - at a wide range of concentrations. The various solvents used for cleaning carburetors and degreasing engine parts are also very flammable. The vapors are also not exactly beneficial to good health.

* ALWAYS store gasoline in an approved gasoline can. These will be red in color. They are not the same as (blue)

kerosene cans! The round metal or thick plastic type sturdier than the rectangular thin (sheet metal) cans which may collapse in cold weather. NEVER NEVER store gasoline in glass or plastic bottles. NEVER store gasoline indoors or anywhere else that any vapors can build up or in a location near an open flame (gas or oil heater, etc.).

- ALWAYS stop the engine before refilling the fuel tank. If possible, add gasoline when the engine is cold - a splash on the hot cylinder could catch fire. Rinse off spills with water or wait till they evaporate before starting the engine.

- NEVER attempt to run a gasoline engine indoors. In addition to the general fire and explosion hazard, internal combustion engines produce significant amounts of carbon monoxide - a colorless, odorless, deadly gas.

- NEVER ever smoke while working on gasoline powered equipment even if you are willing to kill yourself slowly by smoking.

- DISPOSE of used engine oil in a safe manner - don't just dump it down the drain or in the trash. Your local service station or recycling center may accept engine oil or recommend a place for its environmentally friendly disposal. Used engine oil is also a carcinogen. Therefore, avoid excessive skin contact during servicing procedures.

- AVOID going near the spark plug wire when the engine is running or even if you are just pulling on the starter cord. The high voltage is not really particularly dangerous since the available current is extremely small but it will not be pleasant and the reflex reaction may make you do something you will regret.

- ALWAYS disconnect the spark plug wire and tie it safely away from the spark plug terminal (several inches minimum) when doing any work on the engine's moving parts. You don't want any chance of the engine starting on its own. An even better alternative is to remove the spark plug entirely. Even an engine that normally takes 10 pulls to start can do funny things that might lead to unpleasant accidents. Despite the fact that it will not start now no matter what you do, the underlying problem could actually be a flooded carburetor or something else which may correct itself while you are working. Never take chances.

  Note: Modern mowers have at least two systems for stopping blade rotation fairly quickly and keeping it stopped if the dead-man bar is released. These will be either an engine kill and blade brake (on most inexpensive mowers) or a blade brake/clutch which keeps the engine running but stops the blade (on high-end machines).

- NEVER work on or with gasoline powered equipment when overly tired - it doesn't take too many mistakes to ruin your entire day.

- Under no circumstances should the dead-man bar be tied down unless the spark plug wire is removed and safely tied away from the spark plug terminal. Even removing the gas tank isn't necessarily enough to prevent accidental starting. Many types of carburetors contain a reservoir (float chamber) which may still hold sufficient gas for several minutes of operation.

- Older mowers (or other yard equipment) may have no blade brake and only a momentary contact for stopping the engine by shorting the spark plug terminal to the frame. These mowers are on a hair trigger and just rotating the blade can start them up when you least expect it.

Tools and supplies

While you probably did not purchase your lawn mower specifically for the joys of repairing it, there is always a chance that despite all your precautions, the blade will strike a rock that just happened to grow out of the ground when you weren't looking. Therefore, it makes sense to be prepared.

Basic servicing of small engines doesn't require a $500 tool caddy. However, some basic hand tools and other items will be needed.

- A good quality set of socket wrenches is essential. For small engine work, a 3/8" ratchet and a set of sockets from 1/4" to 1" as well as a special spark plug socket. Usually a deep 13/16" type - check for your particular engine(s) will suffice.

  A basic set from Sears (Craftsman) should be fine and will come with a lifetime replacement warranty as well! If you have never invested in a socket set, now is the time. Forget about those $4 specials, however, as they are generally worse than useless. A word to the wise: you really must have a socket set to do any kind of work on small engines. Slip-joint pliers or worse yet - ViseGrips(tm) - just will not do!

  While open-end or box-end (closed) wrenches may be used for certain bolts, some simply are not accessible without a properly sized socket (like cylinder head bolts).

- An impact wrench may come in handy for removing those really stuck bolts and screws. These accept standard screwdriver bits and sockets (via an adapter) and convert a hammer blow to rotary motion. First try penetrating oil like Liquid Wrench(tm) and normal tools though.

- A variety of good quality screwdrivers - both straight and philips.

- Needlenose and utility pliers.

- Wire cutters and strippers.

- Ball-peen hammer or other metal hammer.

- Rubber mallet.

- Funnel, drain pan, plastic milk jug for used oil. These can be discards from the kitchen.

- Old rags, cotton swabs, paper towels, etc. for cleaning. An old but soft paint brush for getting dust and dirt our of various places.

- Wood blocks for propping things up or securing the blade or flywheel when loosening or tightening. Other drift (scraps) of wood and soft metal.

- Torque wrench. An adequate model that will work with your 3/8" sockets can be purchased for around $10. Setting the torque - tightness - on certain engine bolts is critical to proper operation and long life.

- Feeler gauge - a set of precise thickness strips or wires for setting spark plug and point gaps. The .020" and .030" sizes should suffice for basic maintenance.

- Flywheel puller - build or buy. See the sections starting with: Flywheel removal. If purchased, it must be one designed for your model engine, not just something you picked up in the hardware store marked 'flywheel puller'! Briggs and Stratton, Tecumseh, and others sell tools specifically for their engines. This is the easiest way to remove the flywheel.

- Carburetor cleaner - this comes in a spray can. It is also probably as flammable as gasoline, toxic, and will eat plastics and painted surfaces. Therefore, use only in a well ventilated area or outdoors and take appropriate precautions.

- A tube of thread-lock comes in handy as well as some anti-seize compound like graphite grease for the muffler/exhaust bolts and spark plug.

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Lawn Mower Basics and General Maintenance

Gas, electric, or manual?

Many people who have never used a gasoline engine powered piece of yard equipment are intimidated by all the warnings with respect to the explosive nature of gasoline. They then opt for an electric lawn mower instead of gas. For many, this is the correct choice. There are a different set of precautions to follow but they are fewer and seemingly less of a threat.

Electric equipment is in some ways more environmentally friendly generating no pollution (though the electricity had to generated somehow). Once the equipment is unplugged, there is nothing to worry about with no gasoline to store. Little maintenance is needed and there is never any issue of disposing of used engine oil - since there is no engine oil. Electric equipment is also usually - though not always - somewhat quieter.

The main disadvantage of line powered electric equipment is that it is tethered to an electric outlet by the power cord. This can become quite a nuisance after a short while. Battery powered equipment has tended to less powerful and more finicky to deal with than similar equipment powered from a line cord. And, electric mowers tend to be less powerful than similar equipment using a small gasoline engine.

Where your yard is relatively small (say, less than 50 feet to an electric outlet from the farthest point), a corded mower may be a good choice. It will be less expensive than typical battery powered mowers and most gasoline powered mowers, and virtually maintenance-free. Just make sure you use a proper outdoor heavy duty extension cord - probably one size LARGER (lower AWG wire size number) than what the manufacturer recommends. This will assure minimal loss of voltage due to its resistance - and every bit of power you have available will help! A somewhat lighter duty outdoor cord can be used for the first few feet if that makes maneuvering the mower easier. The main thing to watch out for is accidentally cutting the cord by running over it. Mowing in a back-and-forth pattern while moving away from the outlet helps. If you do cut the cord - don't panic. At most, you will need to shorten it a couple of feet and install a new socket on the end of what is left AFTER pulling the plug! If the outlet is now dead, at most you have tripped the circuit breaker or GFCI, or blown the fuse. Of course if you make a habit of this, your cord could get to be quite short. :-)

Battery powered yard equipment and power tools have improved greatly over the years. Some of the newer models are quite capable of cutting a modest size yard (e.g., 1/4 acre, manufacturers specifications may still be a bit optimistic) on one charge with ample power for moderately thick grass. But, there is quite a bit of variability in cutting performance and battery life so shopping around, consulting Consumer Reports, and making sure you get a return option if you are not satisfied are all well worth the effort - to save effort in the long run.

It is interesting, however, that quite capable battery powered tractors for example, have been around for a long, long time.

See the section: Comments on electric mowers for more information.

Having said all that, the fact of the matter is that the vast majority of lawn mowers used for modest or larger lots are gasoline powered.

Of course, if you have a postage stamp size or even a small suburban lot, a manual reel mower may be your best choice - and you get some good exercise as part of the deal as well.

Also see the comments in the Chapter "Items of Interest" on electric and manual mowers.

Types of lawn mowers

Depending on the size of your lot, glowing conditions, and your energy level, one or more of the following options will fit you like a glove:

- Reel mowers - manual type are still available and suitable for small lots. Safe, non-polluting, quiet, low maintenance, and low cost substitute for aerobic workout.

- Rotary mowers (gasoline powered) - Most common type, convenient, relatively low maintenance, some pollution, generally noisy.

- Rotary mowers (electric, AC line or battery powered). Convenient, low maintenance, non-polluting, usually quieter than gasoline powered mowers, limited by cord length or battery charge.

- Teenage kid - low maintenance but variable performance and possible reliability problems.

- Landscaping service - expensive but consistent and may occasionally mow your valuable flower bed as weeds by mistake.

- Cow, goat, or other herbivore - mowing performance quite variable, fencing required, excellent source of fresh fertilizer. The extended warranty is essential! :-)

The first two of these are described in more detail is subsequent sections of this document. For the last, well you should already know if *that* is appropriate for your life-style!

Large mowers (those which carry you) may be of either the rotary or reel type, usually gasoline or diesel powered but some electrics have been produced. For information on riding mowers, lawn tractors, garden tractors and estate tractors (also known as compact diesel tractors), see the Small Tractor FAQ.

Consumer Reports regularly provides reviews and ratings of most common types of lawn mowers. These articles are a good place to start as they include a great deal of the basic information needed to decide on the lawn mower type best suited for your property. They compare a selection of typical models based on features, safety, price, and their tests of performance and operator convenience. If you do not subscribe to Consumer Reports, your local library will likely have access to several years of back issues.

For even more advice, see Consumer Reports Books' Yard and Garden Equipment Buying Guide. It is sold at bookstores and newsstands and is also available directly from Consumer Reports Books using the order form in the back of every issue of Consumer Reports.

Reel mowers

These may be manual or engine powered. A spinning set of sharp spiral cutting blades working against a fixed 'bedknife' snips off grass like a scissors. In principle, reel mowers can produce an exceptionally consistent manicured lawn. However, small reel mowers may have serious cutting height limitations and also result in a wavy uneven appearance.

- The common (some would say old fashioned) manually operated push reel mower is simple in construction, easy to operate (if you have the energy), safe, quiet, compact to store, and modern ones in particular are quite light in weight. However, blade sharpening is something best left to an expert. If your lot is small and/or you like the exercise, a manual reel mower may be for you.

- Small engine powered reel mowers do exist but I do not know if they are still readily available. I have seen them at garage and estate sales. While I have never seen an electric powered reel mower, this would seem to make a lot of sense for battery operation as the power requirement of a reel mower are much less than for a rotary type.

- I don't know if commercial battery powered reel mowers exist but it would make sense as they should be much more efficient than rotary mowers.

    (From: Nigel Cowburn (nigel@hkem.com).)

    "A neighbor of mine had a homemade car-battery-powered reel mower. He used his actual car battery and worked out a mowing time that allowed him to start his car again after mowing."

  (From: Sam.)

  I suppose he had to factor in the height of the grass to guarantee that his car would start. :)

- Professional landscapers often use large engine powered versions of these machines which may have multiple cutting heads and are self propelled, ride-on, or pulled behind a tractor.

See the Reel Mower FAQ for additional information on this type of beast. An Internet search should also turn up a number of informative Web sites.

Rotary mowers

These may be gasoline or electric (AC line or battery) powered. A spinning blade or blades whirls at the selected cutting height and lops off the tops of you grass by side impact. This is most definitely brutal treatment of your poor defenseless grass! The length of the cutting blade determines how much of a swath is cut on each pass - typically 18 to 24 inches for a walk-behind mower; up to 36 inches or more for a riding mower. Mowers with large swath widths may use two or more smaller blades instead.

The uniformity, consistency, and just general appearance of a lawn mowed with a rotary lawn mower is not quite up to the standards of that of a professional reel mower. You will never get the perfect manicured look though some models may come close. However, the simplicity, lower cost, and need for less and more easily performed maintenance will generally overcome the desire for perfection unless your lawn is featured regularly in "Better Homes and Gardens" magazine.

Gasoline powered rotary lawn mowers are by far the most common type used by homeowners and many professional landscapers as well. Most walk-behind mowers use a manual recoil (pull) starter though electric start is available on more sophisticated (and more expensive) models and generally standard on riding mowers and lawn tractors.

The main disadvantages of a gasoline powered mower are the need to deal with the handling and storage of gasoline and routine engine maintenance at the end of the mowing season to assure easy starting next season and to prolong engine life. However, most of this is pretty straightforward. See the section: General preventive maintenance. Small gasoline engines also do contribute to air pollution but new mowers must meet more stringent EPA requirements as of September, 1996.

Electric rotary mowers are also available in both plug-in and cordless (battery powered) versions. However, since gas mowers are generally more powerful and not limited by the length of a power cord or charge of a battery, they continue to dominate the market. Electric mowers are, of course, non-polluting but the electricity had to be generated somehow.

Dead-man control

All rotary mowers manufactured within the past 15 years or so must have a dead-man control to stop the blade quickly (within a couple of seconds) if the handle is released or the operator falls off of the seat of a riding mower or lawn tractor. While not foolproof, this feature greatly reduces the chances of serious injuries due to accidental slipping or falling - or attempting to make adjustments while the blade is spinning.

WARNING: Never defeat the dead-man control for any reason unless there is no chance of the mower starting.

- For gasoline powered mowers, this means that the spark plug wire had been pulled and tied a safe distance (a few inches minimum) away from the spark plug terminal or the spark plug has been removed entirely. Even draining or detaching the fuel tank is no guarantee that the engine will not start as the carburetor often contains a few minutes of fuel reserve.

- For electric powered mowers, this means that the wall plug has been pulled or the battery disconnected and the wire tied or taped to prevent any accidental contact.

Always restore the dead-man control to normal operation before attempting to start the mower.

Types of rotary mowers

In addition to options with respect to gasoline or electric power, rotary mowers can be classified based on such things as: walk-behind vs. ride-on, to bag or not to bag, and rear or side discharge or mulcher:

- Walk-behind mowers may be either of the push type - you provide the power to move the mower; the engine or motor spins the blade - or self propelled where the engine (usually only for gasoline types) drives the front wheels via a fixed or multiple speed transmission. Typical engine power is from 3 to 6 HP with the trend nowadays toward the higher end of this range especially for self propelled models.

- Side discharge mowers eject the grass clippings from the right side (usually) to the rear. These are probably the most common type in use today due to their low cost. Some perfectly serviceable new mowers of this type sell for $100 or less. Optional grass catcher bags permit some of these to be converted to side-baggers if desired but the bags tend to be much smaller and thus less convenient than those for rear bagging mowers to prevent them from becoming side-heavy when the bag fills up.

- Rear baggers eject the grass clippings into a bag mounted behind the mower. Bags tend to fill quite quickly - especially if you keep putting off your mowing assignment - and need to be emptied or changed frequently. The weight of the grass clippings in the bag also contributes to the mass of the mower - which you have to push if it is not self propelled.

  WARNING: Rear baggers should never be operated without a bag unless the opening is fully blocked or the proper deflector is installed. Grass cutting performance will then be similar to that of a mulching or (side) discharge type mower respectively but since this is a compromise, the resulting appearance of the cut lawn may suffer.

- Mulching mowers do not discharge the clippings but continue to chop them up under-deck until they are small enough to cease being sucked up by the airflow. The best will result in almost no detectable evidence of grass clippings though the worst may leave big clumps behind. The appearance of the lawn from a mulcher may be as good or very nearly as good as that from a bagger but this is not assured. Some mowers - both discharge and bagging types - can be converted to mulching mowers by using a special cover to block the discharge port and possibly a different mulching blade.

  Side discharge and bagging mowers can often be converted to mulching with the use of a mulching kit which includes a means of blocking the discharge port and possibly a special mulching blade. However, performance of one of these may not be as good as that of a mulching mower since the airflow requirements differ and these are largely determined by the design of the deck.

- Riding mowers are basically larger versions of the self propelled bagging mower with a seat for the operator, steering wheel, and more controls for cutting rate and forward speeds. The engine is typically in the 8 to 10 HP range and is mounted in the rear beneath or behind the seat.

- Lawn tractors may be even more sophisticated than riding mowers with larger blades and additional options for non-lawn mowing tasks. The engine is higher power - 12 to 18 HP or more - and is mounted up front under a hood as in a real tractor.

WARNING: Most lawn mowing accidents result from reckless or careless use of riding mowers and lawn tractors, not walk-behind mowers. These are not as stable as an automobile especially when their large bags are full of heavy, wet, grass clippings and may tip over on inclines that would not be a problem with someone in control of a walk-behind lawn mower. They are best and safest for use on large flat open lots. A walk-behind mower - perhaps even a manual reel mower - should be used for sloping or irregular areas and for mowing or trimming around obstructions like trees, shrubbery, landscaping timbers, posts, fences, planters, boulders, and so forth.

Putting a mower into service for the first time

If this is a new purchase, you should have a users manual - READ IT!!!

Above all, understand the very important SAFETY information.

If there is some 'simple assembly required', take your time and follow the instructions step-by-step. Despite the apparent efforts of the designers of the mower and the manual writers to make everything as obscure as possible, it will probably go together without undo difficulty if you use the proper tools. With some, all you need to do is unfold the handle taking care not to pinch any control cables - oops - and you are ready to go to work. Happy times are here again!!

IMPORTANT: For 4 stroke engines, make sure there is oil in the engine!!! Learn how to check it and fill it to the proper level if there is none or it is low. See the section: Checking the oil.

WARNING: Running an engine without oil can ruin it in a few minutes and your warranty will not likely cover such stupidity. Since the lawn mower may be shipped without any oil, it is your responsibility to check this and then add the proper amount of the correct type of oil to the crankcase!!!

For 2 stroke engines, special oil (not the usual 10W-30/40 type motor oil, nor WD40 or 3-In-One!) must be mixed with the gasoline in the correct proportions IN THE GAS CAN - not the fuel tank of the mower! See your users manual! Forgetting to use the proper mixture can ruin a 2 stroke engine in a matter of minutes and your warranty will not likely cover such stupidity. Adding the oil to the fuel tank is not recommended because thorough mixing cannot be assured.

If you have yard equipment with both 2 stroke and 4 stroke engines, clearly label the two gas cans to indicate which equipment each is used in.

Gasoline

Use only fresh unleaded gas. Regular octane rating (87) is fine - small engines operate at relatively low compression ratios so knocking should not be a problem. There is likely no benefit to using anything higher. In fact, I've heard that small engines may actually be harder to start and run poorly on expensive high octane gas due to their low compression ratio. Gas that is over a month old may have lost some of its more volatile fractions resulting in hard starting, possible varnish formation, and other undesirable effects. At the end of the season, dump the unused (unmixed, not from a two-stroke engine!) gas into your car (preferably when its fuel tank is at least half full so your old gas gets mixed with fresh gas). This way you won't be tempted to use it at the start of the next season.

If the tank detaches easily as with many Tecumseh/Craftsman engines, just lift it off and drain the gas into a gasoline safety can reserved for this purpose. If the tank doesn't come off easily, I typically use a cooking baster to do this (you know, the thing you use when baking turkeys!) although the gas tends to destroy the rubber. There are similar devices or gas siphons available at auto parts stores that survive better.

For 4 stroke engines, gasoline is used as-is since there is a separate oil supply. For 2 stroke engines, you must mix the proper amount of the correct 2 stroke engine oil (outboard motor oil or whatever is recommended by your engine's manufacturer). Fill your '2 stroke mixture' gas can with about half the amount of gas you are preparing and add the proper amount of 2 stroke engine oil. Put on the top and slosh this around to thoroughly mix the oil in with the gas. Then add the remaining gas to the total amount for which your oil measurement was made.

How do you tell if a lawn mower you just inherited has a 2 stroke or 4 stroke engine? The vast majority are 4 stroke - look for an 'oil filler cap'. On many, this is clearly marked with words like 'oil' or 'oil fill' or with a suitably ambiguous icon. Removing it will reveal a dipstick. (Note that unlike the engine in your automobile, this is both the test and filler location.) However, on more basic models, it may be near the base of the engine and be unmarked. In addition, there will generally be markings as to the need for the gas/oil mixture somewhere on the cover. The only major manufacturer of lawn mowers I know of that has used 2 stroke engines in recent designs extensively is Lawnboy.

If you are unsure of the correct mixture ratio - they typically range from 16:1 to 32:1 gasoline:oil by volume - 16:1 is probably a safe choice. The worst that can happen is that the spark plug may be more likely to foul (and you will pollute more than necessary) but at least you won't risk damaging the internal parts from lack of oil. It is of course best to determine and use the recommended mixture ratio.

Where to buy gasoline

Your nearest auto service station will sell you small quantities of gasoline. As noted in the section: SAFETY, you must use an approved gasoline safety can which will be red in color. These come in sizes from 1 to 5 gallons or more and may be made of plastic or metal. A convenient size is 2 to 2-1/2 gallons. The fuel tank on a typical walk-behind mower will be between 1/4 and 1/2 gallon.

WARNING: When filling your gas can, place it on the ground a few feet from your vehicle - never fill it inside the trunk or truck-bed. See the section: Where to fill gas can.

However, a gallon of gas goes a long way with a walk-behind lawn mower. I don't have exact numbers but a gallon will probably do several acres of mowing (assuming you aren't chopping foot high grass!).

If you must transport gasoline in a vehicle, make sure the container is secured in an upright position and tightly capped (both the filler spout and vent openings). Provide adequate ventilation so there can be no possibility of fume buildup in the trunk or passenger compartment.

Where to fill gas can

Always remove the gas can from vehicle before filling it. In addition to common sense 'what ifs' with respect to spills and fume buildup, there may be an added risk of the buildup of static electricity:

Also see the section: Explosion risk when filling a metal gas can.

(From: Joyce (joduren@ix.netcom.com)

Please be careful about filling the gas can. I saw something on one of those PBS How to do it shows (or was it in the newspaper?) that said that people are filling their plastic gas cans with them still in their trunks or hatchbacks. They said this is dangerous because the can isn't grounded or something and a static electricity spark could make the thing to explode.

Gasoline additives or stabilizers?

The use of a proper stabilizer can often substitute for the task of draining the gas between seasons by preventing the formation of insoluble gum that would otherwise eventually clog up your carburetor.

> "Isn't there a gasoline additive you can add to the gas which will keep it 'fresh' for up to 24 months? I've seen it at Home Depot, though have never used it. I think a tube was less than $1.00."

(From: Floyd Reed (floyda@ix.netcom.com).)

Being an old small engine mechanic from way back, I suggest that you don't use any additives to keep your gasoline 'fresh'. Dispose of old gasoline (end of season) by dumping it in the (nearly full) fuel tank of your car, then refill your gas can at the beginning of the mowing season. It should last you the season. With this method, you spend no extra on additives (that are no good for an engine), you don't waste 'old' gasoline, and you don't dump raw gasoline into the environment.

(From: Dan Weise (dan_yz@cin.net).)

I have found the commercial product Stabil the best thing since sliced bread. It prevents the gasoline in the gas tank from gumming up. I'm too busy to run around emptying gas tanks in the fall.

Instead, I shoot in a squirt of Stabil, run the engine for 5 minutes, shut the gas valve off (unless it's a suction carb mounted on the gas tank) and the engines start next spring.

That was *not* the case before Stabil. I can't count the number of times I've disassembled a carb and sprayed Gumout trying to unclog the main jet or the idle jet. Or had the float stick down and flood everything in sight. All because of gummy gasoline.

I've used Stabil for about 10 years with great success.

I also use that Slick 50 teflon stuff, but have no idea whether it does any good or not. But for the investment in an engine, I can't see that it hurts. The intermittent duty of many engines makes them more vulnerable to oil run-off than vehicles that are used daily.

Before you start mowing

Note: while written with gasoline powered rotary mowers in mind, most of these comments apply to electric models as well.

- Reread the section: SAFETY, particularly with respect to the storage and handling of gasoline.
- Make sure you understand the operation of your mower. In particular, how to stop it! On most modern inexpensive mowers, the engine should stop as soon as a dead-man safety bar is released. This is supposed to both kill the ignition to the engine and apply a brake to the blade (usually to the flywheel). On more sophisticated machines, releasing the bar disengages the blade but does not stop the engine - do you know how to stop the engine?
- Check, and if necessary, set the cutting height. (I will leave it to the gardeners to determine optimal height. Around 2 to 2-1/2 inches is probably acceptable unless you are mowing a putting green.) This is usually accomplished either with levers on each of the wheels or by removing and reinstalling each of the wheels into one of several holes. A few mowers use a single control for all wheels - very convenient. Always make sure all (4) wheels are set at the same height.
- Check the oil and if necessary. top it off.
- Remove any obstacles or debris in your path - rocks, stones, wood blocks, branches, etc. These are a safety hazard and killers for your lawn mower. If the blade hits something small, it can become a high speed projectile traveling at up to several hundred feet per second - this is a substantial fraction of the muzzle velocity of a handgun. If the blade

tip contacts something larger, the engine will stop and serious damage may be the result. See the section: Why you really don't want to attempt to move an immovable object. Mark immovable obstructions with Dayglow orange paint or something else you won't miss!

In some cases, obstructions like tree roots cannot be moved. In this case, you will either have to mow around them or raise the cutting height of the blade to clear.

- Make sure all protective devices are in place on the mower. Rear baggers must have a bag or proper cover installed (many are automatic). Side baggers must have a bag or deflector installed. Change bags only with the blade stopped - and preferably the engine stopped as well.

- Wear proper clothing and sturdy fully enclosed shoes with non-slip soles. Avoid mowing when the ground is wet and slippery.

- Wear proper eye protection - plastic eyeglasses or safety glasses - to protect your eyeballs from flying debris.

- Use some kind of hearing protection - ear plugs or muffs. Even just a wad of cotton or tissue will greatly reduce the noise level to your ears.

- Keep curious kids and pets a safe distance away.

- Avoid mowing a highly sloping area in the up and down direction as the mower can slip or you can slip. Even with the safety blade brake, it takes a couple of seconds for those knife edges to come to a stop. If you must mow such an area, do it from side-to-side and be careful of side-bagging mowers that may tend to tip over particularly when their bag is filled with grass clippings. Better yet - only plant rocks on highly sloping areas!

Starting the mower

Most mowers and other small pieces of gas powered yard equipment use a self retracting recoil type starter. You pull on a handle attached to a cord wound around a one-way clutch affair. Pulling on it rotates the engine's crankshaft and the clutch allows the engine to run without pulling you back into the mower! If yours has an electric starter, then you don't need to tug on anything - plug it in and push a button or turn a key. Of course, finding an outlet at the far end of a large yard may prove to be a challenge. With larger equipment like riding mowers, power is usually provided by an on-board rechargeable battery. In either case, there will be some kind of backup recoil or rope starter should the electric start be unusable or inconvenient.

For the following, we will assume you pull a self-retracting starter rope. With an electric starter, replace the words: 'pull...times' with 'crank for several seconds'.

Move the mower or other equipment to the place where it will be used - no sense in dragging a chugging lawn mower through the neighborhood. Position it on a solid level surface. Make sure there are no loose stones, twigs, branches, logs, etc. underneath to get sucked up and thrown about once you succeed in getting the engine started (if you ever do).

When attempting to pull on the starter cord, it may be helpful to put one foot on the mower deck to brace it. Whether this is needed will depend on the design of your mower and in what direction the cord exits from the starter.

You or the starter motor supplies the power to get it started. However, at the low speed of starting, special modifications may be required to the fuel system for the engine to catch. These may take one of the following forms:

- Primer - a rubber bulb or pushbutton squirts a little extra gas into the intake pipe. Your engine manual will detail the procedure and number of 'pushes' required under various conditions - typically between 1 and 12. Too few and nothing will happen. Too many and you will flood the engine (excess gasoline will prevent it from starting). See the next section.

A typical starting procedure for an engine with a primer might be:

  - Set the throttle control (if any) to the START or HIGH position.
  - Push the primer 5 times.
  - Pull the starter cord once or twice (if it doesn't start on the first one).
  - If it still doesn't start, prime 2 more times.
  - Pull the starter cord again.
  - Set the throttle control to the desired speed once it starts.

- Automatic primer - a chamber in the carburetor which fills with the engine stopped and provides an additional squirt of gas when starting.

  Automatic choke - temperature and engine vacuum control the fuel-air mixture.

  A typical starting procedure for an engine with an automatic primer or automatic choke might be:

  - Set the throttle control to the START or HIGH position.
  - Pull the starter cord once or twice (if it doesn't start on the first one).
  - Set the throttle control to the desired speed.

- Choke plate - a control on the carburetor which partially closes off the air intake and forces additional suction to increase the amount of fuel drawn into the cylinder. Normally, the choke is closed when starting cold and gradually opened in the few seconds after the engine starts. It is left fully open once the engine is running and may not need to be closed when starting warm.

  A typical starting procedure for an engine with a choke might be:

  - Close the choke (usually on carburetor).
  - Set the throttle control (if any) to the START or HIGH position.
  - Pull the starter cord once or twice (if it doesn't start on the first one).
  - If it still doesn't start, open the choke half way.
  - Pull the starter several more times until it starts (hopefully).
  - Gradually open the choke to keep the engine running smoothly.
  - Set the throttle control to the desired speed.

If the appropriate procedure is not successful, the engine may be flooded. You can give it 15 minutes or so for the gas to evaporate and try again or, if there is an IDLE or LOW speed position, open any choke and pull the rope several times in this position which should clear out the excess gas. Then repeat the recommended starting procedure.

If none of this works, you may have a starting problem and should refer to the section: Lawn mower will not start. Probably, you forgot to fill the gas tank!

A primer on priming

Many small engines have replaced the choke with a primer - a rubber bulb or button that is supposed to be pushed several times before attempting to start the engine. Under the right conditions, this is a very effective approach. However, here are a couple of things to keep in mind:

- The number of times the manufacturer recommends for pressing the primer is just an average - in many cases, more is better and won't hurt. (The instruction manual probably even says something like: "If the engine doesn't start and run after N pushes of the primer, do it N more times and try again"). While it is possible to flood the engine with too much priming, it would probably take more than just 2 or 3 times the recommended number of pushes.

- If the ambient temperature is low, priming will be less effective. The engine may run for a few seconds and then die since its interior parts having heated up enough, requiring repeated priming and starting. If the engine then runs fine, there is probably nothing actually wrong. If you work at it, this might be a good excuse to put off the first mowing of the season. :)

Where behavior seems to have changed, first confirm that environmental conditions are the same and the gasoline is fresh before blaming the engine on starting problems.

If the engine operates normally once started (assuming you can get it started by some other means like squirting some starting fluid into the cylinder), then dirt may have made its way into the priming mechanism. Disassembly and cleaning may be all that is needed. However, there really isn't much to it: Pressing the primer just pushes some air into the carburetor, which squirts some gas via the main carburetor jet to the intake pipe. There really isn't much that can wrong as long as the rubber primer bulb and connecting tubing (if the primer isn't on the carburetor itself) is in good condition.

Stopping the engine

On most inexpensive lawn mowers manufactured within the last 10 or 15 years, releasing a dead-man bar on the handle both kills the engine and applies a brake to the blade (well, actually the flywheel of the engine). In this case, there is nothing to think about - just release the handle and it will stop within a second or two. These are quite reliable. The usual problem is that you forget to engage the dead-man bar and attempt to start the mower despite the basic fact that this is quite impossible!

More expensive equipment will have a blade brake clutch meaning that while there is still a dead-man bar but instead of killing the engine when released, it disengages the blade (clutch) and brings it to a rapid stop (brake). This is more convenient especially with a balky engine. There will then be a separate engine stop switch - possibly combined with a speed/throttle control.

Equipment with an electric starter may have an ignition switch just like an automobile and there will be three positions: STOP, RUN, START.

Some older equipment just has a stop contact that grounds the spark plug. Pressing on a lever connects the spark plug terminal to the engine chassis and kills the spark. While this is fairly reliable, it may be a momentary contact meaning that the engine may be on a hair trigger and even rotating the blade a fraction of a turn may cause the engine to take off again. Thus, disconnecting the spark plug wire or removing the spark plug is even more critical when working on this sort of equipment.

Suppose it fails to stop?

What should you do if the engine stop switch has no effect? Probably the safest and surest is to use a wooden stick to pop the spark plug connector off of the spark plug terminal. This **will** stop the engine.

The most likely cause of such misbehavior is a stop wire that has become disconnected or has broken. This is easily remedied.

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Maintenance Guide

General preventive maintenance

Here is what you should do at the end of the mowing season:

- Change the oil. If you do nothing else in this list, at least change the oil. Old dirty oil will shorten the life of your engine and affect its starting and running performance eventually.

- Drain the fuel tank (see the section: Gasoline for tips on doing this). Put this and any fresh (unmixed) gas remaining in your gas supply can into your car's fuel tank (preferably at least half full to dilute it) so you won't be tempted to use it next season. Or, discard it in an environmentally friendly manner. Then run the mower until it stops from lack of gas which will use up the gas still remaining in the carburetor (at most a couple of minutes). Purging the engine of old gasoline is particularly important for float type carburetors. Otherwise, evaporation and oxidation may result in the formation of insoluble gum which will eventually clog up your carburetor.

  Also see the section: Additional comments on winterizing - draining versus the use of fuel a stabilizer. The use of stabilizer is convenient but I think draining is preferred as it is safer not storing garden equipment over the winter loaded with gasoline.

- Inspect the air filter (and fuel filter if present). If dirty or clogged, clean or replace as appropriate.

- Remove and inspect the spark plug. The curved electrode and tip should be smooth and light gray or brown in appearance. If they have deteriorated or are damaged in any way, replace the spark plug. Engine repair books usually recommend replacing the plug in any case - they are inexpensive, under $2. Use the proper small engine spark plug - not one you found in the corner of your toolbox or removed from your automobile! A bad spark plug is a major cause of a hard-to-start engine. Check the spark plug gap (new or used) with a feeler gauge - it should be .030" for most small engines. Carefully bend the curved electrode to adjust - do not file the center electrode!

- Squirt a teaspoon or so of fresh engine oil into the spark plug hole so that it coats all sides of the cylinder. WD40 will work as well since its purpose is protection and not lubrication. Then crank the engine a couple of times to distribute it. The oil will protect the cast iron cylinder liner and piston rings from rust during the off-season.

- If you reinstall the old plug, it is generally good practice to replace the metal washer. Install the spark plug finger tight and then tighten another 1/2 to 3/4 turn or to 15 to 30 ft-lbs with a torque wrench using the proper deep (spark plug) socket.

- Clean above and below deck to remove dirt, leaves, and other debris. Pay particular attention to the area around the cylinder under the shroud (blower housing). Remove any leaves or other debris that might impede the all important air flow.

- While underneath, inspect the blade for serious damage that would require resharpening or replacement. It doesn't have to be honed like a scalpel but there should not be too many deep nicks and it should not wobble noticeably or be bent or have bent or distorted tips.

- If you have a battery for electric start, make sure the water reservoir (if not the maintenance-free type) is topped off, the terminals are clean and tight, and that it is fully charged.

- Put a light coating of oil on any exposed unpainted steel parts. Check any front wheel drive components - chains, idlers, pulleys, and clean and lubricate if necessary. Dribble a few drops of light oil into any throttle, choke, safety interlock, or other cables.

- Store the mower in a dry location supported off of the floor on wood blocks if there is any chance of flooding.

Then, when it comes time to start mowing again (yes, I know, you can't wait), all you should have to do is add fresh gas (don't use last season's). The mower should start on the first (well, maybe, second) pull. There may be some white/blue smoke for a few seconds from it burning off the oil coating on the cylinder walls but this should quickly disappear.

The Lawn-mower-shop.com Web site has great deal of useful information including diagrams of popular carburetors and links to small engine manufacturers.

Here is another recommendation:

(From: Bill Harnell (bharne@adss.on.ca).)

Change the oil at the *end* of the season. No need to leave the acid charged oil in the crankcase over the winter to corrode the engine.

Then add a couple of teaspoons or so of Stabilit to the gas tank. Run the engine for approximately 5 minutes and while you're at it, inject some fogging oil through the carburetor to thoroughly coat all of the interior surfaces. Directions are provided on the fogging oil container.

Wipe the frame and handle with an oily cloth and oil all pivot points lightly. Clean the crud from under the deck - you do that frequently all summer - right? Remove all the grass clippings from around the flywheel and the cylinder fins.

Then store it in the shed or garage.

It will start on the first or second pull every spring.

BTW, you should be able to get both Stabilit and fogging oil at any reputable engine service center.

Checking the oil

The following applies only to 4 stroke engines. For 2 stroke engines, special oil must be mixed in proper proportion with the gasoline.

The proper amount of oil is critical to the happiness of your engine. Too little and it may overheat, cause excessive wear, and in extreme cases (but not unusual), cause engine parts to seize and fail - very expensive. Make it a habit to check the oil regularly. Doing this after about every 5 hours of operation is generally recommended. More frequent checks - such as before each time you mow - are fine as well. A typical small engine in reasonably good condition does not use up a lot of oil but checking oil is easy and will not hurt.

Oil should be checked when the engine is cold or after waiting 10 minutes for it to drain back into the oil sump after running the engine.

Place the mower on a level area.

- If there is a dipstick - remove it, wipe it with a rag, and then reinsert it as directed on the information sticker or on the stick itself - usually threaded fully back in place and then removed to read. If the level is below or near the empty mark, slowly add the proper new oil to bring it up to just below the full mark.

- If there is just a filler plug near the base of the engine, the correct level is just below the top - almost to overflowing. If lower than 1/4" or so below the lip, add new oil to top it off. (There may be exceptions to this but filling to near the top should be safe if you do not have your lawn mower engine manual handy.)

If the oil level is high - you just bought the lawn mower or were careless in filling it last time - drain enough oil to bring the level back down to the full mark. Too much oil can result in problems as well - oil spraying out of various orifices or getting into other places where it should not be like the combustion chamber.

If you find the oil level over the full mark or higher than it was before, gas may be leaking into the oil due to a flooded carburetor - a stuck inlet needle or bad float. If this is the case, the oil will need to be changed once the underlying cause of the leakage is determined. (This is only likely with float type carburetors such as those used on the Tecumseh engines used in a variety of Sears/Craftsman models equipment.

If the oil is very low and you have been performing regular maintenance, there may be a leak or your engine may need a ring job. Excessive oil under the deck - on the shaft or blade adapter - would indicate a bad bearing or oil seal. Noticeable blue smoke while running would indicate that excessive oil is getting by the rings into the combustion chamber.

Typical oil capacity is just over 1/2 quart (usually about 1-1/4 pints).

About engine oil

For the common 4 stroke engines such as Briggs & Stratton or Tecumseh, you don't need to buy specially high priced engine oil. The type likely used in your automobile will work fine and will be much less expensive. Although small engine manufacturers may recommend SAE 30 oil, they usually also state that 10W-30 or 10W-40 are acceptable substitutes - and these are what your car probably uses. New oil should have at least the SG rating though if you have some SF in your garage, that will be fine also (for your lawn mower, not your car!). However, there are situations like equipment that must run in extremely cold weather (probably not a problem with grass mowing!) where specific alternative oil recommendations should be followed.

The capacity of a typical small engine is just over a 1/2 quart. This will probably cost you about 50 cents - a very worthwhile investment!

However, some people do swear by synthetic oil. I remember it worked pretty well on my bicycle as well :-):

(From: Daniel Pope (dpope@l-a-net.net).)

Synthetic Motor Oil in the crankcase and Marvel oil in the gas is the only way to go!

I have a $1,900 MTD tractor style mower with B&S engine (L head twin). It has over 800 hours and 9 years on it and I mean rough hours (bahaya grass and hot weather). The engine does not use a drop of oil (changed every 30 hours) and the compression is the same as when new. These other guys can have there $5,000 fancy mowers. I'll use that money to buy a truck.

Oil change

If you don't do anything else to prolong the life and happiness of your small engines (and your automobile, for that matter) it should be an oil change at the recommended interval. Oil loses its lubrication and cooling effectiveness with use and this will gradually take its toll on your precision engine parts. Even a simple lawn mower engine is machined to very precise tolerances and any contamination will increase wear. Ultimately, its performance - starting and running - will suffer and its life will be shortened.

Since there is typically no oil filter, all the grit, metal particles, and other undesirable stuff continues to circulate with the oil to find its way in between precision engine parts.

For small engines, the oil change interval is usually specified to be about 25 hours of use. More frequent oil changes may be desirable if the equipment is operated in an extremely dusty environment.

A typical mowing season for a modest size lot is around this amount of time so an oil change once a season is probably satisfactory. I recommend this be done at the end of the season so that the old contaminated oil does not sit in the crankcase during the winter months and you will not (conveniently) forget to do this at the beginning of next season when you are eager to get at that straggly lawn.

An oil change isn't really a big deal

The oil change procedure is a lot simpler than for an automobile as everything is readily accessible and there is no oil filter to worry about.

- You will need a funnel, low wide container or drain pan for the used oil, and a container like a plastic milk jug for temporary storage of the used oil for disposal.

- Spread adequate newspaper on the ground to collect any drippings.

- Run the mower for about 2 to 3 minutes to allow the oil to circulate and warm up so that it is less viscous and will flow more easily. Stop the mower and remove the spark plug wire.

- If the fuel tank is less than about 1/3 full, then you will probably not have any problems, otherwise you will have to drain some gas or remove the fuel tank so that gas does not spill out of the breather hole in the cap.

- If there is an oil drain plug, you can use this to drain the oil. However, it is usually more convenient to just turn the mower on its side, carburetor side up. This is usually acceptable for the short time that will be involved. Immediately check for any oil leakage - if there is any, we will need to avoid tipping the mower as much - look for the drain plug.

- Wipe around the oil filler cap with a clean cloth or paper towel to remove the dirt and grime that has likely collected there. The oil filler will either be on or near the bottom of the engine or at the top of the shroud (Eager 1 type). If it is not right at the bottom, there will be a dipstick attached to it.

- Place your wide mouthed drain pan under the oil filler cap and remove the cap. The oil will flow into your pan. Let it continue until the dripping stops - probably 10 minutes or so.

- Set the mower upright on a level surface. Wipe any drips on the engine and deck up with a clean rag or paper towel.

- Use the recommended oil for your engine. SAE30 is usually specified by the engine manufacturer but they will usually state that 10W-30 or 10W-40 (SG rating) are acceptable substitutes. These 'multi-weight' oils are widely available and inexpensive. Typical small engine oil capacity is just over 1/2 quart. Start low and incrementally add oil until just below full on the dipstick or at the top of the oil fill hole if there is no dipstick. DO NOT overfill. Give it time for the relatively viscous oil to find its way into the crankcase. Tipping the mower back and forth a bit will help this process.

- Replace the filler cap. Wipe up any additional drips.

- Replace the spark plug wire. Then, start and run the engine for a couple of minutes. Wait a few minutes, then recheck the level. Top it off if needed.

- Transfer the used oil from your drain pan to the storage container and dispose of it in an environmentally safe manner.

Blade sharpening

The blade in a rotary lawn mower doesn't need to be sharp as a carving knife or scalpel but serious dents and nicks will result in a less than perfect lawn (to say the least!). In addition, a seriously unbalanced blade can result in excessive vibration and eventually, possible internal damage as well.

First, drain the gas or remove the gas tank. If you will be filing steel, you get sparks. Sparks are not the greatest thing to have around gasoline vapor. Enough said. Disconnect the spark plug wire and tie it safely away from the spark plug or remove the spark plug entirely. Turn the mower on its side.

CAUTION: Immediately check for oil leaks at the oil filler pipe or elsewhere. If there are any, you will need to work on the mower just propped up by 45 degrees or so. Or, use this as a good excuse to perform an oil change and drain the oil (even if the engine is cold, most of the oil will drain out but it will take a little longer). Just don't forget to refill the crankcase with fresh oil once you have completed work on the blade!

Check that the blade isn't bent. Locate a reference point on one side and note the height of the blade tip at that location. Rotate the blade 180 degrees and check the height of the opposite blade tip. There should be no significant difference - say no more than 1/8" or so. If it is greater, the blade is bent or the crankshaft is bent. Either will require further investigation as running the mower under such conditions will probably result in excessive vibration and can be dangerous.

Assuming this is fine, inspect the blade:

Slight nicks and dents can be cleaned up with a file while the blade is still installed on the mower. Unless you have run into a curb, this is probably all that is needed on an occasional basis. Removing this small amount of metal will also not unbalance the blade enough to worry about. Refer to the section: Non-violent blade removal if it needs to come off the mower.

If the damage is severe, consider replacing the blade entirely - they are not that expensive (usually under $10). Otherwise, you can use a file, a bench grinding wheel, or a grinding wheel mounted in an electric drill (there are special attachments for this specific application).

Since the rotating blade also contributes to the proper air flow, you do not want to upset the shape. Grind in such a way that the original blade angle is preserved. It doesn't need (or want) to be razor sharp. A 1/64" edge is fine. Anything finer will quickly be dulled by little bits of stone and dirt in any case. Safety is not the main concern here - if any part of your anatomy contacts the whirling blade, you **will** be in trouble no matter how dull or sharp the blade might be!

Attempt to remove approximately equal amounts of metal from both ends and in roughly similar areas if possible. If there are a few large nicks, it isn't necessary to remove them completely - your lawn (and neighbors) will never know the difference.

Check the balance by positioning the blade at the center hole location on a pencil or other rod - you don't need a fancy blade balancer but can use one if you like. If it tips one way or the other, remove more material from the heavy side a little at a time.

Replace the blade along with all its mounting hardware. Make sure you get all parts in the same relationship as they had originally. The blade must have its sharpened edges pointing downward. Don't forget the install the key if it is separate and DO NOT substitute a hard steel key for the soft metal one that should be used. See the section: Why soft metal keys must be used. If the locking key or blade adapter key appear damaged in any way, replace it.

Non-violent blade removal

For just some minor touch up, there is no real need to remove the blade. For major grinding and balancing, removal will be needed. Removal will also be required to inspect for a damaged or sheared blade lock key and to replace it if necessary.

In either case: disconnect the spark plug wire and tie it safely away from the spark plug terminal (several inches minimum) or remove the spark plug entirely to prevent accidental starting.

If the nut holding the blade on is just on very tight, use a block of wood to prevent the blade from turning. Use a good quality socket wrench or box-end wrench of the correct size - an adjustable or even open-end wrench may not be enough. The nut usually unscrews counter-clockwise. However, check this out first! A careful inspection of the threads on the end of the crankshaft will reveal the direction. Or, determine the direction of rotation which will be designed to tighten, not loosen the blade. Most, if not all, single blade mowers rotate the blades clockwise as viewed from above which will therefore use a normal right-hand thread nut.

CAUTION: Make sure that if the wrench slips, your flesh will not contact the blade or other sharp sheet metal - liberal use of rags or newspapers is a good idea. Arrange your position and the mower so you are pulling towards you - this is a more stable controllable arrangement.

(From: Graduate student of school of hard knocks.)

> "I'd wish I'd read this a few years ago. I used an open-end wrench and it 'flexed' off of the bolt. Needless to say, my next week wasn't a lot of fun with 10 stitches in my hand."

Use some penetrating oil (e.g., liquid wrench or WD40) on the nut and threads if there are signs of rust or corrosion. Allow it to soak in for a few minutes before attempting to remove the nut.

You will prevail. A hammer or other more violent approaches should not be needed.

Once the nut is loose, unscrew it the rest of the way by hand and remove any washers or mounting plate and note their exact position and orientation. The blade and adapter should come off easily. Some penetrating oil (e.g., WD40) may help if it is difficult to remove.

If your adapter/blade doesn't pop off after removing the nut or bolt, it may be mounted using a taper like the flywheel. This is somewhat unusual on a walk-behind lawn mower but might be present on a larger machine like a lawn tractor. A wheel puller is best for dealing with this situation but first see if it isn't just gummed up or rusted in position - try the WD40.

Inspect the key or locking tab for damage. You may have:

- A rectangular blade adapter with a welded-on soft metal ring with a tab protruding into a slot in the crankshaft.
- A blade adapter that locks to the crankshaft with a rectangular or D-shaped (Woodruff) soft metal key.

If the adapter's tab is broken off or the key is sheared or damaged, then replacement of the entire blade adapter or just the key (depending on your mower's design) will be needed upon reassembly. For now, if you will be sharpening the blade, replace all the hardware in the correct positions (except the blade) and finger tighten the nut so you won't lose anything.

WARNING: Do not install a hard steel key in place of the recommended blade lock key as you will lose the protection that the soft metal provides and the next incident may be the last... See the section:Why soft metal keys must be used.

Once you have reground the blade or obtained a replacement, reassemble in reverse order and then tighten the nut to the proper torque.

(From: Gib Gahan (gahan@esinet.net).)

Another way to remove a stubborn blade is to take it to your friendly garage or tire changer and have them put an impact wrench on it. Saves knuckles, tempers, etc. Just don't put the blade back on without a touch of oil or anti-seize compound and of course, don't use an impact wrench!

Carburetor adjustments

If your engine is relatively new (made within the last 10 years or so) and has only one speed, then there may be no adjustments (like the one discussed in the section: [Cleaning Craftsman (Tecumseh) carburetors](). It will either work or it won't - in which case it needs cleaning or parts replaced. Or your overhaul was less than 100% effective. You can tell if your carburetor is of this type as there will be no adjusting screws on the carburetor. For Craftsman types, there will be a solid hex nut on the bottom holding the float bowl in place. There may or may not be a primer button.

For adjustable types, it is best to refer to your engine manual. However, here is the general procedure. Some of the specific numbers may differ for your engine, however.

In all cases, before touching any adjustments, make sure your air filter is in place, and clean (or new). Fill the fuel tank about half full with fresh gasoline.

There are three adjustments on a typical carburetor:

- Main mixture - Bottom of Craftsman (Tecumseh) float carburetors.
- Idle mixture - Side into body of Craftsman (Tecumseh) float carburetors.
- Idle speed - Sets relaxed position of throttle plate.

Initially, carefully and gently turn the two mixture controls in until they just seat.

Note: "In" means clockwise (the way you would tighten a normal screw) and "out" means counterclockwise (the way you would loosen a normal screw).

CAUTION: do not force them - you are not trying to tighten anything - as you will damage the needles and seats which will require replacement of the needles or entire carburetor. Then back them out 1 to 1-1/2 turns. Set the idle speed screw 1 to 2 turns beyond where it contacts the throttle plate. Refer to your engine manual for specific recommendations! These settings should allow the engine to start and run, though perhaps not entirely smoothly or with great enthusiasm.

- Start the engine and allow it to reach normal operating temperature - a couple of minutes. Make sure any choke is off once it is started and running stably. This will also flush any old deteriorated gasoline from the carburetor!

- With the engine throttle control set for the maximum recommended rpm, very slowly rotate the main mixture screw counterclockwise (loosen) until the speed begins to drop off due to too rich a mixture. Then, rotate the screw very slowly clockwise (tighten) until the engine begins to cut out. Very slowly means a fraction of a turn at a time - then wait a few seconds for the adjustment to have an effect. Note the number of turns between these two positions and set the screw in the middle of this range.

- Repeat this procedure with the engine throttle control set to the idle or slow speed position but using the idle mixture screw instead.

- If there is a high speed adjustment - possibly on the throttle control itself or the throttle control bracket, it is best to set it using a tachometer. However, it is possible to do a very good job by comparing the speed by ear to an identical type engine that is set correctly. See the section: [Setting engine speed]().

  WARNING: if in doubt, set it low. It is better to end up with a scraggly lawn than bodily injury or a blown engine! Note that by ear, 2 stroke will always sound faster than 4 stroke engines for the same output speed because they have twice as many explosions per rotation of the crankshaft!

- Set the idle speed adjustment just high enough that the engine idles smoothly and isn't about to cut out. A tachometer can be used to set it to specifications but there is no risk is just adjusting it to idle smoothly.

- Test the engine under load. It should respond to load pickup immediately. An engine that dies is set too lean. An engine that runs roughly when picking up load is set too rich. Make a small adjustment (i.e., 1/8th turn) and test again.

Notes on Briggs & Stratton tune-up

(This assumes foam type air filter that needs have a film of engine oil in it to trap dust.)

(From: (Willjim@gte.net).)

Once the air filter is saturated it must be wrung out. I typically place them in a paper towel and squeeze. Then possibly a second paper towel. No oil should be dripping out of the filter when gently squeezed. Chilten's B&S engine section says to simply squeeze the filter of excess oil - no mention of a paper towel, etc.

In adjusting the carburetor, Chilten says about 1-1/2 turns but 2 turns is my standard.

I get the engine running first - warm it up to general operating temp. No applied choke, air cleaner installed. Adjust the main jet if you can get it to run at rated speed - preferably under load (turn in to the lean studder, out to the rich studder then back in about 1/2 way between these extremes). Then adjust the idle, at idle - at no load - using the same operation as the main jet. You may then go back and repeat/refine the process a second time as the idle adjustment may affect the main a bit.

For the 92000 in particular (typical but refer to your specific engine model for exact specifications), from Chilten's second edition, "Repair & Tune-Up Guide for Small Engines" (successor to [2]):

- Plug type: 1.5"/2.0"
  - Champion CJ-8/J-8
  - Autolite A-7NX/A-71
  - A.C. CS-45/GC-46).

- Plug gap: 0.030"

- Point gap 0.020"

- Armature air gap:
  - 2-leg 0.006" - 0.010"
  - 3-leg 0.012" - 0.016"

Setting engine speed

Many inexpensive mowers don't even have a speed adjustment screw. Spring tension and the linkage to the governor set speed - period. Note that actual speed is rarely that critical for engine driven equipment as long as it is within safe limits. See the comments below on string trimmer speed settings. However, what options do you have where there is a need to set the precise engine speed?

- Use a tachometer designed for small engines. If you do a lot of small engine work, this may be a worthwhile investment. For most of us, it would gather dust.

- Use a tachometer designed for automotive engines. You may already have one of these if you do your own tune-ups. Sure, right, that went out of style about the same time as emissions controls! OK, maybe your father did his own tune-ups :-).

  Since an automobile engine spark plug fires on every other revolution of the crankshaft rather than every revolution as with most single cylinder 2 and 4 stroke engines, it will probably be necessary to multiply the reading by a factor of 2.

(Even though there is a power stroke every other revolution for the 4 stroke engine, the ignition system is usually active on every revolution. However, there are a few exceptions to this rule.)

- If you have electronic test equipment such as almost any oscilloscope or frequency counter, it is a simple matter to couple its input to the spark plug wire on its insulation (not to the plug itself!). Then, the speed is equal to the pulse rate for most single cylinder 2 stroke and 4 stroke engines.

- Compare it by ear to another engine of the same type (2 stroke or 4 stroke) that is correctly set (i.e., you didn't muck with it!). This is actually a remarkably accurate way of setting the speed.

For equipment where a shaft with a known speed ratio to the engine crankshaft is available (i.e., a power take-off or trimmer head), an optical stroboscope of one form or another may be used. You will just need to paint or tape some stripes on the rotating part to put under strobe illumination:

- A fluorescent lamp powered by a magnetic ballast (not an electronic ballast) flickers at 120 Hz (in the U.S., 100 Hz in countries with 50 Hz power) and may be all you need to accurately set speed.

For example, for something like a string trimmer which has a direct coupled hub, strobe disks with 2, and 3, and 4 radial lines will appear stationary under fluorescent illumination for 3,600, 2,400, and 1,800 RPM respectively.

There can be ambiguity but if you are already in the ball park, this sort of approach may be all you need.

- Use a stroboscope which is calibrated in RPM or Hz. You may be able to borrow one from a high school physics lab or Disco!

(From: Philippe Habib (phabib@netcom.com).)

Go to a hobby shop that sells radio controlled airplanes. Plunk down $30 or so and get an optical tach. Paint 2 strips on the (crankshaft) hub of your equipment to simulate a propeller, and you're done.

(From: J. Matthew Good (jmg14213@ix.netcom.com).)

You shouldn't need a tachometer on a trimmer. Two stroke engines in the size and power range of line trimmers can't overspeed as they don't have the power with a line head installed. Just set the carburetor up so that it 'two-fours' at wide open throttle and you should be all set. If it needed to be adjusted with a tachometer, it would have some kind of governor on it.

(From: Mowerman (mowerman2687@my-dejanews.com).)

B&S engines have a spring in the governor arrangement. You want to change tension on the spring to change the speed. (This is basically true of most other small engines as well but the details will differ.) The spring is attached to a metal tung in the linkage at front of motor, this is made of a tinny metal so you can easy bend this tung. To lower speed you want to lessen the tension on the spring. You can do this while the motor is running at top speed but it would be safer to do the bending while mower is not running. By pushing in tung you will lessen top speed gently as it doesn't take much to alter that speed. Often this tung gets knocked in while mowing around bushes or other protruding material and "hey presto" your engine is only idling. It is a design problem that briggs should be working on, however I love B&S engines with their simplicity and ease of maintenance.

Adjusting the carburetor on a 2 stroke engine

This is generic advice but probably a good place to start. It assumes that there are 2 adjusting screws - idle and high speed mixture.

(From: foxeye@www.compumise.com).

I would start with them both backed out from the closed position to 2 turns open, for starters. One should be idle mix and the other should be high speed. Crank the motor, get it warmed up. You may have to fiddle with the throttle and or choke until its warmed up. Then slowly turn in the low speed jet, until it starts to die, then back it out another 1/4 to 1/2 turn. Then hold the throttle wide open, and slowly turn in the high speed, until it really starts to smooth out and rev high, and start screaming, then back this out until it starts to run rough or slow down, and then turn it back in to midway between these two positions. Keep playing with the low speed needle until you get rapid immediate response from the throttle, and good idle with the idle adjustment. Then play with the high speed needle, but always back it out from the setting about 1/4 turn or so, from where it runs the smoothest. This setting of backing it out will allow more fuel when under a load, and keep your 2 cycle motor from running too lean. Put a load on it and just tweak the settings just a hair at a time. If you're in the ball park it won't take much adjustment either way to make a difference. Better on the rich side than lean side. Also make sure your oil / gas is mixed at the proper ratio. 99% of 2 cycle motors are adjusted the same, no mater what brand they are. Most will start and run with both screws open 2 turns initially. Just don't close the high speed off any more than necessary no matter how well it runs.

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Troubleshooting Guide

Instant troubleshooting chart - most common problems and possible causes

The following chart lists a variety of common problems and nearly all possible causes. Diagnostic procedures will then be needed to determine which actually apply. The 'possible causes' are listed in *approximate* order of likelihood. Most of these problems are covered in more detail elsewhere in this document.

While this chart lists many problems, it is does not cover everything that can go wrong. However, it can be a starting point for guiding your thinking in the proper direction. Even if not listed here, your particular problem may still be dealt with elsewhere in this document.

(Portions of the following from: Chilten, Small Engine Repair 2-12 HP, (1).)

- Problem: Engine will not start or is hard to start.
  Possible causes:

  1. Fuel tank is empty or shutoff valve is closed, or fuel line or fuel tank cap vent is clogged.
  2. There is water in the fuel.
  3. Carburetor is overchoked.
  4. Carburetor is improperly adjusted or needs service.
  5. Ignition system or its wiring is defective or ignition switch is off.
  6. Deadman or other cutoff switch is open or defective.
  7. Spark plug is fouled, improperly gapped, or damaged.
  8. Engine compression is poor.
  9. Operator needs to read user manual. :)

- Problem: Engine starts easily but dies after a few seconds.
  Possible causes:

  1. Fuel tank is empty or shutoff valve is closed, or fuel line or fuel tank cap vent is clogged.
  2. Carburetor is overchoked.
  3. Carburetor is improperly adjusted or needs service.

- Problem: Engine misses under load.
  Possible causes:

  1. Spark plug is fouled, improperly gapped, or damaged.
  2. Breaker points are pitted or improperly gapped, breaker arm is sluggish, or condenser is bad.
  3. Carburetor needs adjustment or service.
  4. Fuel line, fuel filter, or fuel tank cap vent is clogged, or fuel shutoff valve partially closed.
  5. Valves not adjusted properly or valve springs weak.
  6. Exhaust ports blocked (2 stroke).

- Problem: Engine knocks.
  Possible causes:

  1. Magneto is not timed properly.
  2. Carburetor is set too lean.
  3. Engine has overheated.
  4. Carbon buildup in combustion chamber.
  5. Flywheel is loose.
  6. Connecting rod is loose or worn.
  7. Cylinder is excessively worn.

- Problem: Engine vibrates excessively.
  Possible causes:

  1. Engine is not mounted securely.
  2. Blade or other driven equipment is unbalanced.
  3. Crankshaft is bent.
  4. Counterbalance shaft is not timed correctly.

- Problem: Engine lacks power (possibly after warmup).
  Possible causes:

  1. Old gas, bad spark plug, very thick/dirty oil.
  2. Choke is partially closed.
  3. Carburetor needs adjustment or service.
  4. Ignition not timed correctly.
  5. Air filter is clogged.
  6. There is a lack of lubrication.
  7. Valves are not sealing properly.
  8. Piston rings are not sealing properly.
  9. Head loose or head gasket blown or damaged.
  10. Exhaust ports blocked (2 stroke).

- Problem: Engine operates erratically, surges, and runs unevenly.
  Possible causes:

  1. Fuel line or fuel tank cap vent is clogged.
  2. There is water in the fuel.
  3. Fuel pump is defective.
  4. Governor is not set properly, sticking, or binding.
  5. Carburetor needs adjustment or service.

- Problem: Engine overheats.
  Possible causes:

  1. Magneto is not timed properly.
  2. Carburetor set too lean.
  3. Air intake or cooling fins are clogged.
  4. Shroud or blower housing missing.
  5. Excessive load.
  6. Insufficient or excessive oil.
  7. Improper oil viscosity (4 stroke) or mixture (2 stroke)
  8. Valve clearance is too small.
  9. Excessive carbon buildup in combustion chamber.

- Problem: Crankcase breather passing oil.
  Possible causes:

  1. Too much oil in crankcase.
  2. Engine speed is excessive.
  3. Oil fill cap or gasket is damaged or missing.
  4. Breather mechanism is dirty or defective.
  5. Piston ring gaps are aligned.
  6. Piston rings are worn.

- Problem: Engine backfires.
  Possible causes:

  1. Carburetor set too lean.
  2. Magneto is not timed correctly.
  3. Valves are sticking.

Lawn mower will not start

This is probably the most common problem you are likely to encounter. The cause is very often the same - lack of maintenance.

Note that the assumption here is that it cranks - the crankshaft and blade rotates in a normal manner but the engine never catches. Some larger (Briggs and Stratton) engines may have a low-oil cutoff switch which will stop the engine if the oil level is inadequate. However, this is not likely on a push mower.

- In the case of a recoil starter, you are able to pull on the cord and the crankshaft with the blade rotates and it feels normal but the engine does not start. If it feels like nothing is engaging, then the starter mechanism or clutch may be broken. Of course, if the cord breaks, then the problem is obvious! See the section: Recoil (pull) starter repair for more information.

- In the case of an electric starter, the engine cranks but never catches. If there is no response to the button or key, then the outlet may not be live, the battery may be weak or dead, or there could be a bad connection or bad starter motor. If the motor spins but doesn't engage the engine, the overrunning clutch or gear could be broken.

If you are unable to pull the cord (or the auxiliary starter on one with electric start), there may be a clump of grass stuck between the blade and the deck or there could be serious internal damage, especially if you just encountered an immovable object. See the section: Lawn mower will not start after the blade hit an obstruction. However, you didn't forget to engage the dead-man bar, did you? On most inexpensive mowers this safety interlock is needed to both enable the ignition system and release the blade brake.

Lawn mower is hard to start

Most of the time, the possible causes and solutions will be similar to those where the engine doesn't start at all. So, see the following sections for more information. However, here are some specific issues dealing with engines that do start eventually and then run fine:

- **Cockpit error:** If you have a user manual, read it! The starting procedure for all engines is not the same. Make sure you are following the recommended starting procedure. This may not always be best but it is a starting point (no pun....).

- **Number of priming cycles:** The instructions on priming are often optimistic. In colder weather, twice as many presses of the primer may be necessary. However, overpriming and flooding is also possible. Don't overdo it.

- **Condition of gasoline:** Old or contaminated gas will make any engine harder to start. If the problem is with an engine using last year's gas, drain the old gas and add fresh gas (not from the batch sitting in the can since last year!).

- **First start of the season:** If no maintenance was done at the end of the last mowing (or whatever) season, the first time the engine is started may be tough. However, this may be a one-time problem. Hopefully, maybe. :) Even if all the recommended maintenance was done, the first start may not be perfect. And, for float-type carburetors, after filling the fuel tank, wait a minute or so for the gasoline to fill the float bowl before pulling the cord!

Determining why it won't start

Think: *FAST* - Fuel, Air, Spark, Timing. Diagnosing a balky engine is not difficult but a step-by-step methodical procedure will make it a lot less traumatic. Despite all the warnings, serious problems rarely develop on their own. Most likely, there is a simple, easily remedied cause.

Fuel

Obviously, the engine won't run without gas!

- Is there some in the fuel tank? If it is near the bottom, add enough so that there is no doubt about there being enough to reach the outlet pipe regardless of any slant on which the lawn mower is located.

- Make sure any shutoff valve is open.

- Check for a clogged fuel filter, if there is one. There may be a sediment catching screen at the bottom of the tank as well.

- If your engine uses a primer bulb, does it feel like it is doing something? There is a distinctly different feel when it is actually squirting a little gas into the intake pipe. Check that the rubber hasn't deteriorated but if many pushes still doesn't do anything (and you're sure there is gas in the tank and the engine hasn't flooded from TOO MUCH gas), the carburetor and/or fuel line may need cleaning.

- If you are using gas from last season, discard it and start fresh. While old gas will usually work in an engine in good condition, this is not always the case, especially with one that has seen better days. The more volatile fractions evaporate leaving behind higher flash point gas. Why add another unknown factor to the puzzle?

- There may be water in the gas. If the carburetor has a drain plug, operate it to rid it of the bottom layer which would have the water. If there is no drain, repeated pulling on the starter cord should eventually clear any reasonable amount of water.

Once you have exhausted these obvious problems, determine if gas is reaching the cylinder as follows: Perform the normal starting sequence and then, assuming it shows no signs of wanting to start, immediately remove the spark plug. If fuel is reaching the cylinder, the spark plug should be damp with gas and there should be a very distinct odor of gas from the spark plug hole. If there is none, then there could still be a blockage in the fuel line or the carburetor may need cleaning.

A flooded engine, most likely due to extended unsuccessful attempts at starting or a defective carburetor (float valve stuck open or gas-logged float) will result in inability to start as well and a distinct odor of gas. You might find raw gas coming our of various orifices - air filter as well as exhaust. (Note that in severe cases, enough gas gets mixed in with the oil to significantly increase the level in the crankcase and reduce the effectiveness of the oil. This will require an oil change.

Air

The optimal air:fuel ratio is around 14:1. This must be lower for a cold engine and thus a choke plate or other means to increase the richness of the mixture is usually provided. A choke plate restricts air intake forcing more gas to be sucked into the cylinder. A primer bulb effectively squirts gas into the intake pipe to augment the normal carburetor action. Some carburetors have no choke and no primer but incorporate a small gas reservoir which fills when the engine is off and provides some extra when starting.

To much air results in a mixture that is too lean, burns too quickly, and can result in engine damage over extended periods of operation.

- Check that any choke is not stuck in the open position and not doing its job.
- The carburetor may need adjustment or cleaning.

Too little air results in a mixture that is too rich - there will be loss of power and possibly black smoke from the exhaust. This could be due to several factors:

- Check the air filter. For testing, it can usually be removed to see if the engine will start. However, do not run it for an extended period of time without a properly functioning air filter in place. Some are designed to be washed and reused while others must have their elements replaced.
- Check that any choke is not stuck closed. Though needed to start cold, if the choke remains closed, the engine will not restart and will quickly stop (truly choke!) due to an overly rich mixture.
- A defective carburetor may also cause the mixture to be too rich or too lean.

Spark

All common lawn mower engines require a precisely timed spark to ignite the air-fuel mixture in the cylinder. The existence of a spark can easily be tested as follows:

WARNING: make sure there is no gas in the vicinity when performing the following test!

Remove the spark plug wire and insert the blade tip of an appropriately sized and well insulated (plastic) screwdriver inside the boot or clip in place of the spark plug. While holding the *insulated* part of the screwdriver, position the metal part of the blade about 1/8th inch from the block or frame.

An alternative technique is to use an old, but good, spark plug whose gap has been increased to about 1/8 inch or one specially made for exactly this purpose. In this case, simply connect the spark plug wire to the test plug and hold its threaded part against the cylinder head or other part of the chassis (away from the gas tank!!).

Note: Just positioning the spark plug wire a short distance from the spark plug terminal is not recommended as the results of this test will then depend on the condition of the spark plug as well since the spark will have to jump two gaps.

Have a buddy crank the engine at normal starting speed so that you will be able to hold the screwdriver or test plug steady and be close enough to see any spark clearly. Shield the gap from the sun or bright light if necessary.

You should see a nice healthy spark jump the gap several times on each pull (actually, once per rotation of the crankshaft/blade on both 2 and 4 stroke engines). Note: 4 stroke engines ignite the air-fuel mixture on every other rotation of the crankshaft. The extra sparks fire harmlessly into the exhaust gasses and are wasted. Can you believe it?!

CAUTION: if you are not well enough insulated, *you* will jump several times per rotation of the crankshaft/blade if the ignition system is functioning properly! Hey, that *is* a valid test!

If this test confirms the spark, it is still possible that the spark plug is fouled or bad. See the section: Checking the spark plug.

If there is no spark, then there is a problem with your ignition system.

Lack of spark

If your mower is less than 15 years old, there is an excellent chance that if uses an electronic ignition system. These are very reliable as there are no points or condenser to go bad and no need for routine tune-ups.

However, a number of other problems can result in lack of spark:

Make sure stop switch/stop wire is in appropriate position - confirm with a multimeter, check that flywheel is being spun by starter and that flywheel key is intact to assure proper timing, check condition of points/condenser and setting (if applicable), test magnet (on flywheel) for strength, check the gap between flywheel and magneto core. If these are all fine, test or replace the magneto.

In more detail:

1. Check for a faulty or misadjusted STOP switch. This may be activated by releasing the dead-man bar or by a throttle control lever (STOP, RUN, START). Inspect the cable, linkage, and wiring for damage or for something that may have come loose. Make sure you have the controls set properly to run!

2. Check that your starter is actually spinning the flywheel. If the flywheel is not rotating properly when you pull the cord or turn the electric start key, then there is a problem with the starter, not the ignition system. Or, the flywheel is not tight due to a sheared flywheel key or improperly torqued flywheel nut.

3. Check for a flywheel that is loose and not seating properly on the taper. This could result in no spark if the air gap between the flywheel magnet and magneto core is then incorrect. However, due to the close spacing, you would probably feel and hear serious scraping in this case.

Items (2) and (3) are likely if your just attempted to move a curb with your mower blade (or if someone inadequately tightened the flywheel nut during some previous maintenance).

4. Check for bad connections or defective wiring including faulty or water logged insulation. If you just gave the mower a shower, wait ample time for it to dry out. High humidity may result in more problems if the insulation is not in good condition as well.

5. Check for a weak (or missing) flywheel magnet. Both of these faults are extremely unlikely unless you have been hammering and whacking the crankshaft and flywheel in an effort to remove the flywheel. (This is not recommended - see the section: Flywheel removal.)

6. (a) Electronic ignition - There is likely a single potted module which includes the circuitry and ignition coil. If anything goes wrong with this module, replacement is the only option. Once the wiring and resistance of the secondary has been checked, there are really no addition tests that can be performed on an electronic ignition module without special equipment. A defective ignition module will have to be replaced.

6. (b) Breaker point ignition - Possibilities are bad, dirty, corroded, or loose points or points that are grossly out of adjustment, a bad condenser, or a bad magneto coil. See the section: Maintenance of point-type ignition systems.

See the section: Testing the magneto.

First, check that the dead-man bar is properly disengaging the stop switch when pulled and/or throttle control is properly disengaging the stop switch when in the start or run position.

For anything beyond this, disassembly will be needed to identify and replace any defective parts.

If the no-spark condition happened after the blade hit an obstruction, (1) or (2) are likely. See the section: Lawn mower will not start after the blade hit an obstruction.

Checking the spark plug

Use the proper socket to remove the spark plug and inspect it for damage and general appearance:

- Light gray or brown and smooth - this is the normal appearance. The mixture is correct and there likely no major problems with the engine.
- Excessive black carbon - the mixture may be too rich or the spark plug may be the wrong type for your engine.
- Damage to the electrodes - the mixture may be too lean, timing may be set incorrectly, or the spark plug may be the wrong type for your engine.

The best thing to do at this point is just replace it with a new spark plug and worry about the old one later. Actually, nearly every small engine maintenance book will recommend changing the spark plug every season anyhow.

Testing the magneto

The magneto, like the ignition coil on an automobile, contains two windings:

- A primary with a few turns of heavy wire.
- A high voltage secondary with thousands of turns of super fine wire.

In an automobile, the battery supplies the primary current; in a magneto, the magnet on the flywheel moving past the core at high speed acts as a generator and induces current in the primary.

As the magnets spin past the pole pieces of the magneto core, the points are closed and current builds up in the low voltage winding (and flux builds up in the core). At or slightly before Top Dead Center (TDC), the current (and flux) should be maximum and at this instant the points open. The flux then collapses (and the condenser (capacitor) across the points acts as a snubber allowing the current to bypass the open points and preventing arcing at the point contacts). This rapid decrease in flux results in coupling of the stored energy to the turn high voltage winding and results in up to 10,000 V or more at the spark plug.

(For EE types, this is somewhat similar in basic operation to the flyback converter in a switchmode power supply except that the moving magnet supplies the input power instead of the rectified AC line and the points act as the switch instead of a power transistor.)

The secondary will always be accessible for testing but the primary of an electronic ignition may be not be due to the electronic components:

- Secondary: 3 K ohms (maybe a little higher but not open). Much lower would indicate a shorted winding.

- Primary (if non-electronic and accessible): very low - guessing less than an ohm.

Wires can break due to corrosion or vibration. This would result in an open winding - infinite resistance. Shorts can develop between adjacent windings or to the core. This may be detectable as reduced resistance but without knowing exactly what it should be, there is no way of knowing if a slight discrepancy represents a problem or just slight variations in design or manufacturing.

A more complete test would involve checking the 'Q' or doing what is called a 'ring' test and even more for an electronic ignition. This requires special equipment. Therefore, it is best to swap in a known good unit. They are not that expensive.

Timing

For power to be developed, the ignition of the compressed air/fuel mixture must take place at exactly the correct instant - just before the piston reaches Top Dead Center (TDC) on the compression stroke. With automotive engines, there are mechanisms to advance the spark at higher revs but simple lawn mower engines do not have this complication, at least.

Timing is set on older mowers with point type ignition systems by adjusting the point gap and generally only changes due to wear. However, these changes are gradual and unless the points come loose for some reason, will not likely suddenly prevent the mower from starting. On newer electronic ignition systems, there is basically no adjustment as the position of the electronic ignition coil/module fully determines ignition timing and this is fixed.

However, timing can be grossly messed up if the flywheel key gets sheared and the flywheel then rotates a fraction of a turn on its mount on the crankshaft. The result may be a mower that does not start, backfires or runs erratically, lacks power, won't run and/or start when hot, etc. This is very likely to happen should the blade strike a rigid object causing the mower to stop instantly. In this case one or both of the blade lock key and flywheel key have sheared to (hopefully) protect the very expensive internal parts from damage.

There are likely not going to be any timing marks for that old timing light you have sitting gathering dust somewhere. The only test really is to inspect the flywheel keyway to determine if damage has occurred.

See the section: Lawn mower will not start after the blade hit an obstruction as this is the most likely cause of a sheared flywheel key.

Lawn mower will not start after the blade hit an obstruction

The following description applies to most small rotary lawn mowers with direct driven blades. The vast majority of these use either Tecumseh (as found a variety of Sears/Craftsman equipment) or Briggs & Stratton engines. However, similar comments apply to others as well including Lawnboy two stroke engines and the more modern Honda and other overhead valve type of engines.

The assumption is that the engine started and ran normally prior to the incident. Now, no matter how many times you yank the starter rope or run the electric starter, it will not start at all, bucks, kicks back, backfires, or fails to develop enough power to keep going on its own.

If the blade struck a solid boulder while the engine was set on 'high', more severe damage is possible as even with soft metal keys locking the blade and flywheel to the crankshaft, the inertia of the rotating blade is acting sideways against the crankshaft in addition to suddenly stopping its rotation. This can result in a bent crankshaft. The end of the crankshaft with the blade adapter could be bent without affecting the bearings or internal parts. This would need to be tested for as well. Not that such an occurrence is that much better - the crankshaft would still have to be replaced but at least the bearings in the crankcase will not be damaged.

If the starter will not turn the crankshaft (assuming you remembered in your haste to engage the safety bar) - it is seized or will only rotate part of a revolution before hitting against something solid inside - then you probably have serious internal damage that will require a complete strip down and replacement of some (expensive) parts. If it turns but much more tightly than you recall (assuming you do have the safety bar engaged!) then the crankshaft may be bent - again very expensive. Repair may not be worth it.

However, in most cases, what has happened is that either or both of the blade lock key and/or flywheel key have sheared to protect the crankshaft from serious (and terminal) damage.

If the blade lock key broke, the blade will no longer turn rigidly with the crankshaft and provide the inertia required by many small engines with undersized flywheels. In this case, the engine may try to start but die out with a few "putt-putts" or even kick back on the starter cord. (As a side note, attempting to use a lawn mower engine as a replacement on a piece of equipment that doesn't have something to substitute for the blade's inertia may not work for this reason.)

If the flywheel key broke, the ignition timing will likely be totally wrong and the result may be no ignition, backfiring, kickback, or weak or total loss of power.

To diagnose, proceed as follows:

First, pull off the spark plug wire and tie it securely away from the spark plug terminal (several inches minimum) or remove the spark plug entirely so that there is no chance of the engine accidentally starting. Even though it will not start now no matter what you do, the underlying problem could actually be a flooded carburetor or something else which may correct itself while you are working. Never take chances.

Drain the gas or remove the fuel tank. This will prevent gasoline from spilling out the gas cap vent hole or flooding the engine through the carburetor since you will need to tip the mower to get underneath.

Set the mower on its side (carburetor side up).

CAUTION: Immediately check for oil leaks at the oil filler pipe or elsewhere.

The mower can usually be set on its side for a few minutes without harm but if these occur - you will have to work with it tipped less than 45 degrees or so - propped on wood blocks. Or, use this as a good excuse to perform an oil change and drain the oil (even if the engine is cold, most of the oil will drain out - it will just take a little longer). Just don't forget to refill the crankcase with fresh oil once you have completed your work!

Using an old rag and/or proper work gloves, grasp the blade and attempt to rotate the blade and crankshaft.

CAUTION, despite your lack of maintenance, the blade may be sharp!).

The blade and crankshaft should rotate together. If there is slippage, the key has broken and will require replacement of just the key or the entire blade adapter plate depending on design. If it appears to be intact, then you can assume the flywheel key has broken. The blade key may be broken as well but it is not likely the reason for your failure to start. You should remove the blade to determine this for sure before restoring the mower to service in any case. See the section: Non-violent blade removal.

You can possibly avoid removing the flywheel for inspection of the key by unscrewing the sparkplug, rotating the crankshaft so the piston is at TDC, and noting the location of the magnet on the flywheel relative to the magneto coil pole pieces. The magnet should be pretty close to the magneto in that position. If this is not the case or just to be sure, the flywheel will have to come off to inspect and possibly replace the key.

To get at the flywheel key itself, some disassembly is required.

Flywheel removal

Remove the shroud (blower cover) if you have not done so already. This is usually fastened with 4 screws and hopefully does not involve any head bolts - if so, you will need to tighten them to the proper torque using a torque wrench once you have remedied the problem. You may need to remove the fuel tank (if you have not done this already) and other trim pieces as well.

You should now see the top of the flywheel. In most cases, a large nut fastens the flywheel to the crankshaft. (However, in some designs, part of the starter mechanism is actually used and this is supposed to require a special wrench to remove. However, using a piece of wood as a buffer and tapping the ears in a counterclockwise direction will work also. Refer to your engine manual for details.) Use the proper socket to loosen this nut (counterclockwise). It may be necessary to brace the flywheel securely to gain enough leverage. Make sure this is done against something that can stand the force. Once loose, remove it by hand and then remove any washers or other parts that are under it. Make a note of how these were positioned including which side is up on some cupped washers.

You should now see the keyway. The slots on the crankshaft and flywheel should be aligned. There are two common types of keys:

- A rectangular or D shaped piece of soft metal that locks the flywheel and shaft. You should be able to see if the two identically sized slots are still aligned.

- A piece of soft metal with an L-shaped cross section. The slot on the crankshaft is narrower than the slot on the flywheel and is slightly offset (thus, the L). Again, it should be obvious if the two slots are still aligned.

You may even find that the flywheel is relatively loose on the crankshaft if rotating the blade while holding the flywheel stationary is possible. Either the blade key or the flywheel key or both are broken in this case.

You will have to remove the flywheel to replace the key if it is broken or damaged.

If the flywheel is loose at this point, then the following will not be needed as it can be lifted off.

There are several approaches to flywheel removal:

- The best way by far is to use a special puller designed for your particular engine. Briggs & Stratton and Tecumseh flywheels usually have 2 or 3 holes placed around the center of the flywheel which are used with special puller blocks. These have self tapping bolts which you thread into the holes and then tighten down nuts to pop the flywheel off of the crankshaft. I have made my own blocks for this purpose from scrap steel. If you have a drill press, it is not difficult. Alternatively, you can purchase these from the engine manufacturer. The use of a puller really does reduce the use of 4 letter expletives and virtually eliminates the chance of damage to the flywheel or crankshaft by the alternative techniques.

```
         ___              ___
        |___|            |___|<-------- Self tapping bolts or pretap holes.
         | |              | |
        _|-|_            _|-|_
       | |-| |          | |-| |<------- Tighten nuts to release flywheel.
    ___|_|-|_|__________|_|-|_|___
   |      |-|              |-|     |<--- Plate or block - 1/4" or thicker steel
   |_____|-|______________|-|_____|
         |-|  .-.----.-.  |-|
         |-|  | :----: |<-|-|---------- Flywheel nut - loosen slightly.
         |-|  |_:----:_|  |-|
   ______|-|___ :----: ___|-|______
   //////:-:///|:----:|///:-://////
   //////:-:///|:----:|///:-:////// <-- Flywheel comes with predrilled holes.
   //////'-'///|:----:|///'-'//////     (taper not shown - ASCII limitations!)
   //////| |///|:----:|///| |//////
```

Bolts are screwed into holes in flywheel. Then, plate bears against the flywheel nut (slightly loosened) and the nuts are tightened alternately until the flywheel pops off.

WARNING: do not use an ordinary gear, clutch, pulley, bearing, or other puller unless this is specifically mentioned as a recommended technique in your engine manual. The flywheel could be damaged - possibly not immediately obvious - but the result could be catastrophic failure once the engine is put back into service.

- A 'knock-off tool' is a special closed-end nut that you thread onto the crankshaft in place of the normal flywheel nut. You then are supposed to pry under the flywheel with a pair of large screwdrivers while tapping the knock-off tool with a soft hammer. Aside from the fact that as described, this requires 3 hands, this may or may not work easily. Depending on conditions, the flywheel may pop off at the first tap or may stubbornly refuse to budge no matter how much you whack. If not done properly, it is possible to bend the crankshaft - very expensive. Some people also worry that the shock will damage internal parts or even partially demagnetize the magnet on the flywheel. Thus, my preference for the puller unless the first couple of taps releases the flywheel.

- Many engine books will simply recommend threading the flywheel nut back on flush with the end of the shaft and tapping this with a hammer as above (with the 3 hands). The risk here is that the threads may be damaged in addition to the possibility of bending the shaft or causing other damage. Use a piece of soft metal - aluminum, brass, or lead - to protect the end of the shaft and nut. In any case, only use this approach as a last resort.

Flywheel removal on Briggs & Stratton engines

The following applies to most B&S engines with the square starter shaft. This procedure will be needed to gain access to the points and condenser (on engines without electronic ignition), oil seal, etc.

(From: Foxeye (foxeye@www.compumise.com).)

The square shaft which turns one direction but not the other is the recoil starter pawl. This can be pulled straight up from the round cup that it sits in. There should be a couple of steel balls inside. Some models have a large internal snap ring that holds this in the cup. Remove ring, and pull it straight up. Use a magnet to remove the steel balls. Once you have this starter pawl removed, and the steel balls, hold the flywheel, stationary, and using a block of wood, bump one of the lugs on the outside of the starter cup in a CCW direction.

Once you break it free of its torque, it should be able to be spun off CCW. Remove this starter cup, and the beveled bellville washer under it. Now your ready for your flywheel puller. A strap wrench can also be used to turn this starter cup loose. When installing the starter cup, make sure it is clean and free of grease and oils. A drop of oil or a light coating of grease on the crankshafts stub end (over which the starter pawl goes) is usually recommended. The starter cup only needs to be snugged down, and you don't have to go overboard trying to torque it to ungodly tightness. Snug is sufficient.

Drop in the starter pawl, into the cup over the stub of the crank, and drop in the steel balls, replace larger flat cover over this assy, and insert snap ring if there was one.

Flywheel inspection

Once the flywheel is off, inspect the keyway on the crankshaft and flywheel for damage. Serious damage will require replacement of the affected parts. Slight burrs can be removed with a small file. If there are any cracks in the flywheel radiating from the hole, the flywheel MUST be replaced as this is a serious safety risk - the flywheel could literally explode when run at full speed. However, don't be concerned by surface flash - lines that look like fine cracks resulting from the molding process. To confirm that these are not cracks, there will be no visible penetration inside the shaft hole and fine sanding will quickly remove all traces of this flash.

Assuming there is no serious damage, a new flywheel key should be all you need - about 25 or 30 cents. To confirm that this is all you need, replace the flywheel without the key but line up the two slots as they would be if a key were present. Tighten securely (but it doesn't need to be to the full torque as this is just a test). This should permit the mower to start and run normally but I would not recommend using the mower to actually cut grass until you replace the flywheel key.

To install the new one, insert the key into the slot in the flywheel first and then slip the entire affair onto the crankshaft (I like to use a bit of WD40 for protection as well). The flywheel should seat securely with no detectable free play - it should be on straight and not rock back and forth at all. If this is not the case, the key may be in upside-down or there may be something or some particles of dirt or metal blocking it. Replace the washers, dirt screen, etc., and then hand thread the flywheel nut as far as it will go. Tighten to the specified torque (typically, 30-33 ft-lbs).

Note: There may be a cupped washer between the nut/screen and flywheel. This must be installed cupped-side facing the flywheel or else you will be probably be replacing the flywheel key again very soon :-(.

WARNING: Do not install a hard steel key in place of the recommended flywheel key as you will lose the protection that the soft metal provides and the next incident may be the last... See the section: Why soft metal keys must be used.

Then, replace the shroud, fuel tank, etc. If head bolts had to be removed, it is probably a good idea to slightly loosen all of the head bolts and then retorque them to the proper value in the recommended sequence for your engine.

Why soft metal keys must be used

Normally, the soft metal keys lock the blade and flywheel to the crankshaft. However, should the blade strike an obstacle and stop suddenly, one or both key(s) will shear and reduce the likelihood that the very expensive crankshaft or other parts will be damaged. The reason is that the substantial inertia of the crankshaft and that of the flywheel will tend to try to keep them rotating. Something has to give and you want it to be the 25 cent key and not the $75 crankshaft! However, this isn't foolproof as explained in the section: Why you really don't want to attempt to move an immovable object.

Note that the soft metal flywheel key can also be damaged without totally shearing which may result in slightly incorrect timing. Symptoms may include a mower that is hard to start, runs rough or lacks power, or cannot be restarted when hot. Therefore, always replace the key if there are any signs of damage or wear.

Engine dies or won't restart when hot

(From: Wild Bill (kwag98@tcis.net).)

There can be numerous reasons for the engine to quit running when it gets up to operating temperature.. expansion of metal parts where bolts/screws aren't tight enough, breakdown of the condenser for the ignition points (if equipped), or a possibility of a crack somewhere. An overall inspection of the tightness of fasteners would be a good place to start.

- If the miss is a miss, the problem probably has to do with ignition or the fuel mixture. Check the tightness of the carburetor mounting bolts and where the intake manifold/air-fuel mix tube fastens to the engine block.

- If instead, the miss is popping through the exhaust, this might be caused by a bad exhaust valve or valve seat.

- If there is puffing or popping near the engine head, the head bolts might not be tight.

- If the engine spins over too freely when it's hot.. indicating much lower compression, check the torque of the head bolts.. if they were loose, the engine should now restart.

- If it won't restart until it's cooled down, the exhaust valve (and/or valve seat) may be the problem. If you can remove and disassemble the engine yourself, this isn't expensive to have corrected. If not, the shop labor for tear-down and reassembly will be fairly costly. A common reason for exhaust valve failure is that grass clippings become embedded in the cooling fins around the exhaust port area.

- If the engine is just failing to fire the spark plug when it's hot, there's a good chance that it's time to change the (points and) condenser. This can usually be confirmed by quickly removing the spark plug after it quits running, and grounding the sparkplug base securely to the engine (away from fuel vapors).. then spin the engine to see if there is a hot blue spark with an audible snap, snap noise.

(From: Walt Conner (jerrbear@midwest.net).)

As soon as the engine shuts down, turn the flywheel by hand or DISCONNECT the plug wire and turn the blade by hand to see if there is any compression. I have had several B&S engines that did not have enough valve clearance and when hot, the valve stem expands in length enough that the valve does not properly close. After cooling, engine will be OK. Also could be a bad condenser or the other faults listed above.

(From: Michael Stevenson (mike@gi4xsf.freeserve.co.uk).)

Problems with the ignition coil can make an engine impossible to start when warm (or even stop running when it warms up), apparently this happens on motorbike engines quite often and is caused by a break in the HT coil.

A carbon track forms inside the coil where the wire is broken. When the engine is cold the carbon track has a low resistance and it conducts well enough so the spark is strong enough to start the engine, when the engine is warmer the track resistance is greater and the spark less strong. This problem gets worse over time as the carbon track gets bigger and bigger, the only remedy is to change the coil or electronic ignition module.

Smoke signals

For the most part, smoking is just as bad for a small engine as it is for you. Excessive smoke from the engine may be an indication of problems with the carburetor, rings, or gasoline:

- Black smoke is a symptom of an overly rich fuel-air mixture. This could be caused by a choke that is partially closed, a faulty carburetor, or the need for a carburetor adjustment. Make sure the choke if fully open. See the sections on carburetor adjustment and carburetor cleaning.

- White or black smoke may also result from yard debris, oil, or other contaminants on the exterior of the cylinder as the temperature after a few minutes of operation will reach several hundred degrees F even with proper cooling. Stop the engine and let it cool for a few minutes. Then, check around the cylinder, cylinder head, and under the shroud for grass clippings, leaves, oil or other spills, dead rodents, etc.

- 2 stroke engines will always produce some fine white/blue smoke since the lubricating oil in the fuel mixture is being burnt along with the gasoline. However, excessive white/blue smoke could indicate an incorrect ratio of gasoline to oil or a mixture which has been sitting around for a while - the more volatile gasoline evaporates leaving behind the oil. It could also be an indication of contaminated fuel.

- 4 stroke engines should produce virtually no smoke while running. At first startup of the season, there may be a few seconds of white/blue smoke resulting from the oil squirted into the cylinder at the end of last season (you did the preventive maintenance, right?) burning off as well as white smoke/steam from accumulated moisture. If you tip the mower on its side routinely (to clean out grass clippings, for example), oil may seep into the cylinder resulting in white/blue smoke at startup as well.

  White or blue smoke while running may be an indication of an excessively worn cylinder or rings or a clogged or inoperative breather (the breather assures that there is always negative pressure in the crankcase - if not, oil can get forced up into the cylinder). Or, you may be using the fuel mixture for your 2 stroke weed whacker by mistake!

Lawn mower smoking after oil change

(From: Wild Bill (kwag98@tcis.net).)

I'm assuming that you were trying to use the drain plug at the bottom of the engine, not where the oil is added. Draining is done most effectively when the plug on the bottom is removed and the mower is placed level again, over a catch basin and left to sit.

Oil has gotten into the combustion chamber area. The muffler (if it now contains oil) can be washed (flushed out) in a safe solvent, and allowed to dry.

When tipping a vertical shaft engine to get to the drain plug, keep the sparkplug end of the engine higher than the rest of the engine.. and follow the safety precautions.

Tipping the crankcase end up will put oil at the combustion chamber end of the engine, and seep into the combustion chamber.. and sometimes through the crankcase passage into the carburetor area. In cases where a lot of oil gets into the combustion area.. the engine might not rotate (due to a hydraulic lock), until the oil has returned to the crankcase.

If this should happen.. allow the engine to sit for an hour or so, with the sparkplug end elevated, and most of the oil will return to the crankcase.

If the air/fuel intake area has become flooded with oil, you might need to have the engine serviced.. the carburetor might need to be removed to evacuate the oil from that area.

When the oil gets into the combustion area, the sparkplug is usually soaked.. and after cleaning or replacement, the engine will smoke (for a short time) like a fog machine. This will often foul the plug again, and create a lot of carbon in the combustion area. There isn't an effective way of removing the excess carbon aside from removing the cylinder head. For an old mower, that might not matter much.. for a new one that you'd like to get years of trouble-free service from, you might want to consider having the head removed and the oil & carbon cleaned out.

About squeals and other animal noises

While some may describe the engine of an antique automobile as 'purring', this will not likely apply to most gasoline powered lawn mowers. It would seem that noise reduction is just not a high priority design issue with lawn mower engineers or marketing types. However, even if not exactly quiet, the sound made by a healthy mower should not be similar to that of a pig being tortured.

- A screeching or squealing sound may be the result of worn bearings or inadequate lubrication. This could be due to lack of oil (!!) or a problem with the oil distribution system (pump, passages, slinger, etc.). It could also be a problem with auxiliary mechanical parts - power take-off, front wheel drive, or a starter clutch that fails to disengage.

- Banging or rattling noises may be due to parts that have worked loose due to vibration or by being inadequately tightened (by someone else, of course). The entire engine may be bouncing around on its mount. Or, the flywheel, blade, attachments, or chassis parts may be vibrating. Even if everything appears secure, there is quite a bit of energy associated with an engine running full throttle and parts can work loose.

- A low frequency shuddering or vibration may be due to debris under the deck. Check for wads of matted grass, twigs, branches, and 3 foot logs, caught in the baffles or exit chute. Sometimes, globs of this stuff fall off and get slung by the blades with all sorts of associated strange sounds.

A combination of the above are also possible. For example, a loose flywheel could result in it scraping against the magneto yielding a sound like a cat being squeezed to death (or that of a first year violin student) but possibly only at high revs :-).

Of course, a badly worn engine can also result in piston and rod slap and other mechanical noises as internal parts with excessive clearances whack one another. A complete engine overhaul may be in order or just tolerate it and plan for a new mower when the final day arrives (or your neighbors take up a collection).

Lawn mower fuel tank leaking

Fuel tanks can leak for a variety of reasons including defects in manufacturing, abuse, corrosion, etc. However, before you buy a new tank, a couple of notes:

1. If this is on an Briggs and Stratton engine there are known problems with some models - check with your local small engine repair shop as it may be under a (hidden) warranty.

2. A tank that is filled to the top may appear to be leaking when in fact it is just seepage from the cap vent hole. It may even attempt to fool you into replacing the tank by appearing to come from the seam!

If the tank is truly leaking, DON'T use the mower and drain the gas - you don't want to take chances with a possible engine fire or worse.

Lawn mower too loud

Small engines - especially those on cheaper mowers - are usually loud, no question about it. However, if yours sounds like it is about to explode or take off, there may be something actually wrong.

Obviously, if it is backfiring every other stroke, you have a problem with the ignition timing, mixture, valves, etc. What this section deals with is just the normal noise assuming the engine runs properly - and how to reduce it. Else, you need to perform the proper maintenance first.

- Make sure everything is tight - it may be the engine rattling against the deck or something simple like that.

- Your muffler could be worn out - probably rusted out. Inspect it and if in doubt, just replace. They only cost $3 or so.

Some lawn mowers discharge under the deck. This should reduce the noise level but the proper (probably spark arresting) muffler must be used or else you risk igniting dry grass or whatever as you mow!

- It may be possible to purchase an after-market quieter muffler - check with the suppliers listed in the section: Mower and engine parts sources.

Note that for a 2 stroke engine, the muffler is particularly critical for proper operation and substitution may be more difficult.

Lawn mower wheels

Wheels tend to get banged about and damaged or may just become loose and unstable due to wear. Wheels and wheel bolts are readily available at home centers (or Sears for Craftsman mowers).

- If really frozen, the use of penetrating oil like WD40 or Liquid Wrench should permit the old bolts to be removed using one or two wrenches (sockets preferred).
- In some cases, adding some metal washers on the axle may help to reduce wobble on a worn wheel which is too loose.
- The best type use ball bearings and will outlast the mower but I wouldn't expect to see this on anything less than the gold-plated model! However, ball bearing wheels can be installed as replacements.
- Use of WD40 can help to ease the pain of switching the cutting height of lever operated wheels.

- Back to Small Engine Repair FAQ Table of Contents.

Intermediate Level Maintenance and Repair

Cleaning Craftsman (Tecumseh) carburetors

Simple float carburetors are found on a variety of equipment including many engines made for Sears by Tecumseh. The basic procedures applies to the float carburetors of other manufacturers as well.

If you have been following the recommended preventive maintenance procedures, this may never be needed. But, face it, you do not! The most important PM that is not likely done by 90 percent of mower owners is to drain the gas at the end of the season. With float type carburetors in particular, the result is a buildup which eventually clogs the very fine passageways in the carburetor. What happens is that the gas in the carburetor bowl gradually evaporates leaving behind the gunk and varnish. New gas then flows in from the fuel tank which then evaporates leaving behind more gunk and varnish, and so on and so on and so on. This eventually, well, gums up the works by interfering with float movement and clogging the precision metering holes. Thus, the need for cleaning. Symptoms include difficulty in starting, flooding, surging, lack of power, difficulty in restarting when hot, etc.

The following procedures are specifically for the common non-adjustable carburetors used on the vast majority of Craftsman mowers manufactured in the last 10 years. Carburetors with adjustments and/or a choke are slightly more complex and may differ in other ways. Refer to a small engine repair book or your engine manual for further information.

Carburetor removal

- Drain the fuel, close the shutoff valve if any, or remove the gas tank. On the common Craftsman mowers, the tank either slips off or is fastened with a couple of screws. The gas line should pull right off. Inspect the fuel line for damage or cracking and replace it if these are severe.

- Remove the air filter, inspect, and set aside. The small plastic enclosed air filters twist off counterclockwise. If it is clogged and of the paper type, replacement will be needed. If it has a foam element, this can be reused if it doesn't fall apart. Remove the foam element, clean in soap or detergent and water, dry, and then coat it with a few drops of fresh engine oil. Work the foam with your fingers to distribute the oil. For other types, see your engine manual.

- Use a large philips screwdriver to loosen the two screws fastening the intake manifold to the cylinder block. If the gasket separates easily and cleanly, then it can be reused though a dab of non-hardening sealer is advisable once you have tested the mower to be sure that your newly restored carburetor is functioning properly. If it tears or is damaged in any way, then it should be replaced.

  If the bolts are really tight, an open end wrench may be of help but common sockets may not fit around the bottom bolt. Thin walled sockets may work.

- Disconnect the throttle linkage and governor spring noting which holes they go in. IMPORTANT: If you get this screwed up you could have a runaway situation on your hands when you go to restart it. This can destroy the engine in a few seconds!

- Disconnect the rubber tube from the primer bulb, if any. It should pull off. If it tears near the end, there is probably enough slack so that a new tube is not required.

- Disconnect the speed control and stop switch wire, if any. Note how they are installed.

The carburetor can now be moved to the convenience of your workbench.

WARNING: there is still likely a significant amount of gas inside the float bowl. Initial disassembly at least should be done outside so that you can dispose of this safely. Working outside is advisable in any case as the common carburetor cleaning solvents are both flammable and bad for your health.

Disassembly

Most carburetors on Craftsman mowers are variations on a common float design. Newer mowers tend to have no adjustments and no choke - which greatly simplifies cleaning and adjustment. With respect to adjustment, there is none - it either works or it doesn't. If it doesn't, your cleaning was not thorough enough, some parts need replacement, or the problem is not in the carburetor.

- Under the bowl is a large hex head bolt. On the non-adjustable carburetor, this is closed on the bottom. It is also not a simple bolt but includes the precision main fuel metering hole which will need to be cleaned thoroughly. Use a proper socket to unscrew this bolt (counterclockwise). Drain any residual gas from the bowl. CAUTION: I've heard of people breaking the bolt by either attempting to loosen it the wrong way or overtightening upon reassembly to stop leaks.

- There is a fiber washer under the bolt. There may also be a fiber washer on this nut inside the float bowl. Don't lose these or get them mixed up.

Turn the carburetor upside-down.

- Carefully remove the bowl and O-ring. Inspect these for damage. (Note: there is probably a dimple in the bottom of the bowl in the lower level side. This is normal and probably there to keep the float off of the bottom where gunk and varnish collect because you didn't drain the gas.)

- The float will now be visible. Rotate it to the fully up position. The inlet needle will come up with the hinged part of the float. It is held in place by a wire clip but will now be free. The inlet needle is actually a four sided metal rod with a polished conical tip. Remove the needle and clip.

- Use a pair of needlenose pliers to pull out the hinge pin which will free the float. Careful - the float is made of relatively thin brass and is susceptible to damage.

Check the throttle plate for free movement - there should be absolutely no hint of binding or tightness. If there is, then this will need to be disassembled as well and cleaned:

- Use an open-end wrench to loosen the intake pipe and then remove the nuts and bolts. The manifold will probably come free with the gasket intact. Don't lose the metal strip to which the governor spring attaches. Check for dirt and other debris and set aside.

- Use a 1/8" straight blade screwdriver to remove the screw in the center of the throttle plate. Note the position of the hole in the plate and the orientation of the plate. (The hole should be toward the engine side with the carburetor body upright. Mark it before removal if in doubt.)

- Tap the carburetor if needed to remove the throttle plate.

- Pull the throttle shaft out of the carburetor body. Take care not to lose the spring with the felt and/or metal washer. Note their positions.

Cleaning the carburetor parts

Use carburetor cleaner and lint free cloths or paper towels to remove all built up brown or green gunk, varnish, and other contamination from the metallic parts. Pay particular attention to the machined passages and metering holes.

WARNING: Carburetor cleaner is both flammable and the fumes are toxic. Do all cleaning away from open flames and outdoors if possible. Wear eye protection. The stuff will also eat plastics including some plastic eyeglass lenses.

Take care where non-metallic parts are still in place as extended contact with harsh solvents may degrade their properties (inlet seat and primer bulb, if present). Low pressure compressed air may be used to blow out passages but only use this on the fuel line from inside the carburetor body - else you may end up with the inlet seat clear across the driveway never to be found again.

DO NOT use wires or metal instruments to clear any of the passages as their size is critical.

The small hole in the hollow bolt on the bottom is most critical. Make sure it is cleaned down to the shiny brass and that this hole is unblocked and fully open:

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     _     _
    | |   | |
    | |   | |
    | |   |_|
    | |    _  Hole in nut (approximately .025") - use carburetor cleaner
    | |   | |  and wooden toothpicks to clear it out down to shiny brass.
    | |   | |  DO NOT use metal wires!
   _| | _ | |_
  |    \_/    |
  |___________|
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If you are absolutely sure there is no hole in the bolt (some models may forgo this), check further up on the central tube - there may be a tiny hole about 1/2" from the bottom. There has to be a hole somewhere for the gas to be sucked up through the carb!

I first use carburetor cleaner inside and out with cotton swabs to remove all traces of gunk from the inside. Use as many as needed till no more discoloration shows up. Then, use the broken end of a wooden toothpick or popsicle stick to clear the .5 mm diameter hole in the side. In severe cases, this hole may not even be immediately visible due to the varnish and gunk buildup.

If this hole is narrowed or clogged, the engine may start but then die in a few seconds. Gas enters the reservoir in the nut slowly or is forced in by priming but the normal suction cannot replenish it quickly enough.

Fine steel wool may be used on the float hinge pin if it is rough or there is evidence of rust but do not use anything abrasive on any of the other parts. Persistence with carburetor cleaner and cloths or paper towels should prove sufficient.

Inspect the inlet needle and seat. The needle should have sharp uniform edges and no visible damage to the conical tip. Any damage half way down the conical part - where it actually contacts the seat - will result in leakage and flooding. The seat can be removed if damaged by pulling it out with a hooked wire - careful - you do not want to scratch the body! If removed, do not reuse but install a replacement. The new seat goes in groove side first (lubricate with a drop of oil) and can be pressed home with a blunt rod.

If the throttle plate was disassembled, clean these parts with carburetor cleaner. Use a cotton swab to get into the bearing surfaces in the carburetor body.

DO NOT attempt to disassemble the carburetor beyond this point - the pressed in main fuel nozzle is precisely fitted and is not removable. The welch plug (pressed in disk) should not be removed unless you suspect contamination in the primer chamber (if any).

Carburetor rebuild kits are available and are economical where almost any parts need replacement.

(From: Jim Williamson (Willjim@gte.net).)

If soaking the carburetor in cleaner:

When you remove each part from the dip tank rinse it with warm/hot water (as hot as your hands can reasonably stand). The parts that have passages - force water through the passage. This does two things: (1) rinses the internal passage of the cleaner and any old junk (2) gives you a VISUAL check that water is coming out the other end of the passage. The visual check is the key here - you could use compressed air to rinse the passages but you don't see the exit stream. On a clean passage the exit stream will be nice and solid indicating no particles hanging up in the passage.

Now as for the hot water - this is to help dry the parts off - evaporation. Sometimes once I've rinsed the parts off I'll use compressed air to further dry the passages - or at least manually blowing through them.

Critical considerations for proper operation

- The inlet needle and seat must be in good condition or else the carburetor will flood due to leakage or result in erratic operation due to uneven gas flow. If there is any evidence of damage, these parts will need replacement. The 4 edges of the needle should not be worn (the sharpness would change about 2/3 of the way from the pointed end). If the edges are noticeable rounded, replace the needle. There may be varnish deposits on the needle, rubber seat, and the metal casing in which it is installed. These must be totally removed using carburetor cleaner and soft (wooden or plastic) tools.

- The float height adjustment should be fairly accurate. With the float and inlet needle reinstalled (and the seat replaced if it was removed), invert the carburetor - the float should sit just about horizontal. For more precision, a .210" (#4) drill bit should just fit between the body and the non-hinge end of the float.

- The machined passages must be free and clear and not damaged - never use wires to clean them. Use compressed air, carburetor cleaner, wooden sticks, etc. However, do make sure that they are fully open. There are no blind passages in these carburetors so a strong light should permit you to see that they are unblocked (the following are typical - your model may differ slightly):

    - Air bleed, inlet side angled down toward main jet.
    - Passage to primer chamber, inlet side.
    - Slot towards center at edge of welch plug (may not be present).
    - Pair of main fuel passages in central cylinder in main body.
    - Main metering hole in bowl bolt.

- The hole in the bowl bolt is the main metering orifice and it is critical to the proper operation of the carburetor. This area also tends to collect a lot of crud. It will yield to repeated use of carburetor cleaner, cotton swabs (Q-tips), and wooden sticks. Continue cleaning until you are down to shiny brass. Just don't become impatient and use any wires or sharp tools to speed the process!

- Any primer should be air-tight for it to function properly and for the engine to run properly. Any leaks will result the primer being partially or totally ineffective. In addition, the engine will run rich and contaminants may enter the carburetor. Check for damaged rubber parts or hoses that have fallen off.

  If the primer bulb is on the carburetor, there is a 'welch plug' (a metal disk pressed into a mating cavity) sealing the primer chamber. On the side toward the center, there is a tiny rectangular hole that must be open - it often gets clogged and may not even be readily apparent. Do not attempt to remove the welch plug unless you seriously suspect something is inside. If pressing the primer bulb results in a blast of air out of the hole, it's probably fine. Where the primer is separate from the carburetor, there is usually no welch plug.

- The float must be air (and gas) tight. Shake it - if there is any gas inside, the float will need replacement. (It's possible there may be metal particles or other debris sealed inside at the time of manufacture - this will cause no harm.) Put the float under water - there should be absolutely no evidence of bubbles and leakage. Pinholes sometimes develop in the thin brass and while these can be soldered, this practice is not recommended.

- The large O-ring must seal properly. If it leaks, the engine will run rich and contaminants may enter the carburetor bowl. Replacement is usually recommended whenever the carburetor is disassembled. However, if it is in perfect condition, you can try to reuse making sure that the mating surfaces are clean and smooth. Use some engine oil on the O-ring to assure a tight seal.

Reassembly

Once all parts have been cleaned and inspected - replaced where needed, proceed as follows:

If you removed the throttle assembly:

- Reinstall the throttle shaft along with its spring and felt and/or metal washer. Hook the spring onto the ridge on the carburetor body. Make sure it moves freely. DO NOT lubricate.

- Attach the throttle plate to the shaft with the original screw. Make sure the plate is correct side out and that the hole is positioned on the right facing the upright carburetor from the throttle plate side. As you tighten the screw, slightly rotate the throttle shaft to allow the plate to seat properly - jiggle it a bit at the same time. When properly installed, the plate itself limits the return movement of the throttle. It should be fully closed at this point.

Confirm that the throttle plate moves freely between a fully closed and fully open position - there should be no hint of binding or stiffness.

- Reattach the air inlet pipe with gasket using the two sets of nuts and bolts. Don't forget the metal strip for the governor spring if your carburetor uses this. Tighten securely - 4 to 6 ft-lbs if you use a torque wrench.

Now for the main event:

- Install a new seat if you removed the old one. The new seat goes in groove side first (lubricate with a drop of oil) and can be pressed home with a blunt rod.

- Install the float using the hinge pin.

- Insert the inlet needle hooking the retaining clip on the tab near the float hinge. Check for free movement of the float.

- With the carburetor body inverted, check the float height adjustment. It should seat almost horizontally. For a more precise test, use a 0.210" (#4) drill bit as a gauge across the outer ring of the carburetor body - the float should just touch this. Bend the tab on the float to adjust. (Note: unless you replaced some parts, this setting will probably be fine.)

You can test for proper operation using low pressure compressed air (i.e., by blowing into the fuel hose), or water or gas. Water is safest but you must make sure to dry everything thoroughly before final assembly. To do this, temporarily reassemble the bowl with the hex head bolt. With the carburetor upright, dribble water into the fuel hose until it accepts no more - perhaps an ounce or two. There should be no leakage - the level of water in the hose should not change at all once it stops. If there is any leakage, there is still a problem with the inlet needle or seat - or the float is gas-logged.

- Install the large O-ring around the carburetor body. Use a small amount of engine oil to aid in assuring a good seal.

- Place the bowl over this assembly making sure that it does not pinch the O-ring. Orient it so that the deep part is almost opposite the float hinge (it should actually point directly away from the engine when the carburetor is mounted.)

- Install the hex head bowl bolt and fiber washer. Tighten securely (but there is apparently no recommended torque for this bolt). CAUTION: I've heard of people breaking the bolt by either attempting to loosen it the wrong way or overtightening upon reassembly to stop leaks. If gas leaks out in the area of the bolt head, the fiber washer may be missing or damaged. For testing at least, a non-hardening gasoline resistant sealer like Form-A-Gasket B(tm) can be used.

Carburetor installation

With the carburetor positioned in its approximate location on the engine:

- Reinstall the throttle and governor linkages Where there is no speed adjustment or idle position, the direct governor linkage goes in the hole closest to the engine and the spring hooks onto a fixed vertical metal strip with only one hole at one end and the lower hole in the governor lever at the other. Thus, in operation, the spring attempts to keep the throttle open and the governor pulls on the throttle to close it. Increased spring tension results in higher speed. Don't get these backwards when you go to reinstall the carburetor on the engine!!! See the section: Throttle/speed control linkages on Craftsman/Tecumseh engines.

- Reattach the primer tube, if any.
- Reattach the stop switch wire, if any.
- Install the carburetor onto the engine with a new gasket if needed. Tighten securely (6 to 8 ft-lbs).
- Double-check that the throttle linkage and governor spring are in the proper holes and nothing is binding - you should be able to move the throttle back and forth without any sticking or tightness. It should return to the full counterclockwise position instantly as a result of the governor spring tension.
- Do not replace the air filter at this time.
- Reinstall any throttle selector or cable. Confirm that it operates properly - usually STOP, LOW, HIGH. STOP should engage the stop switch. LOW should leave the governor spring tension where it was. HIGH should increase the governor spring tension slightly. If there is an IDLE position, the throttle plate should be almost closed.
- Reinstall any trim pieces that were removed.
- Reinstall the fuel tank and fuel hose with clamp, if any. Open the fuel valve, if any.

Throttle/speed control linkages on Craftsman/Tecumseh engines

The following is for one model! NOT ALL ENGINES ARE SET UP THE SAME! It is best to consult your engine manual. Getting it wrong is not something you really want to do! :(

The user speed control (if any) pulls on a spring which is attached to the 2nd hole from the top on the governor lever. For engines with no speed control, there is a fixed plate or tang to which the spring is attached. Some amount of adjustment is possible by bending this plate.

The carburetor throttle plate has several holes in it. The one that is probably used is that closest to the little cutout (which I can't show with ASCII art) and the tip of the throttle plate return spring. You can probably confirm this by looking for which hole has the paint worn off!

```
             __                              _
  Open <-- /    \ --> Close                 | |
          |o=========.               ,=======o| Top hole
           \ O   /    '============='       | |
             \_/ Carburetor   +-- ===========o| Next hole
     _           Throttle     |             | |
    |o|          Plate        +-straight-+  | |
    | |                                  |  | |
    |o=====o---/\/\/\/\/\/o========== ---+  | |
    | |           Spring                    | |
   | O |                                    | |
 Speed Control                              | |
 or Fixed Tang                    Governor  |_|
(linkages may cross)                 Lever | O |
                                           +---+
```

See: [Neil's Tecumseh Throttle and Carburetor Linkage Page]() for some slightly better diagrams. :)

Initial tests

Add a small amount of gas to the fuel tank - perhaps half a glass or so. Just enough to assure that it will reach the carburetor even if the mower is slightly tilted or jostled.

Inspect around the fuel hose and carburetor body for fuel leaks. If gas starts dripping from the air inlet or anywhere else, there is still a problem with the inlet needle and seat. Disassembly will be required.

Only a few seconds are needed for the gas to fill the carburetor bowl.

Assuming there are no leaks, install the air filter and reattach the spark plug wire or reinstall the spark plug. Attempt the normal starting procedure - prime if recommended.

The engine should start on the first pull! Immediately move the throttle selector to LOW if you have this option. Confirm immediately that it stabilizes at a reasonable speed - stop it quickly if it sounds like the mower is preparing for takeoff - your governor connections are incorrect or binding. If it runs at a fast speed with the speed selector set at LOW, the governor spring is probably in the wrong hole. Check it.

Listen and feel for any significant unevenness, surging, or other unusual behavior. Stop the mower, wait a few seconds, and restart. It should restart with a single pull without priming.

Mow for a few minutes. Stop the engine and confirm that it restarts without priming. Listen and feel for any indication of lack of power or other unusual behavior.

Go take a dinner break. Then confirm that the engine will now start - priming may be needed since it will now be cold.

Maintenance of point-type ignition systems

In most cases, missing or total lack of spark will be due to dirt, pitting, or corrosion of the points or a failure of the condenser. Timing may affected as well by excessive wear. The following procedures should restore the ignition system to good health:

First, test for spark. If there is a spark, try replacing the spark plug since this is the most likely cause of ignition problems. With a spark present, there could still be ignition system problems but this is much less likely.

You may be able to test the points to some extent if you can get to the wire that connects to the magneto or the STOP switch. A multimeter on the low ohms scale will the permit you to watch the opening and closing of the points.

If this confirms that the points are operating the condenser could still be defective, the breaker arm could be sluggish, or the point gap could be grossly out of adjustment.

To proceed further:

- Remove any trim pieces and the shroud/blower housing to access the flywheel, magneto, and points assembly under the flywheel.
- Check the flywheel magnet to magneto core air gap. While it is extremely unlikely that this increased, it is an easy test. The correct value is usually .015 inches but some engines use other gap spacings. A non-magnetic feeler gauge is best for this. If it is much larger than specified, adjust it and test for spark again.
- Remove the flywheel. See the section: Flywheel removal.

- Test the flywheel magnet. No actual strength is usually published but if it attracts a steel screwdriver from at least a 1/2" distance and seems strong, the magnet is likely fine. If it is weak (or missing, though this is mostly a theoretical possibility!), the flywheel will need to be replaced.

- Remove the cover over the breaker points assembly, if any.

- Inspect the points. There should be no serious pitting, corrosion, evidence of arcing or sparking. Nor should they be welded together!

  If any of these problems are present, replace the points and condenser as well - a bad condenser may be the cause of the points failure it is not really possible to fully test it.

  You can also test for electrical operation of the points using a multimeter on the low ohms scale while rotating the crankshaft (you will have to use the blade - careful) or operating the breaker arm manually.

  Or better yet, just replace the points and condenser. The cost is minimal (probably under $5 for a rebuild kit) and you have already done most of the work.

- Note the mounting arrangement and remove the old points and condenser and install the replacements. Do not tighten the locking screws at this time.

Setting the point gap and ignition timing

Perform the following whenever the breaker points assembly is replaced or where a timing problem is suspected.

- Rotate the crankshaft so that the cam that operates the points is at the highest location and the points are wide open.

- Adjust the point gap setting to specifications using a feeler gauge. This is nearly always .020 inches.

- Set the crankshaft position. This is usually done statically and does not require a timing light (Darn!).

  - On many engines including Tecumsehs, there is a timing dimension in the engine specifications. This is the distance of the piston below Top Dead Center (TDC) at which the points should just open.

    While measuring piston position with a scale through the spark plug hole, rotate the crankshaft until the piston is precisely at TDC and note this distance. (There are special timing gauges for this purpose with lock screws to hold the setting but a little ruler will work just fine.)

    Now, turn the crankshaft in the opposite direction from normal rotation (usually counterclockwise as viewed from the flywheel end) until the piston moves down .25 inches or so and then turn it slowly in the normal direction of rotation until the piston position is precisely at the timing dimension listed in your engine specifications.

  - On some engines there will be timing marks on the flywheel and engine block or the manual may tell you to line up the one edge of the flywheel magnet with one of the magneto pole pieces.

    The flywheel should be temporarily re-installed without tightening the nut.

    Rotate the crankshaft until the timing marks are precisely aligned.

    Carefully remove the flywheel without disturbing the crankshaft position.

- Adjust the timing. Loosen the locking screw on the points assembly. Rotate the points assembly until the points just open (use a thin piece of cellophane or a multimeter on the low ohms scale. Lock the position by tightening the set screw.

- Double check that your settings have not shifted.

- Replace the cover over the points assembly, if any.

- Reinstall the flywheel and associated hardware and tighten to the specified torque (30 to 33 ft-lbs). Make sure the cupped washer, if any, has its cupped-side facing the flywheel. (Defer tightening to full torque if the engine is not presently mounted solidly on the equipment. Just don't forget!)

- Check, and if necessary, adjust the magnet to magneto coil spacing using a non-magnetic (preferably) feeler gauge or shim stock (typically .015 inches though some are .005 to .008 inches, see your engine manual).

- Replace the shroud/blower housing and any trim pieces that were removed if no other servicing is to be performed on the engine.

Recoil (pull) starter repair

- Broken starter ropes or failure to retract are both repairs that are fairly easy. However, the spring can be nasty as it is under tension (or should be when reassembled). This can be risky if you are not familiar with the internal construction as you disassemble the unit.

  The cause of a broken cord is obvious. The cause for a failure to retract could be a broken spring, tangled or frayed rope, or some other mechanical failure. A broken spring will require total disassembly of the starter mechanism - fortunately there really isn't that much involved.

  With some designs, it is possible to replace the cord without fully disassembling the starter mechanism - by threading the cord in and tying a not in the end - but after rotating it several turns to put the proper tension on the spring. This is relatively safe but may be frustrating as 3 hands are sometimes needed.

  Where safe disassembly is not obvious, I would recommend that you refer to a book on lawn mower or small engine repair from the library or the service manual for the mower, if possible. You may be able to find specific step-by-step instructions which will minimize your risk of injury from an encounter with an uncontrolled spring.

- When the rope pulls out and retracts normally - but doesn't do anything else - the most likely cause is a problem with the one-way clutch. This may be part of the spring-rope assembly - usually removable as a unit - or attached to the flywheel. The most common problems are gummed up lubrication or a broken spring or other damaged or worn parts. For common engines:

  - On Briggs & Stratton starters, the clutch is often part of the flywheel nut assembly. The entire unit can be easily removed and replaced if it fails to engage reliably.

  - On Tecumseh starters, pawls in the starter assembly engage a serrated cup held in place by the flywheel nut. Check for damaged parts or gummed up lubrication.

WARNING: Take extreme care should you need to disassemble the portion of the starter that includes the mainspring - that can be nasty.

Broken lawn mower handle

Should the tubular handle on your mower break at some point (yes, I know this should be unlikely but I know of two people who have managed to do it!), the use of a splint is probably the best approach. Obtain a length of steel pipe with an inside diameter just a hair larger than the outside diameter of the handle. About 8 to 12 inches should be enough. Even electrical conduit may work. Use this to splice the joint. Drill holes through both the pipe and handle and secure with sheet metal screws. This will maintain the required strength and keep the handle the same length as it was originally so you will not have to become a midget to mow your lawn.

Diaphragm carburetor problems

> "I Recently inherited a BobCat Snow Blower from the 60's or 70's. It has a Lausen 3.5hp (HR35P-2403P). I just installed a Tecumseh Rebuild Kit#631893. The unit runs way too rich, I run out of gas in 10 minutes, the muffler starts to glow red. I cannot get it to idle. I installed a new needle, seat/jet and diaphragm. During the rebuild I did not remove the welch plugs. I tried swapping the idle screw with the high speed screw (not sure which is which). One screw has a smooth taper while the other has a taper with a step to it (no evidence of scoring). Could I be missing a key piece that regulated fuel flow? The rebuild kit did not come with directions, so I just installed everything in reverse."

The idle mixture screw is the one with the step.

I assume you have any choke off, throttle connected properly with spring return, etc.

What happens if you close both idle and main jets? Does it starve? I would expect that you should be able to stop fuel flow totally. If this is not possible, your needles or something else is incorrect/worn or fuel is somehow bypassing the jets which is also wrong.

Did you compare the old and new parts to make sure they gave you the correct kit?

It also recommend removing the Welch plug and blowing compressed air through the passages to clean.

It might also be a problem in the diaphragm spring pressure but without seeing it, no way of knowing. The diaphragm acts against atmospheric pressure. There is a spring on the inlet needle which if missing would run very rich. Chilten has a detailed diagram - really no way of knowing if your assembly was done correctly. Also, warns again using harsh cleaners on non-metallic parts and clearing all vent holes.

However, I rather suspect that comment about running rich is not correct as an engine running very rich would lack power if it continued to run at all. Your throttle may be stuck wide open and it may be over revving.

Your public library should have some Chilten or other books like those listed in the section: References. These should include diagrams of the diaphragm type carburetor.

Metal gas tank repair

Yes, you have to remove the gasoline first! And, make sure all traces of vapors are gone - if it smells like gas, it may very well explode!

(From: Greg Fretwell (JRFC31A@prodigy.com).)

The best way is to braze it, but before you get your torch out take a bottle of ammonia to the car wash and have them steam the tank out, pour in some ammonia and rinse. Repeat a few times. Ammonia will remove the residual gasoline and make it safe to weld on. This is the procedure required by the welding shop that fixed my tank. They needed to see the receipt from the car wash before I could even bring the tank on the property.

(From: Doug Younker (dougy@ruraltel.net).)

I have gotten lucky and have been able to solder repair leaks in small engine tanks using my 140 watt soldering gun after leaving the tank to preheat in the sun all afternoon while I was at work. You have to be patient to do so...

- Back to Small Engine Repair FAQ Table of Contents.

Engine Overhaul

When does this information apply?

This chapter deals with the following:

- Indications for the need for an overhaul.
- Engine disassembly down to the last nut.
- Inspection of major parts for wear and damage.
- Basic replacement or repair of any broken or damaged parts.
- Engine reassembly.
- Post overhaul testing.

For detailed instructions on valve grinding, cylinder reboring, or main bearing reaming, for example, you should refer to one or more of the books listed in the section: References. However, this chapter will give you the general feel and basic information needed to perform many common types of simple overhaul operations and to evaluate the need for more drastic action - such as a trip to the new lawn mower store!

Depending on your particular problem(s), only a subset of these sections may apply. For example, inspection and cleaning of the valves and combustion chamber - even valve regrinding (but we said we weren't going to talk about that!) can be done with a minimum of engine disassembly.

Do you need an overhaul?

Many common problems can be remedied without going into the deep dark recesses of the engine. However, some will require either a partial or total overhaul. Eliminate all other possibilities from consideration before considering an overhaul - it will not be a fun afternoon (or weekend, or week, or month,....).

The following are indications that at least a partial overhaul may be needed:

- Mechanical damage - broken, damaged, or bent parts resulting in inability to start or even turn the crankshaft for starting or excessive vibration while running. In most cases, this will be obvious - the mower died very suddenly - possibly with a loud clunk or p-ting and now the crankshaft hits something really really solid inside when attempting to pull the starter.

- Low compression - this is due to wear or abuse (lack of oil) of parts like the rings or valves or due to a blown head gasket. Perform the compression test described in the section: Compression testing. Symptoms would be difficulty in starting and unusually little resistance when pulling the starter cord, and perhaps, loss of power once you get it started. If rings are bad, there may be excessive oil consumption and blue exhaust smoke. If only the valves are involved, only the cylinder head may need to be removed.

- Excessive oil leaks - a failure of the oil seals (the lower one on mowers at the PTO/blade end, most likely) will result in oil dripping or pouring from under the mower deck. The blade will be coated with oil and there will be a puddle where the mower is stored. Of course, if this is severe enough or neglected, you may end up with much more serious problems when the internal parts fail due to lack of lubrication. Replacing an oil seal is not difficult. The old seal is removed by piercing its thin metal shell with an awl or ice pick and carefully prying it out. Take extreme care not to scratch or dent the mounting surface or crankshaft. This may be possible without extensive disassembly. The new one is then pressed on. In fact, installing the new seal is best done with the crankshaft in place as there will be less likelihood of damage to the new seal and it can then be driven in straight. There is a special tool for this but a piece of pipe that just fits over the crankshaft cut off square will work just as well. Remove any burrs on the crankshaft to prevent damage to the new seal and take care that any rubber lip on the seal does not get folded over.

- Excessive noise - knocking, banging - while an engine powered piece of machinery is not exactly quiet, there should not be unusual or excessive mechanical noises. Such noise can be an indication of an excessively worn engine or of some part that is about to fail. Should you strip the engine based on this? I cannot say - it is a judgement call. It something about the sound suddenly changed, then investigating the cause is certainly warranted.

In some cases, multiple problems may be present and/or there may just be excessive wear of parts like the cylinder, rings, and piston. Under these circumstances, the cylinder may need to be rebored to accept a replacement oversize piston and ring set. The cost of the parts and labor (you really don't want to rebore a cylinder) will likely be more than you want to spend. This is when a new engine or mower is the best option.

Comments on engine rebuilding

While the specific question dealt with a medium size snowblower engine, the comments should apply to other yard equipment as well.

> "Is it economical or feasible to properly rebuild a 7 HP Tecumseh engine on a snowblower? Compression seems fine. Has been burning oil to some degree for the last 3yrs, but this year its' burning a lot - maybe 1/2 pint oil for each gal of gas. Until last year, was using 5W30. This year, switched to straight SAE30. I could get a new Tecumseh SnoKing engine for about $350 including shipping."

(From: Mother (jmg14213@earthlink.net).)

As a finalist in the All-American Engine Repair Championships formerly held at the Outdoor Power Equipment EXPO (an industry trade show) in the Tecumseh division, and as a Briggs and Stratton Master Service Technician, it has been my experience that:

1. Yes it is POSSIBLE to rebuild one successfully, although if it is not an HH model with cast iron bore, it probably will not hold up (single H models are aluminum bore).

2. It is not cost effective to do so.

3. Short blocking this engine requires special tools if it is more than ten years old, as the ignition timing is not fixed, as it is on newer, solid state models.

4. Engines from companies like Northern Hydraulics may be adaptable to your unit, but will likely not just bolt on.

If this engine is on a top of the line product, such as Ariens, Snapper, or BearCat, it is probably worth repairing, as a new comparable product is big bucks (and overpriced).

If this engine is on a mid-range product, such as Toro, Simplicity, John Deere, Husqvarna (European product, not USA built), etc., then repair is probably still a good option, due to the overpricing of similar replacement products.

If it is on a Murray, Noma, AMF, Dynamark, Ultra, Sears, MTD, YardMan, White, Husqvarna (USA built by Murray/Noma), or other discount store brand, go buy a new machine. The cost of a new unit is not much more than the cost of the engine repairs, and then you won't have a worn out piece of discount store equipment to break down again in three weeks when something else goes bad...

Compression testing

Special compression gauges are available at auto parts stores or small engine parts suppliers. These will catch and hold the highest pressure reached so you don't need to be in two places at once.

Note that this procedure may always yield a very low reading if there is a compression release mechanism on your engine - which is very likely. In this case, the crankshaft must be spun in the opposite from normal direction by the flywheel (counterclockwise when viewed from the flywheel end, with the starter removed).

- If the compression gauge has a screw thread, install it in the spark plug hole so it snug - it doesn't need to be really tight. If it just has a rubber boot, have a buddy hold it in place in the spark plug hole as you perform the following tests.
- Pull the starter cord several times or use the electric starter in the normal manner.
- New Tecumseh engines should have a compression reading of at least 80 psi. If your reading is at least 60 psi (or the specification found in your engine manual), then compression is acceptable.
- If it is less than expected, squirt a small amount of engine oil in through the spark plug hole so it coats all around the edge of the piston and cylinder.
- Repeat the compression test.
- If the pressure reading is now acceptable, then the rings need replacement or the piston/cylinder are excessively worn. If there is little change, there is a valve problem.
- If the measurement is very low under both conditions, there may be a blown head gasket or damaged (punctured) cylinder or head. (Or your engine has a compression release mechanism which is reducing the reading - see the note above).

For Briggs & Stratton engines, the manufacturer simply recommends spinning the crankshaft by the flywheel in the opposite from the normal direction with the normal spark plug installed. A sharp rebound (as it compresses the trapped air since the compression release mechanism is not active in reverse) indicates good compression. Little or no rebound indicates low compression and need for service.

Should you even bother?

Only you can decide if the time and effort will be worth it. If you enjoy a challenge, then engine overhaul may be for you. However, this is probably not going to be your idea of fun. Doing something like this for the first time *will* result in scraped knuckles and the liberal use of 4 letter expletives. If the mower was a Hechinger's $100 special and has seen several seasons of use, then it may be time for a new one.

If you are not the detail oriented meticulous type, you may be better off leaving this sort of overhaul to a professional or buying a new engine or mower. Most parts must go back in exactly the same orientation as they were originally - including matching of timing marks on the crankshaft and cam gears. Even the piston is not symmetrical - though this is not obvious except by taking detailed measurements. Nonetheless, it will not work well if at all, or will wear quickly if rotated 180 degrees upon reassembly.

Furthermore, once a wear pattern has developed, it is generally a good idea to replace parts in exactly the same position - the direction of the piston (wrist) pin or location of the intake and exhaust valve lifters. Violating this rule won't result in immediate failure but could lead to excessive wear and reduced life

What this means is that you cannot assume anything about the parts you remove. Even if they look identical at first glance, they may have a definite right and wrong orientation and/or may want to be replaced in exactly the same location. Even lowly head bolts may be of different lengths. Make notes and diagrams. Most of these will be pretty simple but they will save your hide in the end!

Bearing surfaces are very finely ground and polished - just dinging the crank pin journal surface against a steel part will put a nick in the relatively soft bearing which will need to be carefully removed as best you can - affecting as little else as possible - with very fine emery cloth.

In addition, if you don't like to get your hands dirty and oily, forget it. You will have disgusting black crud under any surviving fingernails for days. This is a messy operation! The outside of the engine will be coated with decayed grass clippings, dust, and dirt. The inside of the crankcase will have the remnants of old used motor oil (also a carcinogen) and the combustion chamber will be coated with filthy carbon deposits.

At the same time, cleanliness is critical when reassembling as any particles of dirt or metal will find their way between rotating parts resulting in excessive wear or worse.

Having said all that, overhauling a small engine is not like overhauling an automobile engine. In the words of a colleague: "It's just a frick'n lawn mower". What this means is that you can get away with tolerances, imperfections, and mistakes in dealing with a small engine that would be unacceptable for the health of your Chevy or Porsch.

Special tools

For most of the procedures described below, the basic set of items listed in the section: Tools and supplies will suffice. However, some of the following more specialized tools may be needed depending on how far you go:

- Micrometer - many of the measurements of wear to engine parts requires determining the diameter of shafts or bearing surfaces. Except for the piston, most of these can be accommodated by a micrometer with a maximum opening of 1 to 1-1/4 inches. However, in many cases, what is important is not actual diameter but clearance - and this can be determined with the inexpensive 'plastigauge' or a substitute.

- Plastigauge - these are disposable pieces of calibrated plastic used to determine the critical clearance between the rod bearing and crank pin journal.

  You place one in between the rod bearing and crank pin journal and tighten to specifications. When removed, simple measurements on the markings on the squashed plastigauge will very precisely determine the clearance, taper, and out-of-round specifications for your bearing. It is also possible to obtain most of this information by using slips of paper or foil of known thickness but this will not be as accurate or convenient.

- Flatness gauge - a good machined straight-edge and a set of feeler gauges will suffice for checking the mating surfaces of the cylinder and head.

- Ridge reamer - the 1/8" or so above where the piston slides in the cylinder will develop a buildup of carbon. In addition, if the engine has seen really heavy use, the metal in this area will be higher (less worn) than the section below. In order to remove the piston, this ridge must be eliminated or else it either won't come out or you risk breaking the rings.

Fortunately, the metal ridge is rarely a problem on lawn mower engines and the carbon ridge can be removed with a simple homemade tool which is just a soft metal (i.e., aluminum or brass) piece with a straight edge or inside right angle. You probably will not need an expensive commercial ridge reamer tool. You will not need one at all unless you will be removing the piston.

- Piston ring compressor - when reinstalling the piston and rings, it is virtually impossible to squeeze the rings together to fit into the cylinder without some help. Commercial piston ring compressors are available for about $5 or you can make your own from a large hose clamp and strip of sheet steel (say, 1" x 12" x .020"). This tool is not needed unless the piston is being removed from the cylinder.

- Piston ring expander - this allows the easy removal of piston rings from the piston. With care, you can do this by grabbing the two sections of the ring and guiding it off the piston by hand. In any case, unless you will actually be removing the rings from the piston, this tool will not needed.

- Valve spring compressor - in order to remove and reinstall the valves, their rather powerful spring must be squeezed together tightly. This is almost impossible to do without this tool. I have done it with an improvised clamp designed for holding lab equipment but it was barely up to the task and not fun. However, unless you are going to remove the valves, this tool will not be needed.

- Rubber mallet - the engine overhauler's 'persuader'. In particular, to break free the crankcase/oil sump joint and for reinstalling the piston using the piston ring compressor. A small one will be more than enough.

- Scrapers - to remove built up carbon deposits and stuck gasket material - start with a strip of aluminum. For stubborn deposits, a flat edge paint scraper or straight blade screwdriver will come in handy. Take care not to scratch any machined surfaces. Coarse steel wool can then be used to finish up after the major deposits have been removed. For fine work, an X-acto knife also is useful.

- Wood blocks (4" x 4" x 8" typical) for supporting the engine on your workbench.

- Rags, paper towels, and more rags. Just make sure to dispose of oil soaked material safely. Plenty of old newspaper to protect the ground or table top.

Prepare your work area

Once the gasoline and oil is drained, all overhaul work can be done indoors. Without gas, there is little risk and working indoors is generally much more convenient. Therefore, you need to decide where to set up for the overhaul. The best location will be relatively dust free, well lit, and not likely to be required for other purposes. Your engine may be remain in a disassembled state for some time if you need to obtain replacement parts. Also, even with its bodily fluids removed, an old engine will stink. Therefore, the dining room table is probably not the ideal choice!

Lay out a healthy layer of old newspapers to protect the workbench from oil and solvent drips and damage from heavy tools and parts.

Engine overhaul procedure

The following description applies directly to a large number of Craftsman mowers using Tecumseh engines (most do). However, with minor modifications, it is also applicable to most other mowers using 4 stroke engines.

Mechanically, 2 stroke engines are very similar. In many respects, they are simpler having no camshaft operated valves or oil pump. There is no oil to drain or change. However, needle bearings are used in key spots which complicate matters slightly. Refer to one of the books listed in the section: References for detailed 2 stroke overhaul procedures.

Prepare the engine for removal

While for certain repairs it is quite possible to work on the engine while still mounted on the mower or other yard equipment, it will almost always be much more convenient to disconnect and remove the entire engine to the convenience of your workbench. There are generally only a handful of actual connections. A typical small engine is remarkably light and compact once stripped of the mower deck!

- Disconnect and secure the spark plug wire.
- Drain the gasoline or remove the fuel tank and store in a safe place.
- Drain the oil from the crankcase/oil sump. While this is not essential for all overhaul operations, it will eliminate any risk of oil pouring out or going where it should not when you turn the engine over or on its side. In addition, this further reduces the risk of explosive fumes which might result if excessive gasoline has contaminated the oil. Finally, now is a good time for an oil change! Refer to the section: An oil change isn't really a big deal. (However, you won't be refilling until later.) Don't reuse the old oil even if you recently changed it and dispose of it in an environmentally friendly manner.
- Brush or vacuum off the exterior of the engine above and below the deck and then wipe it down with an old rag to remove decayed leaves, grass clipping, dirt, oily grime, dead (or live) rodents, whatever. The cleaner it is when you actually start work, the better off you will be and there will be less chance of contaminating the interior.
- Detach (and label if there is any doubt about how they are connected) any throttle or dead-man control cables.
- Remove the blade (or anything else driven by the crankshaft). See the section: Non-violent blade removal. Don't lose the locking key if it is separate!
- Remove any auxiliary drive (self propelled) or power take off. This may be a belt or chain above or below deck.
- Disconnect any electric start wiring from the mower.
- Check for and remove anything else that would prevent the engine from being detached from the equipment.

Remove the engine

At this point, the engine should be free of all its attachments to the mower except for its mounting. For a typical rotary mower, there will be three large bolts accessible from under the deck. Removing these with the proper socket will allow the engine to be lifted and moved to your workbench. You will probably be surprised at how light it is! I recommend just screwing the bolts back into their threaded holes finger tight. That way they will not get lost and the threads will be protected. Also, Protect the threaded end of the crankshaft with a bit of rag or paper towel fastened with an elastic band.

Engine disassembly

The following sections provide the detailed procedures for disassembly and initial inspection for major damage. As noted, these apply directly to most Tecumseh engines but most other 4 stroke engines are very similar.

Removal of the accessories

Now it is time to get down to business! As noted, depending on your situation, not every step will be needed.

- Remove any trim pieces which cover the engine. Depending on how much you paid, the engine may be nearly bare or have multiple plastic doodads covering up what is essentially that same bare engine!

- Remove the gas tank if you have not done so already. A spring loaded screw clamp may be used to attach the fuel line to the tank - use a pair of pliers, socket, or screwdriver as appropriate to loosen it.

- Remove the oil filler pipe, if any. This is usually fastened to the shroud/blower housing with one or two small screws. Thread these back into their holes finger tight so they will not get lost.

- Remove the shroud/blower housing. This is usually fastened with 4 small bolts (they may be different sizes - replace in the threaded holes so they will not be lost. If there is a primer tube running to the carburetor, disconnect it at whichever end is convenient.

- Remove any electric starter components - starter motor, gears, etc.

Carburetor

- Detach the throttle control (may not be present on all models). Two screws hold it to the carburetor. Replace these screws so they will not get lost. (Yes, I know this is getting kind of repetitious!)

- Disconnect the stop wire if there is one.

- Use a large philips screwdriver to loosen the two screws fastening the intake pipe to the cylinder block. If the gasket separates easily and cleanly, then it can be reused though a dab of non-hardening sealer is advisable. If it tears or is damaged in any way, then it should be replaced.

  If the bolts are really tight, an open end wrench may be of help but common sockets may not fit around the bottom bolt. Thin walled sockets may work.

- Disconnect the throttle linkage and governor spring noting which holes they go in. IMPORTANT: If you get this screwed up you could have a runaway situation on your hands when you go to restart it. This can destroy the engine in a few seconds!

The carburetor can now be set aside or disassembled and cleaned. (See the section: Cleaning Craftsman (Tecumseh) carburetors.

WARNING: there is still likely a significant amount of gas inside the float bowl. If turned on its side or upside-down, this gas will come gushing out. Therefore, it is best to set the carburetor aside in an outdoor area in an upright position. Plug the intake manifold and fuel pipe with wadded up paper towels or rags to prevent the entry of dirt.

Muffler

Note that in addition to decreasing the noise from your engine, the muffler serves a very important spark/flame arresting function. Therefore, it is important that it be in good condition.

Some mufflers simply screw into the cylinder using pipe threads. Others are mounted with a couple of bolts.

- Remove the muffler. Use penetrating oil (e.g., Liquid Wrench or WD40) if the mount is heavily rusted or corroded and does not yield to normal efforts.

- It is ok to ruin the muffler in the process. Mufflers are inexpensive and you probably needed a new one anyhow. Just do not damage the cylinder threads as the metal is relatively soft.

- If the muffler comes off intact, inspect for serious corrosion, holes, or other damage and figure on replacing it if needed.

Flywheel

- If you will need to remove the crankshaft or get under the flywheel to check or adjust the points (non-electronic ignition), then now is as good a time as any to remove it. See the section: Flywheel removal.

- Inspect the flywheel and set it (and associated washers, starter clutch, etc.) aside in a safe place - away from steel filings that will be attracted to the powerful magnet!

- Thread the flywheel nut back onto the shaft and then protect it with a rag or paper towel secured with an elastic band.

Ignition

This can be left in place but will be susceptible to damage.

- Inspect the high tension lead for cracking or broken insulation. Temporary repairs using several layers of electrical tape may be made but replacement is best for long term reliability.

- Inspect the stop wire and any others for similar damage and repair or replace parts as needed.

- The electronic (e.g., Goldkey or Magnetron) ignition can be removed as a unit since there is nothing under the flywheel except possibly a (plastic) sleeve/spacer. Inspect the potted unit for cracks or other damage.

- For point type ignitions, the magneto coil along with the components under the flywheel (points, condenser, cam) can be easily removed if the flywheel has been pulled. Inspect for worn, pitted, welded, or corroded points and other damage.

Cylinder head

- Use the proper size spark plug or deep socket to remove the spark plug counterclockwise. Inspect the spark plug and threads in the head for damage.

- Use the proper size socket to remove the (usually 6 to 10) head bolts counterclockwise. It is best to loosen each a half turn at a time in an alternating pattern until they turn freely to minimize possible stress on the head. They will be fairly tight but should not be frozen. Check each one after removal as some may be longer than others and then must go back in their respective holes. Hold the head with one hand as you remove the last couple bolts - it should pop right off.

- Separate the head and head gasket from the cylinder. This should occur easily without requiring your persuader.

- Inspect the head, head gasket, and cylinder mating surface for major damage. While it may look really ugly, once the carbon is removed, the metal should be virtually like new.

- Remove built up carbon from the head, valves, piston, and cylinder. This is best accomplished by chipping it away with a soft metal tool like a scrap of aluminum. Take care if you use a steel paint scraper or screwdriver not to scratch the relatively soft cylinder or piston. WD40 will often help to loosen this carbon buildup. Most of the carbon will probably be on the exhaust valve and on the exhaust valve side of the head and piston.

Valves

You should only need to do this if you are replacing or grinding a valve. In most cases, the valves are undamaged but may appear in poor condition due to carbon buildup - which can be removed in-place fairly easily.

- Remove the valve cover on the side of the engine next to the valves.

- Use a feeler gauge to check the gap between the valve lifter and valve stem with the valve lifter in the relaxed - lowest - position. A typical value is .010 inches. Excessive clearance will require replacement of the valve or valve lifter. There could also be too little clearance - which is also bad - but the valves stems can be ground down to repair this problem which is either a defect in manufacturing or a result of a cam shaft replacement which is oversize.

- Use a valve spring compressor to remove pressure on each valve.

- The retaining clip or split cup should now be free. Remove these.

- The valve should now slide out.

- Loosen the valve spring compressor and remove the spring and any other hardware. Don't interchange the intake and exhaust valve springs.

- Remove the built up carbon deposits from the valves and valve seats using a soft metal scraper. Some WD40 may help to loosen the caked on carbon.

- Inspect the valves for serious burning or pitting especially on the seating (angled) surfaces. Once free of any carbon, they should be smooth and undamaged.

- Similarly, inspect the valve seats for serious burning and pitting.

- Inspect the springs for rust or other damage. Stand them on a flat surface and check for serious droop/tilt. Measure their free length and compare with your engine specifications.

Oil sump/crankcase cover

We are now going into the lower section. I can hear you saying "Joy!".

- Check the crankshaft for burrs at the blade lock key or other key and/or where any front wheel drive pulley setscrew was tightened. It is essential that these be carefully removed with a fine file before you attempt to remove the cover to avoid damage to the main bearing. In addition, any rust and/or dirt buildup must be removed with steel wool, sandpaper, or emery cloth to allow the shaft to pass through the main bearing without damaging the bearing or oil seal. Remove all traces of rust and grime but don't go overboard - it doesn't need to shine. Wipe with a very slightly damp cloth to remove **all** abrasive residue.

- Set the engine flywheel-side down on wooden blocks so that the flywheel mounting shaft is clear of the table.

- Once again, wipe down the underside of the engine, especially around the crankcase/oil sump mounting bolts and the seam where the cover will separate from the engine block.

- Remove the 6 to 10 hex head crankcase/oil sump mounting bolts and set them aside.

- Use a soft rubber mallet if necessary to help free the cover. If mild persuasion doesn't work, check for any bolts you may have missed.

- As the cover comes free, gently lift and turn at the same time. It should slide right off the crankshaft. If there is any resistance, you probably didn't find all the burrs or rust. Go back, identify, and correct the problem. Don't force it as you will end up with scratches on the bearing surface and/or damage to the oil seal.

- The gasket will likely tear in the process of removing the cover and will need to be replaced. It is not worth trying to repair it. You will have to scrape the remnants of the old gasket off of both mating surfaces before installing the new one (later).

- Check for any washers that may come free with the cover. There will be at least one on the crankshaft. It may be sticking to the bearing surface on the cover.

- Usually, the flyweight governor is just left in place unless parts need to be replaced. Inspect it for damage to the gears, flyweights, or cup. Individual parts can be replaced if needed (and if you can get them!). The post is a press fit and should not be disturbed unless damaged.

Camshaft/camgear

- Remove the camshaft driven plunger type oil pump. This is in two sections which have a definite relationship (the flat faces out). Inspect for damage and set aside.

- Carefully rotate the crankshaft until the timing marks align. These will be a line, dot, or hole on the camgear and crankshaft gear. For most engines, these should line up perfectly with each other at one position of the crankshaft. However, on some Craftsman engines, they are offset by one tooth. Check and note this before removing the camshaft/camgear!

- With the timing marks aligned, valve pressure should be released (if you removed the valves, this won't matter) on the camshaft and it should slip out easily.

- Inspect the camgear for chipped or broken teeth and wear. There should be no chipped teeth and no detectable wear on any of the gear teeth. Chipped teeth or significant wear will require replacement.

- Inspect the cam lobes for wear or wear. There should be no detectable wear and no damage.

- Check the compression release mechanism on the camgear for damage and free operation. The weight should snap back to the shaft when released. The little lift pin should move smoothly.

- Remove each of the valve lifters and inspect for wear. There should be no significant wear. Note which went where so that they can be replaced in the same location. Most are of the same length but once a wear pattern is established, replacement in the same location is desirable. Sometimes, they are of different lengths and then this is more critical.

Connecting rod

- Rotate the crankshaft so that the rod bolts or nuts are accessible.

- Bend out any lock plate that may be associated with the rod bolts or nuts. Many Tecumseh engines use 'Durlock' rod bolts with integral locking serrations and there is no lock plate and no lock washers. Note: Durlock bolts, lock plates, or lock washers should always be replaced with new ones if removed and not be reused. You really don't want the rod coming apart!

- Use the proper size socket to loosen the rod bolts or nuts counterclockwise. Start with small equal increments on each of them until loose to equalize stress.

- Remove the bolts or nuts and cap. Note the orientation of the cap and rod. If yours is the slant type, this is easy.

Otherwise, look for match marks, casting numbers, or other identifying marks and make a diagram in any case.

- Where bolts protrude from the rod, immediately cover these with some bits of rubber tubing or tape to prevent them from hitting and dinging the crank pin journal or other precision surfaces.

Piston

- Remove any carbon ridge you find at the top of the cylinder. This will catch the rings and prevent you from removing the piston or if force is used, break the rings. Usually, it is a simple matter of scraping with a piece of soft metal like aluminum. On rare occasions with a really well worn engine, enough of a metal ridge will also be present to require the use of a ridge reamer tool.

- Push the piston up and out of the cylinder bore. The rings will expand but will not pop off unless they are actually broken.

- Replace the rod cap and finger tighten the nuts or bolts. This will help to protect the bearing surfaces from accidental damage.

- Inspect the piston for damage. There may still be significant carbon deposits but once these are carefully scraped off, the piston should be fairly smooth. There may be some vertical scoring but a modest amount of this is not serious.

- Inspect the rings and ring grooves for damage. It is usually not necessary to actually remove the rings from the piston to do this - which should be avoided if possible to minimize the chance of breakage. The outer surface of the rings should have an almost polished appearance with no significant pits, scratches, or corrosion. There should be no chips or other visible damage.

- If you must remove the rings, use a ring expander if possible and make sure you note the exact orientation - top/bottom and location - for each.

- If you are removing the piston pin, note the orientation of both the rod and pin as they must be returned in the same relationship. Pistons are not symmetric! Look closely and you will see that the pin is offset a fraction of an inch to one side. This is done to optimize the center of force on the rod bearing and rotating crank pin journal.

- Use a pair of needlenose pliers to remove the 'circlip' from one side. The piston (wrist) pin usually floats (moves easily) in between the two circlips but a slight lip of metal (probably resulting from the pin banging back and forth) may prevent it from being easily removed. Very slightly scraping around this lip will free it up or you can remove the other circlip and then use a drill or arbor press to push the pin out far enough to free the rod. There is no need to remove the pin entirely. Then, there will be no question as to the direction upon reassembly.

Crankshaft

- Lift while rotating the crankshaft out of the top bearing. There should be no resistance (unless you forgot to remove something).

- Inspect the crankshaft to determine if it is bent. Any deviation from perfection is cause for replacement. The proper way to do this is with some V-blocks and a run-out gauge. However, you won't have these tools so a visual inspection is the best you can do. However, unless your blade kissed a boulder, a bent crankshaft is not likely.

- Inspect the small gear for broken teeth and wear. There should be no chipped teeth or detectable wear of the gear teeth. If there are chipped teeth or significant wear, then this gear and the camgear will need replacing.

  Note: the small gear on the crankshaft may be a press-fit and may not be considered serviceable by itself without replacing the entire crankshaft. However, I have been able to remove it non-destructively by gently tapping on each side using a soft metal bar (e.g., brass) and a small hammer. (When I had to do this, the guy at the engine parts store was surprised that I was able to get it off without damage.) Heating the replacement gear will expand it and reduce the force needed to press-fit it onto the crankshaft. Similar gentle tapping will then work once the gear is aligned with the indexing pin.

- Check for any washers at the flywheel end of the crankshaft and set these aside. There are probably none.

Breather

- The breather allows the pressure inside the crankcase to vent to the outside and should result in negative pressure inside as this contains a (leaky) one-way valve.

- The breather cover is under where the flywheel is located.

- Remove the screw to remove the cover plate. There is a gasket but it will probably separate cleanly.

- Check the spring and valve disk for rust, dirt, and wear. They will likely be fine. Make sure the small vent hole is clear.

- Replace the cover as there is nothing else to do in there.

Oil seals

- Do not remove the oil seals unless you intend to replace them. If oil leakage has not been a problem and you don't think any damage resulted from removing the crankshaft, leave them alone. It should be possible to replace the oil seals after reassembly if oil leakage turns out to be a problem.

- It is very unlikely that the flywheel side oil seal would be defective or damaged.

- The PTO/blade oil seal can be damaged by neglecting to completely remove burrs from the crankshaft before removal of the crankcase/oil sum cover.

- To remove the oil seals, use a screwdriver to pry them out from the crankcase/oil sump cover and/or the flywheel side of the crankcase. Take care not to gouge the mounting surfaces.

Detailed inspection

A complete overhaul can restore a small engine to like-new condition. Any parts that are found to be damaged or out of tolerance are repaired or replaced.

Determining this requires a visual inspection and taking measurements of all critical dimensions of bearings, cylinder, piston, and rings. Some of the inspection is subjective - how badly scored a bearing surface is before it must be replaced or reground. A few score marks around the circumference of a bearing surface will not adversely affect operation or wear. How few is a few? Perhaps if less than 10% or so of the surface is affected. You are not going to spend as much to repair the mower as it cost in the first place in any case so don't lose sleep over it.

Measurements may come up marginal as well. For example, if the limit listed in your engine specifications is .0015" and you measure .002" will this be a serious problem requiring the replacement of expensive parts? Probably not. You may get less than optimal life out of the engine but it will probably still work fairly well and for a long time. So many other factors can affect life that this may have no effect at all.

The following items should be visually inspected. If any significant wear is indicated, precise measurements should be made:

- Crank pin journal and rod bearing. Inspect for wear, pitting, and scoring on both the crank pin journal and the inside bearing surface of the rod and cap. On a new engine, both of these surfaces are nearly mirror smooth. On a well worn engine, there may be significant scoring due to particles from the oil getting trapped. An engine that has failed due to a severe lack of lubrication may result in some pretty spectacular failures of these parts. Minimizing wear and the change of catastrophic failure is the primary reason for performing regular oil changes.

    - A few score marks around the entire circumference of the journal are unimportant as long as they represent a small percentage of the surface area.

    - Scratches, pitting, or score marks that run side ways are more serious. If slight, polishing with very fine emery or crocus cloth may be all that is needed. If they catch a fingernail, this may not be enough.

    - A serious out-of-round condition is unacceptable.

  Follow the instructions that came with the plastigauge to take measurements. Consult your engine specifications for acceptable limits. Use judgement in determining whether slight out-of-spec measurements will necessitate replacement or major rebuild.

  If you had a rod failure due to lack of oil (remember what we said about the importance of oil - see the section: Rod disasters - or why the oil and governor are kind of important) - then there could be a variety of types of damage that will make these measurements academic. The rod my have broken in half or the cap may have literally exploded into multiple pieces. In many cases, the crank pin journal will escape relatively unscathed but needless to say, you will need a new rod and cap - not cheap!

- Main bearing - PTO (blade) end. Inspect for severe scoring, corrosion, or other damage. It may no longer be mirror smooth but should not appear excessively worn.

- Main bearing - flywheel/magneto) end. Inspect for severe scoring, corrosion, or other damage. This will probably appear almost like new even on an old engine as there is a lot less load on this end and it is relatively well protected and well lubricated.

- Cylinder. Inspect inside the cylinder for excessive wear and scoring. If it appears fairly smooth without much scoring, it is probably ok but only exact inside measurements would confirm.

- Piston. Examine the sides for vertical scoring. There will probably be some but as long as the piston is not mostly score marks, it is probably fine. Only exact measurements would confirm. Check for damage to the lands - the surfaces between the ring grooves. If any are cracked or broken, the piston will need to be replaced.

- Piston (wrist) pin. This should be mirror smooth. There should be no detectable free play if you try to jiggle the rod.

- Rings. Inspect for damage, pitting, and scratches. The outside surfaces should be pretty much mirror smooth. Use an appropriate sized feeler gauge to check clearance between the rings and piston grooves.

- Oil passages. Inspect and use compressed air if necessary to clear the various oil passages in the crankcase/cylinder, camshaft, connecting rod, and crankshaft. The typical small Tecumseh engine has a hollow camshaft which is part of the oil pump and drilled passages in the crankcase. The oil path is from the plunger/barrel oil pump up through the center of the camshaft, over top via the passages in the crankcase to lubricate the main bearing (flywheel/magneto end) and also to drip on the connecting rod and crank pin journal. Some larger engines also have drilled passages in the crankshaft and connecting rod. There is even an oil pressure test port normally sealed by a small screw. A typical pressure measurement on an engine running at full speed is 7 psi but you won't measure this so just make sure everything is clean and clear.

Engine reassembly

Once you have performed whatever magic is required to repair or replace broken or damaged parts, here are the steps that will transform your pile of parts into a (hopefully) working engine.

If any filing, sanding, or grinding was involved, make sure all traces of abrasives have been removed from every part. The best approach is to clean with soap and water or mild detergent and dry thoroughly. Then immediately coat all ferrous parts with engine oil to prevent rust.

Where the internal moving parts are involved, liberal use of fresh engine oil will also make things to go together smoothly and help protect the surfaces from damage due to initial lack of lubrication.

- Oil seals: If you removed the oil seal(s), clean the inside surfaces where the seals go and install new ones by pressing them in straight and square with a block of wood and rubber mallet or better yet, use a drill press or arbor press. Make sure you get the correct side facing out! Installing the new oil seals after the crankshaft has been replaced may be easier. There is a special tool for this but a piece of pipe that just fits over the crankshaft cut off square will work just as well. Remove any burrs on the crankshaft to prevent damage to the new seal and take care that any rubber lip on the seal does not get folded over.

- Breather: If this was removed, replace valve plate, spring, gasket, and cover. However, this is probably already assembled.

- Valves: Use a valve spring compressor to fully compress the spring for the intake valve and install the valve, any washers, and retaining clips. Do the same for the exhaust valve. Install the valve cover. <>
- Piston rings: Replace any that were removed. Use a piston ring expander if available or your hands to expand the rings and slip them over the piston and into their proper grooves. Note orientation and position! Avoid scratching the relatively soft piston. Do not expand more than needed - the rings are fragile.

  Note the typical arrangement (from top to bottom):

  - Compression ring (solid).
  - Compression ring (solid).
  - Oil ring (slotted with internal expander spring).

  But, you drew a diagram, right?

  Note: if new rings are installed, you should deglaze the cylinder wall with fine emery cloth in a cross-hatch pattern (diagonal strokes). This is needed break in the new rings. Then very thoroughly clean the cylinder to remove all traces of abrasive residue.

- Piston pin and connecting rod: Put a few drops of engine oil on the pin, position the rod, and then slide the pin into place. Use a press if it is a tight fit. Use new circlips to secure the pin. Make sure you get the orientation of both the rod correct! It is also desirable to install the pin in the same orientation as it was originally. If the pin was never entirely removed, this should not be a problem.

For the following, position the crankcase flywheel/magneto side down on some wooden blocks so that when the crankshaft is installed, it's end will be clear of the table-top.

- Crankshaft: Using a gentle rotating-while-inserting, place the crankshaft into the flywheel/magneto-end bearing. Use engine oil to prevent scratches. Take care not to bend over the lip of the oil seal.

- Piston into cylinder: Coat the piston and cylinder wall with engine oil. Orient the rings around the piston so that the gaps are staggered by 90 degrees and not above the pin location. Suggest from top to bottom: 45, 135, 225 degrees. Use a piston ring compressor (commercial or home-made). Tighten until the rings are fully compressed and then release just a hair. Position the piston in the correct orientation - rod with respect to crankshaft - and gently tap into cylinder using a wood block and rubber mallet. If it hangs up, the compressor is too loose. If it does not move at all, the compressor is too tight.

  CAUTION: Do not use a metal hammer - there is a good chance you will crack the fragile aluminum piston.

  CAUTION: Don't let the bottom of the rod or rod bolts hit the crankshaft! Put a wad of rag inside to prevent this.

- Rod and cap to crankshaft: Coat the crank pin journal with engine oil. Position the crank pin journal and rod bearing so that they are in contact. Place the rod cap in position - noting match marks. Using a new lock plate, lock washers, or rob bolts, as appropriate, hand thread the nuts or bolts on as far as they will go. Jiggle the cap to adjust and then tighten some more by hand.

  CAUTION: double check that you have the match marks aligned. If correct, the bearing formed by the rod end and cap will fit the crank pin journal perfectly - seated fully - with no free play even when only finger tight. If you attempt to fully tighten the rod nuts or bolts and the cap is backwards, you may ruin the rod and cap by distorting the soft metal.

  Now, use a torque wrench to tighten the nuts or bolts to the proper torque as listed in your engine manual. Alternate between the two nuts or bolts tightening in small equal increments until the proper torque is reached. Where a range is specified, aim for the middle.

  Where a lock plate is involved, torque to the middle of the acceptable range and then tighten the nuts or bolts just enough further to align a flat with the edge of the plate. Then, bend the plate over to lock it in place. DO NOT reuse an old lock plate.

  It may be a tight fit to get a torque wrench inside the crankcase. Here are a couple of comments:

  - I use a basic 3/8" deflecting beam type torque wrench - nothing fancy. To this, I add a 3/8" to 1/4 inch adapter (short) and a 1/4" socket.

  - Position the piston/crankshaft to provide the most clearance for each nut or bolt. These will differ.

  - This can also be done with an open end wrench and spring scale but the torque wrench is so much easier!

  It is just possible to get both the clearance and angle to use the torque wrench effectively. With a ratcheting torque wrench it would be easier but this is not essential.

  THIS ASSEMBLY IS MOST CRITICAL and is probably the single most important place to get the torque just right. Too tight and (especially for aluminum alloy rods/caps) you will strip the threads and/or distort the precision fit. Too loose and the bolts will eventually work their way out. You really don't want the cap to pop off while the engine is running at full power!

- Valve lifters: Install the valve lifters in their respective holes.

- Camshaft/camgear: Carefully rotate the crankshaft until the timing mark faces the camshaft bearing location. Slip the camgear in place so that the timing marks exactly align (or if your engine is one of those exceptions, so they are off by one tooth - see your engine manual if in doubt). For most Tecumsehs:

The camgear timing mark (if not marked) is in line with the center of the hobbing hole (small hole in the face of the gear).

  - The corresponding timing mark on the crankshaft is either a beveled tooth on its gear or in line with the keyway.

  - If the engine has a Craftsman type (float) carburetor, advance camshaft 1 tooth clockwise (except for the Craftsman variable governed fuel system, whatever that is!).

- Oil pump: Install the two piece oil pump. The flat must face out.

- Crankcase/oil sump cover (temporary): Install the washer(s) that go on the crankshaft. Without using a gasket, install the crankcase/oil sump cover. Use a gentle twisting motion and take care to avoid damaging the oil seal. Slip the ball end of the oil pump plunger into its cavity in the cover before it is fully lowered. With a little jiggling, the cover should seat properly. Thread a couple of the mounting bolts in hand tight to hold it in place.

- Test for free rotation: Use the blade adapter and key as a means of grasping the crankshaft and rotate it through two complete revolutions. There should be no binding of parts though you will feel the resistance of the piston as it moves up and down in the cylinder and the valves as they are lifted once in every two revolutions (which you will also see from above).

- Remove the cover. Double check that the mating surfaces are free of old gasket material and dirt. Use a new gasket. Again, take care not to damage the oil seal and line up the ball on the end of the oil pump plunger so that it fits in its cavity in the cover as it is slid into place. Install all the bolts and tighten in a staggered order incrementally to the proper torque.

- Cylinder head: Position the cylinder head and new head gasket and install all the head bolts finger tight. If any are of a different size, make sure they go in the proper locations so that they do not bottom out or engage too few threads. (Tecumseh bolts seem to be all the same size.) Tighten the head bolts in the recommended sequence in 3 or 4 equal increments to the torque specified for your engine.

  Engine repair manuals always recommend using a new head gasket. The old one has shaped itself to the texture and imperfections of the head and cylinder and you could never match this up perfectly upon reassembly. The result can be leakage of hot combustion gases and ultimate failure of the gasket and possible damage to the mating surfaces.

  However, if you have not done anything to the head or cylinder surfaces and the gasket is in essentially perfect condition, you can risk reusing it but I won't guarantee long term reliability! My general recommendation is that you use a new head gasket once you are sure that everything works properly and thus there will be no need to remove the head again. Unless the old one is damaged, it will work fine for testing purposes.

  A typical Tecumseh bolt tightening sequence is shown below (except 8 HP). Check your service manual for the specific recommended procedure for your particular model engine.

```
    Flywheel/magneto end
     ___________________
   /| | | | | | | |  8  |
  |5| | | |3| | | |=|=O |
  | O=|=|=|=O=|=| | | | |
 /| | | | | | | |  _  | |
|1| | | | | | | | |O| |2|__
| O | | | |  Spark Plug O  |
| | | | | | | | | | | | |  |
```

```
    \|7| | | |4| | | | | | |  |
     | 0=|=|=|=0=|=| | |6| |  |
     /\| | | | | | | |=|=0 |__|
___/____\|_|_|_|_|_|_|_|_|_|___\___
-----------------------------------
         PTO/Blade end
```

For the following steps, position the engine on wooden blocks blade/PTO side down.

- Ignition: Install the components (if any) that go under the flywheel (e.g., points, condenser, cam). Install the magneto coil or electronic ignition module. Temporarily position it so that it is as far away as possible from where the flywheel will go. Tighten the bolts.

- Set the point gap and ignition timing (point type ignitions systems only). See the section: Setting the point gap and ignition timing.

- Flywheel: Place any inside spacers proper side up onto the crankshaft. Position the flywheel key in the keyway and then install the flywheel onto the shaft. Jiggle it a little to seat solidly. It should not now move from side-to-side at all. Add the washers, starter cup, and flywheel nut. Screw the nut on by hand and then tighten securely (but not to full torque necessarily at this time) using a socket wrench. Torque to specifications once the engine is mounted as this will be a lot easier.

- Set the flywheel magnet-magneto gap (if you have not done this already): Place an appropriate spacer (e.g., .015 inches) between the flywheel magnet and magneto pole pieces. Loosen the magneto coil mounting bolts. The magnet will draw the pole pieces tight against the spacer. Tighten the bolts to the recommended torque.

- Install the spark plug with a new washer (and a dab of anti-seize compound). First, thread the plug in by hand to get it started and then tighten to specifications (15 to 30 ft-lbs typical).

- Install any electric starting components.

- Install the muffler. A dab of anti-seize compound will make removal of exhaust system components much easier at a later time should the need arise.

- Carburetor: Position the carburetor assembly in its proper location.

- Reinstall the throttle and governor linkages: Where there is no speed adjustment or idle position, the direct governor linkage goes in the hole closest to the engine and the spring hooks onto a fixed vertical metal strip with only one hole at one end and the lower hole in the governor lever at the other. Thus, in operation, the spring attempts to keep the throttle open and the governor pulls on the throttle to close it. Increased spring tension results in higher speed. Don't get these backwards when you go to reinstall the carburetor on the engine!!!

- Reattach the primer tube, if you removed it at the carburetor end.

- Reattach the stop switch wire, if any.

- Install the carburetor onto the engine with a new gasket if needed. Tighten securely to the proper torque (6 to 8 ft-lbs).

- Double-check that the throttle linkage and governor spring are in the proper holes and nothing is binding - you should be able to move the throttle back and forth without any sticking or tightness. It should return to the full counterclockwise position instantly as a result of the governor spring tension.

Engine installation

It will be easier to tighten the flywheel nut to the recommended torque once the engine has been reinstalled on the mower. Therefore, now is a good time to install the engine to the mower deck:

- Remove the three mounting bolts from the bottom of the engine. Position the engine on the mower deck and install these bolts finger tight. Then, use a socket wrench to tighten securely.
- Tighten the flywheel nut. Brace the flywheel against something solid and tighten the flywheel nut to the recommended torque (30-33 ft-lbs).
- Shroud/blower housing: Position and install using the proper bolts.
- Oil fill pipe: Put a little engine oil on the O-ring. Position the fill pipe into the oil hole in the base of the crankcase/oil sump cover. Make sure the O-ring seats inside the oil hole. Tighten the screw(s).
- Gas tank: Slip the gas tank into its mounts and tighten any screws. Connect the carburetor fuel hose to the gas tank.
- Trim pieces: Reinstall any trim pieces.
- Reattach any dead-man and throttle cables to the engine.
- Install any front wheel drive components - pulley to crankshaft (using proper key) and belt, or chain drive.
- Install the blade adapter and blade. Tighten to the recommended torque.
- ADD OIL!!! Add fresh engine oil to just below the top of the oil filler hole or just below FULL on the dipstick. This will be about 1-1/4 pints.
- Use the starter cord or electric starter to crank the engine a few times. This will help to distribute the oil.
- Add a small amount of gasoline to the fuel tank - say, a half a glass.

Initial post-overhaul testing

Assuming you didn't make any mistakes, the engine should start on the first pull. As you start it, look and listen for any abnormalities and immediately stop it if any are detected:

- Engine overspeeds due to screwed up governor or linkage.
- Unusual knocking or banging due to parts hitting one another.
- Excessive black, white, or blue smoke from exhaust (or 3 foot flames, I suppose).
- Overheating.
- Leakage of oil or gas.

Assuming nothing appears wrong, run it for a while at slow speed (if you have the option). Continue to be on the lookout for anything unusual. After a few minutes, stop it.

Let is sit for 10 minutes or so and then check, and if necessary, top off the oil.

Now, restart and run it at high. Mow a few lawns.

Congratulations! Hopefully, your engine will now serve you for many more years - or until the blade hits the next curb!

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Items of Interest

Explosion risk when filling a metal gas can

Although rare, there have been reports of fires resulting during fuel transfer. Simple precautions can minimize this risk.

Here is how to fill a gas can to minimize the danger of fire:

- Turn off your vehicle's engine.
- Use only an approved container.
- Do not fill any container while it is inside a vehicle, a vehicle's trunk, pick-up bed, or on any surface other than the ground. This includes pickup trucks, sports utility vehicles, vans and others.
- Remove the approved container from the vehicle and place it on the ground a safe distance away from the vehicle, other customers and traffic.
- Keep the nozzle in contact with the can during filling.
- Never use a latch-open device to fill a portable container.
- Follow all other safety procedures, including No Smoking.

More information can be found on: Chevron's Technical and Safety Publications Page.

Why you really don't want to attempt to move an immovable object

The rotating blades and mass of the internal engine parts pack quite a punch. Speeding along merrily mowing away one doesn't think about this. However, if the blade should hit an obstruction, you may have no choice.

There are various safeguards to protect the mower from damage should a blade tip hit something but these don't always work. Why?

There is protection for the upper and lower parts of the crankshaft after all:

- The soft metal blade lock key can prevent damage due to excessive torque on the blade-end of the crankshaft when the mass of the engine parts continue to attempt to rotate after the blade hits something solid. The blade adapter then breaks away allowing the crankshaft to rotate freely. A 25 cent blade lock key or a $4 blade adapter will remedy this.

- The soft metal flywheel key will protect the upper part of the crankshaft and flywheel from damage should the blade and crankshaft stop suddenly and the inertia of the flywheel attempts to keep it rotating. A 25 cent flywheel key will remedy this.

In many cases, both of these will break free at the same time.

However, if the shock is severe enough, much more serious damage can result. Here is why: When one end of the blade hits a curb, for example, the inertia of the mass of the blade alone (rotating at high speed) will attempt to push the shaft sideways. This is pretty much independent of the rest of the engine.

In the diagram below, the blade is rotating clockwise. When the left-hand tip hits the curb, the right-hand side due to the inertia of the entire right-hand half of the blade wants to continue to move (down in this diagram) with the 'X' as the fulcrum. The entire left-hand half section of the blade contributes relatively little. This results in a net significant sideways (downward in the diagram) bending force on the crankshaft. The unavoidable arrangement of the fulcrum at one end and the shaft in the middle makes the situation even worse as the force resulting from the blade tip (the right hand one in this example) is amplified by the up to 2:1 mechanical advantage of the lever arm (the tip is twice as far from X and the shaft).

```
    Blade tip   /
  hits curb.  X-------____________________________________
    Ouch!   / |                                           |   Inertia of this
          /   |                   - O -                   | | side of blade
        /     |____________________________________       | | attempts to
                                    |   |   |   |  -------  | continue in same
                                    V   v   v   v   v   v   v direction.
                            Net sideways force
                              on crankshaft
```

While the rotating mass of the engine is attempting to shear the blade lock key, the inertia of the blade is trying to push the crankshaft sideways. The net result could be a severely bent crankshaft - a very expensive repair. An 8 to 10 degree bend is not unusual for a typical Craftsman-class mower running at full power. Any detectable bend in the crankshaft requires replacement - it is not safe to attempt to straighten it. A bend resulting in the blade tips wobbling by more than a fraction of an inch, there will be unacceptable and dangerous vibration when the mower is run. In addition, the original trauma (as well as attempting to run with a bent crankshaft) can damage other parts like the main bearings and connecting rod. The blade lock and flywheel keys will likely be broken as well but these are insignificant in comparison to the cost of major replacement parts and the labor involved in their installation.

The time and effort needed to disassemble the engine is significant and the crankshaft is probably the single most expensive part of the engine. In fact, purchasing a new crankshaft may be more expensive than an entire new lawn mower! It is quite possible that unless you have access to low cost replacement parts from a salvage yard and have the free time to do the work, repair may not make sense.

Therefore, don't let this happen to you. Your curbs and rocks don't grow that quickly and do not generally require mowing!

How about a crankshaft friendly blade?

It is too bad that most lawn mower blades are made of heavy rigid steel (though I do recall a mower that used a super thick nylon cord - sort of like a weed whacker on steroids). The chance of serious engine damage from curb kissing would be greatly reduced if a blade were used which had less inertia and increased flexibility. Then, no matter how hard you tried to whack something solid, only the blade lock and/or flywheel keys would shear and thus spare the expensive engine parts.

Apparently, some mowers are made with swing tip blades:

(From: Roderick Carmichael (carmic@nex.net.au).)

> "I use a top notch Supa-Swift with a gravity cast alloy chassis and swing-tip blades (Australian invention, no bent cranks on our mowers mate!)"

Why are these not common in America? Conspiracy to sell replacement parts by the small engine manufacturers? :-). You would have to really work at bashing a curb to bend a crankshaft with such a mower.

Another possible approach - applicable for both new lawn mower designs as well as field upgrades - would be to replace the heavy steel blade with one made of nylon with a molded-in steel edge. An auxiliary flywheel might have to be added (under the deck) to provide the needed inertia (normally supplied by the steel blade) for the engine to start and run properly and to help the mower plow through tall grass. However, since this additional flywheel could never be stopped abruptly due to hitting a rock or curb, its inertia would never contribute to a sideways bending force on the crankshaft. The greatly reduced mass and increased flexibility of a reinforced nylon blade should virtually eliminate the possibility of a bent crankshaft from such unfortunate incidents. See the section: Why you really don't want to attempt to move an immovable object.

(From: Mowerman (mowerman2687@my-dejanews.com).)

I have been reconditioning lawn mowers for many years and find it fascinating what design goes into some of this equipment. Like arrangements to prevent the crankshaft from bending if the blade hits something. Most engines have an aluminum key at the flywheel but this will not stop shaft bending most of the time. Mower manufacturer uses many methods. Lawn boy has a tapered shaft at blade level and so the shaft has no key and the blade slips if hit. Some other mowers had steel washers and fiber washers nearest the blade like a clutch I seen this on some antique mowers. The best idea is disc with small flail blades or short blade with flail at end. Manufacturers in New Zealand and Australia use this method on their domestic mower mostly and it works well. Victa of Australia was one of the first ones around here with this idea. I am sure you have them over there to no doubt. I hope this information will be to some help.

Crankshaft-friendly blade sighted

(From: Thomas Prufer (Prufer@compuserve.com).)

I recently came across a description of a blade assembly similar to the one suggested by you to make bending the crankshaft difficult. This is in the Royal Horticultural Societies' "Encyclopedia of Gardening". In the tools and accessories section, under the "lawn mowers" subsection, a caption says: "Plastic disk. This cheap replacement part cuts the grass by rotating horizontally". The inset shows rotary, cylinder, and "Flymo" mowers. A picture of the part shows a disc almost the diameter of a regular blade, with one blade joined to the circumference by a pin so that centrifugal force keeps it radial. This blade is short and narrow compared to the plastic disc; no telling if it is plastic or metal. There is no further reference to this part in the text. In my translation, it is on page 465.

If only they had included a name or supplier!

Another reason not to mow rocks!

(From: Forbes Family (fbsfam@clear.net.nz).)

I have recently purchased a new rotary lawn mower and appear to have started wrecking it in the first two weeks of use! Problem is, my property has lawns that run alongside a gravel driveway, and its often very hard to guarantee there are no stones lying in the grass before you start mowing. Not surprisingly I often hit small stones. These usually cause no harm, but today some teenagers were mowing my lawns and hit a real monster that measured approximately three inches by two by one, and weighed more than half a pound! Although the mower seems still to work OK, the impact has created a three inch long tear in the mower's cast aluminum body. Not a nice thing to have happen to a new machine!

Despite the stone's size, I was surprised at the size of the resulting tear in mower's more than 1/4 inch thick aluminum casing. I hadn't imagined a rotary mower blade powered by a 5 HP Briggs and Stratton motor could produce such force!

It would be interesting to hear from others who have survived similar experiences and to get an idea from any budding engineers on whether its perfectly reasonable for a stone this size to do such damage to the body of my mower - or whether it's more likely the body casting had a manufacturing defect that made it split prematurely?

Rod disasters - or why the oil and governor are kind of important

A combination of low oil (well, actually, almost no oil) and probably too high RPMs resulted catastrophic failure of the connecting rod and cap on my garage sale Eager 1 Craftsman mower. I had just completed cleaning the carburetor and was testing it when p-ting!! and it stopped dead - the rod had broken and it was dead-dead. Extremely embarrassing since there was no excuse for such a disaster.

The primary cause was likely a lack of oil - I should have checked it before attempting to run the engine for more than a few seconds. I have no idea whether someone had actually drained the oil for who knows what reason or it was just very low. In addition, I may have accidentally put the governor link back in the wrong hole permitting the engine to run at an abnormally high (and dangerous) speed.

There was no warning. The rod cap just exploded into e pieces (and this was at normal speed) and took a nice chunk out of the interior of the crankcase. Based on a post mortem of the rod, it appears as though one of the cap screws just loosened and backed its way out totally - there was no evidence of thread damage that would be expected if it were ripped out - and fell into the sump. With only one screw holding the rod and cap together, eventual failure was inevitable. Due to the offset design of the cap, this probably worked for a while since most of the force is on the rod.

Discoloration indicated excessive heating but no obvious bearing damage was evident that could be attributed to the lack-of-oil condition. The bearing was not in pristine condition but the type of scoring seemed to be more due to just poor general maintenance - lack of regular oil changes - than to this incident in particular.

Lessons: Check the oil level no matter what if there is any question or you are working on an engine of unknown history. Double check the governor linkages - take notes during disassembly - and be aware of what a normal speed sounds like for your type of engine (2 stroke or 4 stroke). If in doubt, install the link in the hole that would result in lower RPMs - closer to the carburetor. You can always move it later.

I forgot the oil and now it's stuck

OK, so you didn't read this document first or just got distracted while changing the oil and you ran the thing with no oil until it came to a screeching halt. Assuming nothing actually broke - it just won't turn at all, there may still be hope without a complete refurb (which in reality probably means a new mower):

(From: David Thomas (dthomas@NO.cityutil.com).)

The following assumes it is (was) a small push mower with a vertical shaft engine and that you drained the oil the preceding fall.

What little oil that was left in the bushing areas on the crank have burned down to tar. The piston may or may not be seized. Either way you'll need to break the engine down (pulling the flywheel is the hardest thing about it) and clean the tar out.

If this is beyond your abilities, try spraying penetrating oil on the crank around the bushing areas both on top (may still have to remove the flywheel to get to this area) and bottom as well as around the piston as the other gentleman suggested. (If you can't remove the head, pull the spark plug and spray penetrating oil or WD40 inside the chamber using one of those straw things that comes with the can so that you can direct the spray around all the walls of the cylinder, put the plug back in so it doesn't all evaporate and then set the engine so the piston is pointed straight up and let it soak a few hours.)

Last choice is to fill the crankcase with about a pint or two of penetrating oil (and spray inside the combustion chamber as stated above) then slosh it around the engine, turning the engine every which way and upside down, let it soak for a couple of hours repeating the sloshing every so often and changing the position of the engine so that you alternate soaking each bushing area and the bottom of the piston and then try the pull rope again. Be *sure* to disable the spark 'cause you *sure* don't want it to start with that light oil in the crankcase.

If it does free up, drain out the light oil and add the normal recommended oil before trying to start it. If it starts (it will smoke like the devil while it burns that light oil), let it run at idle speed until it warms up then shut it down and change the oil. It may still burn oil and smoke since the piston walls are probably scored badly so check the oil every time before starting it even after a short break until you get a feel for how much its going to burn.

(I had one engine that I did this with that used all most as much oil as it did gas. I had to clean the crud out of the spark plug before each mowing.)

(From: Brian Fistler (brian_34_@yahoo.com).)

If it's a Tecumseh engine, throw it away... Even if you get it running, it'll probably throw a rod soon (not like it wouldn't even if you hadn't seized it... :-)

If it's a Briggs, try putting oil in it first, then remove the spark plug and spray a liberal amount of WD 40 in there... You might have to let it set for a day or so, then, LEAVING THE SPARK PLUG OUT try turning the engine using the blade... Once you get it freed up, most likely it's run fine and probably last a few more years...

When I was a kid, my best friend and myself used to "work" on Briggs engines, we'd tear them down, fix broken ones from the junk yard, and most fun of all was "torturing" one... After seizing it up by finding out what would, and would not keep the thing running by spraying it in the carburetor (i.e., using hair spray, WD-40, paint thinner, etc...) We finally found that a certain spray engine degreaser of the era *would* run the engine, it would not run it for *long* because it removed the oil from the cylinder walls, and the engine would seize up...

That gave us an excuse to tear the engine down and find out how to get it going again... After the 3rd or 4th time seizing the engine with various products, we just decided to cut a hole in the side of the block and put a piece of Plexiglass there, so we could get easier access...

We ran that poor engine with every possible thing in the crank case, including pure water... (Side note: Water didn't seize the engine, as long as you didn't allow all of it to evaporate)

When the engine would seize up, all we ever had to do was put oil back in the case, spray a little WD-40 in the spark plug, and hit the blade a few times with a hammer to get it starting to turn...

That motor kept us entertained for an entire summer... :-)

So you got oil in the cylinder

> "I tilted my Toro to work on it and now can't start it because oil flooded into the cylinder. I already cleaned up the plug. Is there anything I can do to clean out the oil without taking the engine apart?"

Possibly, just letting it sit for awhile (in the normal position!) will allow the oil to drain back into the crankcase sump.

If oil is really trapped between the piston and the head, then you may be able to just tip the lawn mower so that the spark plug hole is down (a buddy may come in handy) and drain the oil out through there.

Alternatively, you should be able to suck most of it out with a kitchen baster and narrow extension tube (make sure it is made of something that won't scratch the interior of the cylinder and the piston) through the spark plug hole.

You don't have to get every last drop. What is left should not prevent you from starting the engine - it will just belch gobs of white/blue smoke for a few seconds after it kicks over as the remaining oil burns off. Keep in mind that squirting a half an ounce or so of engine oil into the cylinder is recommended when winterizing to protect the cylinder from rust so it should not be a problem.

In fact, I would expect that pulling the starter a few times will clear most of it in any case. It is possible that you have other problems - hopefully you didn't turn it over carburetor side down!. (In this case, the air filter may need to be removed and cleaned or replaced.) It may even be that your initial attempts to start it with an oil in the cylinder have resulted in a flooded the engine (excess gas) and waiting will clear that as well.

Some of the following information may be model specific but most applies to any engine that has gotten oil in the cylinder and/or carburetor due to tipping:

(From: J. Matthew Good (jmg14213@ix.netcom.com).)

First, my guess is that it is a Briggs QUANTUM or SIGNATURE SERIES engine, with the paper air filter. Go buy a new filter, as that one full of oil is shot.

Next, remove the plug and secure the plug wire away from the opening. Crank the engine a few times to clear the liquids out of the cylinder. Reinstall the plug. Now take a 1/2 inch box wrench and loosen (don't remove) the plug/nut on the bottom of the carburetor until gas flows clear through it, and retighten it. This should get the oil out of the carburetor. Now, check the oil.

Since you lost so much into the carb, and air filter, and it only holds 2 and 1/2 cups total you will probably need to add oil. If not, you may have gas in the oil as well. Drain the oil into a pan for recycling by tipping the mower air filter up, and dipstick tube down. Fill with clean SAE 30 HD oil. DO NOT use 5W30, 10W30, 10W40, or any other W oil. Just SAE 30 HD from any discount store will be fine. Do NOT use SAE 30 ND, it does not have the needed detergents.

Now you have the liquid out of the cylinder, the oil out of the carb, the gas out of the oil, the air filter OFF, and you are ready to start the engine. If it has a CHOKE, set it for full choke, if a primer, press it 3 times. Pull the rope until it starts. Let it JUST RUN until the smoke clears, don't mow or anything else until the smoke clears and you reinstall the NEW air filter.

The reason I guessed it was a Quantum is that this is the only engine I know of that automatically puts oil in the air filter if you tip it for sharpening. That's why the first thing I do to any Quantum that comes in for service is remove the air filter and put it in a safe place.

(From: Lloyd E. Sponenburgh (lloyds@fiscalinfo.com).)

Actually, a judicious tilt *away* from the carb will coat the underskirts of the cylinder and piston with oil so as to make starting *easier*. This improves compression. It's an old salesman's trick to show just how easy it is to start the engine.

So you put gasoline in the oil filler hole

Don't panic, just get it out of there. Drain the oil/gas mixture completely and refill with the proper new engine oil. If you want to be doubly sure, run the engine for a minute or so to mix any of the remaining contaminated oil with the new oil, then drain and refill again. It really shouldn't have done any damage if you get it out of there reasonably quickly (I don't know what effect gas might have on the oil seals over time though).

Oil starvation from mowing at too steep an angle?

4 stroke engines require oil to continuously coat the various moving parts during operation. There are two types of systems used in most small engines: splash lubrication and forced oil lubrication.

- Splash lubrication - there is an 'oil slinger' driven (via a gear) from the crankshaft. It dips into the oil sump and literally slings oil onto (hopefully) the moving parts in such a way that it makes its way down into the critical bearing surfaces.

  For the slinger to operate, it must dip into the oil! At too steep an angle, the slinger may be whipping up fumes and no oil!

- Forced lubrication - there is an oil pump (as with an automobile engine) and oil passages drilled through various parts to channel the oil directly to the bearing surfaces. (However, on the typical small lawn mower engine, there is no oil filter and no idiot low oil warning light or automatic shutoff - thus the need for periodic oil changes!)

  At too steep an angle, the intake of the oil pump may be exposed sucking fumes instead of oil!

With the oil filled to the correct level (yet another reason to check the oil every time you mow!), the oil starvation angle should be greater than anything you are likely to safely encounter unless you have a very hilly lawn. However, if you do mow steep slopes for more than a few seconds (e.g., to turn around), it would be worth determining if this could be a problem for your engine.

Two stroke engines do not have this problem since the oil is mixed with the gasoline. As long as the fuel feed is working, the engine should be happy and the mower will mow! However, I do not like 2 stroke engines because of their generally higher production of smoke and pollution.

(From: Walt Conner (jerrbear@midwest.net).)

Oil starvation can happen. If you must mow on a very steep slope, look to see which side the valve cover plate is on. This side of the engine will also have a semi-circular bulge in the crankcase while the opposite side will be pretty well flat. The side with the bulge will have the oil slinger located below the bulge. Keeping this side down slope should keep you in oil anywhere you can stand.

When failure occurs, usually the connecting rod is first to go, sometimes the top main bearing seizes. Either occurrence usually means it's time for a new mower.

For really hilly mowing, you may want to consider a model that uses a 2 stroke engine such as Lawn Boy.

Additional comments on winterizing - draining versus the use of fuel a stabilizer

Not everyone agrees with the recommendation to drain the fuel at the end of the season as described in the section: General preventive maintenance.

(From: Dwayne (Dwayne@mddc.com).)

There is some argument that draining all the fuel from the system is bad, allowing the carb to dry out and the inside of the fuel tank to rust. That was the case on my motorcycle; the guy who had it always drained the fuel for storage and it ruined the tank. I always just add fuel stabilizer to the tank, fill it completely, and run it for a short time and have never had problems.

(From: Matt Howell (howell@ll.mit.edu).)

Fuel stabilizer's purpose is to prevent souring, and hence, the need to drain the fuel system before storage. In my experience, my equipment starts right up each season with stabilizer in the fuel. I would suggest you clean/rebuild the carburetor. Repair kits are cheap, and easy. Good luck!

(Editor's comments).

I have cleaned and rebuilt too many Tecumseh carburetors (mostly from neglected Craftsman lawn mowers). The cause in most of these was almost certainly gasoline left in the fuel tank between mowing seasons. You might get away with it for a couple of years but eventually the goop will prevail. I would definitely recommend draining the gas with these. The fuel tanks are plastic in any case and there are only a few steel parts in the carburetor and rusting of these is not that likely. A fuel stabilizer may not prevent the buildup of gunk and varnish as a result of the slow but inevitable process of fuel evaporation in the carburetor and replenishment from the fuel tank.

For other types, I would still recommend draining the fuel tank and running the engine until the carburetor is dry. I believe that this will result in the best long term reliability in most cases. Now, if you live in a swamp and mow the seaweed.... :-)

Testing a used lawn mower before you buy

A used mower at a bargain price may not turn out to be such a bargain if you have to do extensive repairs. There are two types: the living and the dead.

If the owner claims the mower will start and is prepared to demonstrate, this is usually a good sign! However, first, take a moment to check the following:

(Disconnect the spark plug wire, and tie it safely away from the spark plug terminal to prevent accidental starting if you are doing anything more than looking.)

- Check for significant oil leaks particularly around the main bearing at the blade/PTO end. This could indicate a defective oil seal or extremely worn main bearing.

- Check the oil both for level and condition. If the oil level is low and/or really black and icky, the owner probably did not follow the recommendations in this document! The oil should also not smell of gasoline.

  CAUTION: the oil will be hot if you check it after the engine has been running for more than a couple of minutes.

If there is gasoline in the fuel tank and it will start without undo effort, then there is an excellent chance that the engine is in good condition.

- How much effort does it take to start? If 10 pulls on the starter cord are needed, this probably means that some maintenance, at the very least, will be required.

- Check for unusual vibration and noise which could indicate an unbalanced, bent, or broken part. The blade of a rotary mower can be replaced easily and inexpensively if it is bent but any internal problems will be costly or time consuming to remedy.

- Check for any unusual unevenness, surging, or sputtering. If there is more than one speed, see how smoothly the engine switches between speeds. Put it under load if possible (offer to mow some foot tall weeds) to see how well the engine deals with actual conditions that will be encountered during normal use. Problems here usually indicate at most that the engine needs some long overdue maintenance but it might help your bargaining position.

In most cases, if the engine starts reasonably easily, there will be no really serious problems. The ignition system may require a tune-up or the carburetor may need cleaning and/or adjustment. Even a hard-to-start mower may very likely restored to tip-top shape with this type of intermediate level maintenance. Of course, the blade may have to be sharpened or replaced.

If the engine doesn't work - no gas in the fuel tank and no handy gas can is usually a tip off of this - how can you be fairly sure that there are no major mechanical problems? Note that the objective here is not to identify **the** problem but to have a good idea of whether repairs will be really expensive or difficult. Thus, we won't even bother checking the carburetor or spark as problems in these areas are minor compared to those caused by internal mechanical damage. Here are some simple tests you can do without tools and without overly upsetting the people running the sale or junk yard:

WARNING: disconnect the spark plug wire and tie it safely away from the spark plug terminal if you will be doing anything under the deck. Yes, I know, there is nothing in the fuel tank but it doesn't hurt to be safe. Use a rag or proper work gloves if you attempt to rotate the blade directly.

- The single most important test is to determine if the pull starter will rotate the engine without binding or unusual noises. If it doesn't turn at all or with great difficulty - and there isn't a clump of grass stuck between the blade and housing, there may be severe internal damage including broken parts or seized bearings. However, make sure that the blade brake is disengaging before walking away - it could be that simple (you did remember to grab the dead-man bar or set the throttle control to RUN, right?). There is also a very slight possibility that the starter itself is simply tangled or rusted and that the engine itself is fine. In this case, you should be able to rotate the blade and it should rotate the crankshaft.

- For a 4 stroke engine, you should feel the resistance of compression once every two rotations of the crankshaft (blade). If there is a tough spot every rotation, the valves are not working probably due to broken teeth on the crankshaft gear or camgear. (For a two stroke engine, there should be compression on every rotation.)

- If it turns too easily with minimal resistance (and the blade is actually rotating, not just the starter) - you should have an idea of the effects of proper compression on a typical mower - then there may be stuck valves, worn piston rings, or other internal mechanical damage.

- If possible, perform this simple compression test: Spin the crankshaft is the opposite direction from normal. A sharp rebound on the compression stroke indicates decent and probably acceptable compression. Little or no rebound means that the compression is probably low. (This is actually the only compression test Briggs & Stratton recommends.)

- If the cord pulls out with no resistance and doesn't rotate the blade, the starting clutch may just be broken - a very minor repair. Then, you will have to check for binding by rotating the blade itself (carefully).

- If you found the starter cord broken, this could be minor and simply due to wear or forgetting to engage the safety bar once too often - or major resulting from attempting to start a broken and seized mower.

  I picked a mower off the curb once where the cord was broken due to guess what - a clump of grass stuck between the blade and deck. Apparently, the cord was quite worn and the mower stalled on the clump of grass. The next yank likely resulted in a stream of 4 letter expletives and the mower was put out in the trash. Extracting the grass clump and replacing the cord yielded a rear bagger in perfect operating condition.

  Another mower found in the trash was not as fortunate requiring the replacement of the gear on the crankshaft and the camshaft/camgear assembly due to broken gear teeth ($35 - it was a learning experience), carburetor overhaul, and a tune-up.

Assuming the engine doesn't flunk any of these tests, then you may end up with a functioning mower with relatively little additional cost and effort.

Discussion of 2 stroke engine rebuilding

> "I am in the process of refurbishing an old Eska 7.5 H.P. outboard boat motor. The engine (a 2-stroke Tecumseh) runs fine when under load at full throttle.
>
> I can only get the engine to idle at a high RPM. If I lower the idle speed, the engine will eventually die.
>
> Once the engine is started and idling, any attempt to put it into gear will cause the engine to die. Sometimes it will stay running and I can get the throttle revved up at which point the motor will push the boat and run just fine. When I lower the engine speed (approaching the dock) the motor will eventually die.
>
> I am totally stumped. I've completely rebuilt the carburetor (new seals, etc.), replaced the condenser, points, and spark plug. I've set all adjustments to factory specs yet it still won't idle or go into gear."

(From: Al Savage (asavage@iname.com).)

Although I haven't worked in the field in 15 years, two stroke theory doesn't change much .

Is your high idle (out of gear, unloaded) smooth? It shouldn't be. Two strokes without electronic mixture controls are almost always calibrated to be slightly rich when unloaded, as the nature of all three induction systems (piston port, reed, rotary valve) is such that adding a load leans the effective mixture. Something to do with flow dynamics, I didn't need to know, as I don't design them.

You've covered the common problem area -- ignition. I suspect you have an air leak somewhere. Upper or lower crankshaft seal, reed plate gasket, intake gasket, and upper housing gasket are common areas, in that order.

Mind, this is generic two cycle troubleshooting advice; I don't pretend to know the model you're working with.

To track these things down in the shop, we'd build custom block off plates and pressurize the crankcase to a few inches, then watch the gauge to see the leakage rate. Not terribly practical unless you're rebuilding, but you sometimes found porous castings and cracks that way.

When I'm feeling adventurous I'd spray starting fluid (with a tube nozzle attached) around all the seams with the engine running to see if the run behavior changed. Not recommended; too dangerous.

Does your 2 stroke engine use reed valves?

Since a bad reed valve can be the cause of a variety of problems, knowing if you even have these can be useful - not all 2 stroke engines use reed valves.

(From: John Barry (jb@zedak.keepyourspam.com).)

One easy way to tell is to note where port is behind carburetor. If it just "dumps" into crankcase, like diametrically opposite cylinder, most likely it's got a reed-valve. If the passage from the carb connects to the cylinder at a point closer to the crank center-line than the exhaust port, perpendicular to cylinder axis and perpendicular to crank, it's mostlikely piston-ported. If the carb passage is parallel to the crank eventually (starts out perpendicular on Rotax engines), most likely you have a rotary-valve engine; this is usually the case for serious specific-output.

Some problems with Briggs and Stratton engines

(From: Mike Brandt (mwbran1@uswest.com).)

A quite common problem with these engines is the gasket between the carburetor and engine. It is usually a thick fiber gasket and sometimes gets blown out if engine ever backfires. This is more common with age, as the nuts holding carb on do sometime get loosened. Also gum buildup can and does clog the main and low-speed jets at times which means removing carburetor. Cleaning out with a good carburetor cleaner then blowing out all passages. This happens quite often here where they add 10% alcohol to gasoline. Gas goes bad a lot quicker than without alcohol!

Comments on Briggs and Stratton repair

The following was in response to a posting on alt.home.repair about a 12 year old lawn mower. Of course, if properly maintained, such an engine may still have quite a bit of life left in it :-).

(From: foxeye (foxeye@www.mindspring.com).)

The best method is if you do not have a flywheel puller is take it to the nearest Briggs dealer and have them remove it. Since you do have a puller, just put some tension on the flywheel with the puller you already have, and then hit the top of the puller (the threaded shaft that centers on the crankshaft end) with a heavy hammer (16 to 24 oz.) should do it. Sometimes all it takes is a sharp blow with tension exerted on the flywheel to break it free. One or 2 raps should be enough. If it fails at that, there are still other ways to remove it.

Some have points and condenser some do not. There is a points/condenser replacement kit that makes it solid state available for less than $10.00 called Atomic Ignition. Also rust on the magnet of the flywheel and the ignition coil laminated portion can also cause it to have no spark. The measurement is critical for the ignition coil to flywheel space (called air gap) for proper ignition as well. Unless very badly corroded and worn, the points can usually be cleaned up and readjusted. Its not uncommon for the little fiber plunger that operates the points on some models to get stuck.

You should pick up a manual, for proper dimensions, and bolt torque. Even though it may list special tools for some repairs, there is usually a work-around in most cases. I would not really spend to much money on this motor, as the age is against it, but a new one from a source like Northern Hydraulics can be had for $99 to maybe 125.00. I picked up a 5hp highwheel lawn mower with a Briggs I/C motor at the end of last summer at a local builders supply and garden center for $130.00 new in the box.

Experience with Briggs & Stratton carburetor

(From: Dan Hicks (danhicks@millcomm.com).)

Last Monday, while I was mowing the lawn, our 21-year-old Snapper mower quit on me. I could start it up but it would run for a few seconds and then quit again. After futzing with it in the yard for several minutes I took it back to the garage, and, after several more attempts at getting it going, I decided it was likely getting too much gas.

I disassembled the carb and cleaned it good. It's a "PulsaJet" model with the carb mounted on the gas tank. The diaphragm looked good -- no visible holes.

I reassembled things and the thing started and ran well enough to finish mowing, but it didn't have much "oomph".

During the week I got a new diaphragm, and I got around to installing it today. What a difference!! It used to take several tries to start the mower, now it starts on one pull. And it has more power than it's had in years.

Hard to say what may have been wrong with the diaphragm, but likely it had some microscopic holes in it.

McCulloch chain saw hard to start

> "This weekend I picked up a 14" McCulloch chain saw and have had a hell of a time getting it started. I am no novice at this as I already have a gas trimmer and blower. I am sure my fuel mixture is right and have done just about everything else by the book. In how many pulls do I consistently start a cold McCulloch chain saw. I should mention that I HAVE started it but can't believe it should be this hard."

(From: DanDee I had the same problem with mine!

If yours is like mine , it has a throttle latch knob to use during starting. Mine never worked. After pulling myself silly trying to start it, I just decided to hold the throttle trigger open manually and it starts every time very easily.

You may want to give it a try if you haven't tried it already.

Riding mower stops periodically

(From: Mike Odryna (modryna@ix.netcom.com).)

You might want to check the oil level. Some of the Briggs & Stratton engines have a low oil pressure cut off. Some of these cutoffs are very sensitive. They will stop the engine when it's less than a cup low on oil. As far as I know, you can't adjust it either.

How do you get the blade off a tractor mower?

(From: Lloyd E. Sponenburgh (lloyds@fiscalinfo.com).)

Typically, you remove the entire mowing deck, then manipulate the deck, rather than the whole mower.

Alternatively, shops often LIFT the whole tractor, and work from underneath. I built a beam-supported block and tackle affair in my barn to do just that... it's lots faster than taking the deck off a stupid Murray. Those pieces of trash require that you remove about a dozen fittings and nuts to get a deck off.

Now, my Wheel Horse, on the other hand, requires only ONE hand-released fastener, and off-she-comes!

About Wico magnetos

These are separate units (not part of the flywheel assembly) and may be found on larger (usually horizontal crank) engines.

(From: Al Savage (asavage@iname.com).).

The design is such that it uses an impulse spring to fire at low speed (less than 10 rpm, yes 10). It does a complex wind spring/release spring action until the engine fires. Other than the straightforward "replace the points/condenser" maintenance, I don't think I ever had to have the mechanical section apart, they're that reliable. I do think I had to clean up a couple of them, and relube them though.

If you rotate the engine by hand (careful!) you should hear the impulse spring release, with a very audible bang. With the high tension lead hooked to your spare-plug-on-the-head, you should be able to have at least 3/8" spark; less is probably not enough.

If you don't hear that loud bang from the mag, while very slowly cranking the engine by hand (two turns per bang on that impulse unit), you probably have a mechanical problem. If you hear the bang, but can't get the mag to fire repeatably, I'd refurb the points and condenser. It's a bit tricky, and I haven't even seen one in 15 years, much less worked on one in twenty, but there are many still in service and parts should be readily available.

Oh, yes. I worked most of my teen years in small engine repair. So I *do* know whereof I speak. On that vintage equipment, anyway.

What is inside a small engine electronic ignition module?

The advantage of these systems is that there is no maintenance as there are no points to wear out or gum up. Timing is fixed by the relationship of the flywheel magnet and sensor. There are also no adjustments except to set the magneto coil pole piece to flywheel air gap.

Replacement modules are available for many small engines to take the place of their original point type ignition system. These can be designed in several different ways but all must emulate the behavior of the point type ignition replacing just the magneto coil/pole piece assembly and without requiring alterations to the flywheel.

- One design uses the flywheel magnet passing the coil pole pieces to induce a moderate voltage - a few hundred volts - and store this in a capacitor. A sensor coil then triggers a solid state switch which dumps the charge in this capacitor into a high voltage transformer (ignition coil) to produce the spark.

- Another possible approach is to provide a coil in which current builds up until the moment when the points would have opened and a transistor switch to interrupt the current flow at that instant. So, perhaps something like a switchmode power supply or TV horizontal output transistor with a current coil like the ordinary magneto coil and a network to control base drive to the transistor so it turns on and off at the proper times. Some designs may use a separate sense coil to control this more precisely.

  If you are really curious, check out **U.S. Patent #4163437: Transistor ignition circuit**. There are diagrams of several possible variations on the basic circuit. (The US Patent & Trademark Office currently has a search facility with free access to complete text and graphics.)

Not that any of this profound knowledge does you any good for repair as these things are usually quite well potted and impregnable.

Capacitor discharge ignitions systems

(From: Matthias Meerwein (mmerwei@eis.k8.rt.bosch.de).)

I once fixed a CDI unit for a 3-cylinder Evinrude 2-stroke outboard motor. The storage capacitor (1 uF, 400VDC) had a short. Quite simple to replace, but digging the PCB out of the silicone RTV sealing compound inside the ignition box was a real pain! But considering that Evinrude charges real big bucks (about 800 DM = 500$) for the ignition box, it was worth the effort. Another possible cause of failure of the CDI are the SCRs. Also, check the charging and trigger windings as well as the cables and connections.

Which manufacturer makes what brand names?

The following could be retitled: Sales people don't have a clue of what they are talking about most of the time or make something up to please the customer (and pad their commissions). I'm not sure how much of the following can be trusted though in all fairness, it may be that manufacturers switch around like musical chairs. :)

(From: Tom Bellucco (bellucco@netacc.net).)

I recently moved into a new house with a very large lawn and went shopping for a riding mower / lawn tractor. This is what I was told by various people, both in and out of mower sales:

- Toro makes Toro and Lawn Boy.
- MTD makes all of the store brands (i.e., a mower that might have the Home Depot name on it), along with MTD, Dynamark, YardPro, Weed Eater, Noma, and Sears Craftsman.
- Murray makes MTD.
- MTD makes the low end (non-commercial) John Deere tractors.
- John Deere makes all John Deere.
- MTD makes White.
- White makes White.
- American Yard Products makes MTD, Noma, Dynamark, YardPro, Weed Eater, Sears Craftsman, and all store brands.

Now THAT'S confusion! I'd like to hear what anyone out there knows or has been told. It ought to be interesting to hear what other stores are telling people.

Note: The guy that told me that MTD makes John Deere sells Toro and Ariens. He has publicly stated that he HATES John Deere (I won't post his exact words). I never realized how defensive a guy gets about his tractor -- you should have seen the reaction I got when I told a guy his John Deere was made by MTD! I probably got a worse reaction than if I said something bad about his wife!!!! Anyway, he got right on the horn to his John Deere dealer and was promptly told that John Deere makes all John Deere products.

(From: Duane (djdubay@ix.netcom.com).)

Hmph... That *is* confusing. Just make sure that sucker says *Briggs & Stratton* on the blower cover!

(From: John P. Curcio (jpc@philabs.research.philips.com).)

According to my Cub Cadet dealer (from whom I purchased my snow blower), Cub Cadet, White, and MTD all come from the same factory. The only differences are color and features. They are located somewhere in Ohio, near Cleveland, if I recall correctly.

(From: Carol (carol@willard-oh.com).)

I live just up the road from the MTD plant - never saw a John Deere. I don't think they do that one.

(From: Peter Szymonik (Xorg@msn.com).)

John Deere makes *all* of their riding mowers. The walk-behinds are assembled by a "third party", and many Deere dealers don't carry the walk behinds for that reason, and because the walk behinds had electrical problems.

(From: BELJAN E (lvpy67c@ix.netcom.com).)

HUH??? That doesn't sound right at all. MTD makes that, MTD, Ariens, White, Cub Cadet, Yard Man, and Lawn Chief. Murray, another famous store brand makes some of them. Dynamark was and probably still is its own.

John Deer is John Deer.

(From: DeWayne McKay (dmckay@geotec.net).)

You have several people misled on who makes what lawn equipment. I've been in the repair business for about 12 years now. Murry is made by Murry. John Deere is made by John Deere. There are several hundred names that can be found on the side of an MTD product, but MTD does not make any AYP, Noma, Dynamark, or Sears product. Sears in the late 80's was made by AYP and Murry depending on model. Now they are only made by AYP. The new line called Scotts is partially made by AYP. And, as for John Deere: The cheaper smaller tractors are AYP and the bigger tractors are made by John Deere. Huskvarna mowers are also made by AYP except a few high-end commercial models. Also the bottom-end or should I say cheap trimmers and chain saws from Huskvarna are made by Poulan. Have you ever heard of Gilson? They built a lot of the Sears products in the 70's and 80's and also built Lawnboy's tractor line and some of the Ford line in the late 80's.

Comment on modern manual mowers

(From: Peter Szymonik (Xorg@msn.com).)

Sears still sells push mowers, I bought one this summer and use it for the trim areas, works great. The only downside is that you have to go to a professional mower shop to get the blades sharpened correctly.

Comments on electric mowers

(From: Leslie Gerstenfeld (lgerst1@umbc.edu).)

I bought a Ryobi Mulchinator in '94 (cordless electric). I found it cheapest at Home Depot, I think it was about $325. I really like it.

Pros:

- Cordless, no gas, no oil, no tune-ups, no starter cords. It starts literally with the touch of a button.

- Comes only as a "mulching" mower, so there is no bagging, and the mulching action really works - it shreds the grass into 1/2 inch pieces that you don't see on the lawn. I had previously purchased a Black and Decker corded mower (which I think is also available as cordless), MM450 I think, and it had a mulching "conversion" kit that blocked the bag chute, but just caught lots of grass and didn't really mulch.

- Ryobi says it will cut 1/2 acre on a charge, which I find a bit of a stretch, but it does cut my 1/4 acre of grass (on 1/2 acre lot) without any problems.

- It has a 'Remaining Charge' gauge that works pretty well, though its not very progressive, it kind of jumps in 1/4 'tank' increments.

- Designed to be stored either upright (normal orientation), or upended - the handle folds down over the main deck and you can tip it on end; it takes up very little space this way.

- Cutting height is easily adjusted with one lever located by one of the rear wheels.

- Recharges in 11 hours. The instructions say to always leave it plugged in, even through the winter.

Cons:

- Fairly heavy as mowers go since it has on-board batteries, but I don't have any problems using it.

As for the big issue - how does it cut. Well, it cuts pretty well, but it certainly can't take down anything like a gas mower can. As the grass gets higher, it starts to leave a bit along one edge of the cutting strip slightly higher.

If you are the type who knocks a foot off your grass every few weeks, this isn't the right mower. But if you mow regularly, it works pretty well.

(From: Carol J J (caroljj@ix.netcom.com).)

I have used Black and Decker electric mowers for over 20 years. I Love them. We have a small property and a 100 foot extension cord is all we need. Since my husband is disabled, my young sons and I have done all the mowing for years. There are no worries about pouring or storing gasoline, no pulling like crazy to get it started. The blade is easy to replace. The grass bag is awkward but okay. My latest is a mulcher. It switches between regular and mulching easily. The mulch works well, not as good as a Snapper, but we're not paying Snapper prices either.

(From: Nann Blaine Hilyard (hilyard@pol.org).)

I bought a Black & Decker cordless electric mower for $150 at Menard's last year. It is lightweight and very easy to use. I have not calculated the energy cost (we keep it quietly charging between mowings, though we unplug it in the winter) versus a gas mower, but I don't have the strength to pull the cord for a gas mower so the extra electricity doesn't bother me.

(From: Geoffrey G. Shepherd (gshepherd@seanet.com).)

When my old Craftsman gas mower gave up this summer (gas leak) (what, you didn't read this FAQ?? :-) --- sam), I decided it was time to replace it with a new electric mower (my brother-in-law has the old mower now and is working on it for his own use). I ended up purchasing a Black & Decker CMM-1000 5 HP Cordless Mulching Mower from the local home improvement warehouse for just over $350.

So far, I'm quite happy with it. It mulches better than the Craftsman did, and rear-bags when I want to add to the compost pile. It mows my entire city lot on a charge (in fact, the built-in meter still reads full charge when I'm done - admittedly, my house takes up a large portion of the lot). I also like how it adjusts height with one clever lever. It's fairly quiet, and my clothes don't smell like gasoline when I'm done. Call B&D at 1-800-762-6672 and they can send you literature and a free video on the CMM-1000.

My only complaint with it is the weight. It seems to weigh about the same as the gas mower it replaced - it might even be few pounds heavier. But that's OK - I can use the exercise.

(From: Steve Hill (hills@inficad.com).)

I spent 3 years with a push reel mower. If the blades where sharp and the grass short then it was fine. If the blades where dull or out of adjustment or if the length of the grass to be cut at all long, it would leave the lawn a mess. I'd have to make 2 or 3 passes to get decent results. Also some types of weeds with resiliant stems where very difficult to cut.

Finally, last year I bought a Black and Decker cordless electric. It was magnificent. It was a mulching mower so my raking days where over and it gave much better results. Also, it was very quiet and was always ready to go in an instant. All of my neighbors with gas mowers were very jealous.

(From: William Lee (w-lee2@nwu.edu).)

I have had a Ryobi for 4 years and found it to be adequate for our small lawns. It takes me about 20-30 min.to do everything. In my opinion, it does not cut as well as a "good" gas powered mover that has a sharp blade. The batteries do degrade over time, although I'm am still working on the originals. It had an charger problem the first year, but that was fixed without charge. The blades are non-standard and I have an extra so that I can have a resharpened blade ready to go.I do enjoy not having to "listen" to the noise of a gas engine! Good luck!

(From: Andy Dennie (adennie@instinctive.com).)

As a former reel mower user and a current cordless electric mulching mower user, I can comment on both of these items.

I used a reel mower for about a year and a half. I found that it worked well if I cut the grass pretty short, but when I did that I got more weeds. I tried raising the blade height, but then it didn't cut as well.

This year I got a Ryobi Mulchinator cordless electric mower. So far I have been pretty happy with it. The charge is good for about 1-1.5 hours, supposedly, but it only takes me about 45 minutes, so I don't know what its limit is really. It's louder than the reel mower, but quieter than a gas mower. While charging it can stand on its nose and the handle can be folded up so that it takes very little floor space in my garage (this was important for me). One minor inconvenience is that you have to leave it plugged it all the time (at least that's what they recommend), so it is helpful if you have a plug near the place where you will store it (you don't want to be tripping across a long cord all the time). This didn't turn out to be a problem for me. Another thing is that you're not supposed to store it in very cold weather (bad for the battery I guess), so I had to move it inside recently for the winter.

(From: Jim (jstrohm@texas.net).)

The only problem we've had with our plastic-decked B&D is that it tends to collect grass when it's wet, and clogs frequently. We've chunked a few rocks with it, but with no damage.

We haven't actually tried to cut rocks with it, and my experience is that a rock will penetrate the deck of any mower if it hits right. You should pick up the rocks before you mow, not try to hide from the shrapnel.

In general, electric mowers are best suited for smaller lawns with less vigorous growth and without extensive landscaping to tangle the cord. A frequently sharpened blade makes a tremendous difference on electric mowers.

(From: Robert Smits (rs@ham.island.net).)

I've had experience with both electric mowers and gas mowers. I live in an area where the grass can grow quite quickly and thickly, and the B&D electric one just doesn't have the oomph to cut long, thick grass. (Even when you make sure you're using as short a heavy duty cord as is practical - to avoid voltage drop in the cord). My 5HP gas model just whizzes through the same stuff, and not having to hassle with the cord is really an advantage - my lot size is just under an acre.

The battery operated electrics may run out of steam quite soon if you have a larger lot, and count on replacing the battery pack every few years.

(From: Roger Fillingim (rfilling@uab.edu).)

I've had two electric mowers, both cordless - a Ryobi and a Black & Decker. The B&D was rated as a 5 HP engine, although I have no way of knowing whether it delivered the same power as a 5 HP gas mower. I used my electric mowers on a small lawn. I would agree that the electrics don't do as well on a overgrown lawn, but other than that my electric, especially the B&D, were great. I still have the B&D, but I'm in an apartment right now so I don't have much use for it. But, when our new house is completed, I plan to use it again.

While charge time and power are potential downsides of electric, not having to change the oil, fill up with gas, pull a starter cord, etc... are substantial benefits in my opinion. Also, electric lawn mowers are much quieter and more environmentally friendly. If your yard is not too large and you mow fairly regularly, electrics are an option to consider.

(From: Pat Kiewicz (kiewicz@mail.wwnet.com).)

I hung up my reel mower for my Black & Decker rechargeable electric, for the very same reason. My mower also can bag grass for those occasions when due to circumstances beyond my control I must cut grass that is too tall or too damp or when I want grass clips for mulch or composting.

It runs on a lead-acid battery (same technology as your car battery) and can survive the winter in an unheated garage. I have to go rechargeable if I want to go electric as my lot stretches back 200 feet or more from the nearest plug. The battery should last a good, long time if not abused. (How often do you have to replace your car battery?)

I believe the most recent issue of National Gardening Magazine has an article on electric mowers, with comparison between the features of different brands and models.

(From: user@execpc.com (C. Ligh).)

I bought the Toro 24V rechargeable $349 based on the free video tape Toro provided describing all its features and options. The problem with the rechargeable is run time.

I have a 10,000+ sq feet lawn and after about 35 minutes mowing the battery level lights went out. The owner's manual states: one should stop and recharge after the lights are out or the batteries' life will be shortened. Anyway there was still power left and I finished the lawn in about 65 minutes. With the prospect of replacing the batteries every year and run time shortened after every use, I returned the mower.

Toro does offer a 30 day return. You might want to give it a try when you have grass. Get the corded model if you don't have too many trees and save a $100.

When ever my 13 years old Honda dies, I'll probably get a corded electric mower. But I do miss the quietness of a electric and absence of exhaust fume.

P.S. There is a 36V rechargeable, but it's a $100+ more. So, will replacing the two batteries = $200?

(From: Michael Lamb (michael.lamb@nciinc.com).)

I own an electric mower now. It's a beefed-up Sunbeam. I found it on the side of the road and did a bit of 'customizing' to it. I like it MUCH better than the gas thing I had for years. The cord is a bit of a bother but when I think that I'm polluting far less and it uses far less power (costs about 25 cents less energy to cut the yard compared to the old gas one) AND it doesn't stink and be a pain to start and a health hazard and is quieter too. I might get a new cordless eventually but the $375 price tag is a bit much. I tried one out and think they are pretty nice, far lighter than a gas mower. Besides the one I have does very well for now. A friend of mine bought a B&D cordless, she likes it and has no problem doing her yard and her neighbors too! (she likes cutting grass)

(From: ap052137@idirect.com).

Have really enjoyed the convenience of a cordless mower. Bought it in 1992 and went to replace the battery. It is a model 3300m and got the shock off my life when the first place I tried quoted me a price of approx $236 cdn. I got in touch with B&D and they directed me to another dealer where I got it for $93. However, this dealer told me that the new price list does indeed show $236 cdn for new stock. Goodbye B&D the next time the battery needs replacing. I can buy a complete gas or ac unit for the amount of money.

(From: Mike).

The problem you state does not exist for only B&D lawn mowers, but *any* rechargeable product. Batteries do not last forever, and typically account for more than 50% of the cost in any tool. Often times the batteries are a standard size and you can get relatively inexpensive replacements at electronic stores. As an example, most cordless drills use sub 'C' cells which run about $1.75 a piece from Tanner Electronics in Dallas, Tx. For comparison, B&D wants $20 for their replacement (four batteries).

At the risk of sounding like a zealot...the people that think they are "saving the environment" with their electric lawn mowers are fooling themselves. In the first place, all you've done is moved the pollution from your backyard to somebody elses, and soon we're going to extend this fallacy to cars (oh, joy...smog in the country). In the second place, the process used to produce Cadmium plating is so toxic that even the US military is phasing out its use, while most foreign (non-US) governments outlaw its production entirely. "Green factor" wise, we're all probably just as well off with oil burning tub-thumpers.

I predict in the not so distant future (10-20 years) we'll see the end of NiCad powered appliances either because governments ban them, tax the daylights out of them, or nobody will be dumb enough to build the batteries anymore. At the very least, expect to see mandatory recycling programs for *all* types of batteries (not just lead-acid). Regardless, prices will sky rocket.

Ok, soap box mode off :).

(From: J. Matthew Good (jmg14213@ix.netcom.com))

First, battery powered lawn mowers use Lead - Sulfuric acid batteries, just like in your gas powered car, only smaller. Second, these batteries are one hundred percent recyclable. Yes, that is 100%.

To the original poster: The only problem with battery mowers is that you must follow the directions about over- charging. Also, they are sealed, as most of them are installed laying on their sides, so ordinary replacement batteries would leak.

Ryobi has replaced the pair of batteries in their machine with a single 24V unit which lists for about $95 US, PLUS FREIGHT. From what I've seen, they are lasting anywhere from 2 to 3 years for most users. To make it last longer, charge only until the indicator says it is fully charged, then unplug it. On a Ryobi, the light turns from red to green to indicate full charge, and supposedly goes into float charge. Don't take a chance, when it turns green, or whatever Black and Decker's equivalent is, Pull the Plug.

(From: Ronald Kramer (kramerr@oasys.dt.navy.mil).)

This is my third year with a so-called 5HP Black and Decker battery electric. I think they are crap! I couldn't mow the lawn due to rain this weekend once again so the grass got to be twice the cutting height. This requires that I cut without the bag which causes the grass to clump. I then have to go over the area again with the bag. For my 12500 sq. ft. yard takes 4 days because I have only 50 min of charge. So when I finish I have a yard of grass at different heights and it is time to start mowing again.

(From: Jeff Canavan (Canavan@foodfac1.rutgers.spamfree.edu).)

I recently had the decision to make regarding a new lawn mower. I went with all electric stuff for the yard; corded combo weedwacker/edger, 16" chainsaw and Black and Decker CMM1000 rechargeable lawn mower. Searching through prior usenet posts with Dejanews.com, I found mostly good comments about the lawn mower and thought I'd give it a try. It comes with a 30 day money-back offer, so if I really hated it, I could return it to get a corded one or a fume belching fossil fueled model. After plugging it in overnight, I mowed the grass for the first time last Sunday, (it hadn't been mowed for 7+ weeks) After mulching the 1/2 acre of shin- to knee-high grass and weeds, the charge indicator was still in the green zone halfway between the Fullest and the yellow. The box states 1/2 acre range, including driveway, walkways, and house. It must be conservative or I got a really great set of batteries.

Discounting all ecological debates regarding macro pollution issues;

Pluses:

- No gas or combustion fumes to take away the fresh cut grass smell (Do ANY gas mowers have catalytic converters?).
- No starting hassles.
- No gasoline to store, spill, or deal with.
- No oil to change, ever.
- Quieter than gas mowers.
- A real metal cutting blade, (some corded model have nylon cords).
- Better cutting power than most corded models, (5hp).
- No power cord to trip on or wrap around trees (I have many).
- Mulches or bags mulch, (I tried it with leaves, it worked well).
- One lever to control cutting height for all wheels

Pluses, neutrals, or minuses, (depending on your view of yardwork):

- Won't cut wet grass well, (i.e., wait for a nice evening)
- Limited run time, (If it won't cut all your grass at once, I'd consider something that would, unless you don't mind waiting for a recharge).

Minuses:

- Expensive, I paid $359 at Home Depot.
- Only a 19" cut, smaller than most gas mowers, corded ones are equal or greater.
- As heavy as gas mowers, corded models are lighter.
- Require a dedicated outlet to store and charge.
- Long term battery life (?) & Battery replacement costs ($?).
- Push mower, not self propelled.

(From: Frank Wilder (frank.wilder@intrlnk.com).)

We have an 18" rechargeable Black & Decker electric and we really like it. We bought a refurbished unit at a Black & Decker outlet.

Pros:

- Can use during Ozone Action Days

- Easy to start -- just engage the switch. (It's always entertaining to watching the neighbors with the gas mowers try to get them started).
- Quiet -- you can cut your grass early in the morning or late in the day and not bother anyone. I also use my walkman while cutting and I don't have to have the volume all the way up.
- It cuts my yard (1/3 acre) with plenty of charge left over. Every so often I run the batteries all the way down before recharging. It runs for another 45 to 60 minutes after I am done, but this is with the mower sitting on the driveway (no load on the cutting blade).
- Very little maintenance.

Cons:

- Mine only cuts an 18" track, but some may cut wider.
- Mine only cuts a small yards (< 1/2 acre)...but each mower is different.
- What do you do when the batteries ware out? and how long will that be?
- Mine doesn't allow you to raise the deck as high as I would like to.

I am happy with the one I have but I can't wait to upgrade to a bigger one. The newer B&D lawn mowers look really great.

(From: Dave Clark (Dave_Clark@dg.com).)

Country Home Products, the people who make the DR Field and brush mower offer a cordless lawn mower that has a removable battery. The battery has a built in handle and lifts out of the mower housing for easy replacement and charging. If it is half the quality of the DR Brush mower it is a great mower, and a great company to do business with. They are located in Vermont, and you can get their number from 800 information (1-800-555-1212).

I don't own the mower (yet) but am considering it for my mothers house. I do own the DR and I love it. I have no interest in this company - but I am a very satisfied customer.

(From: Topher Eliot (eliot@alum.mit.edu).)

I'm happy with my Sears electric. I discovered on trick for dealing with the cord: use a heavy duty, long cord (100', 12-gauge in my case) with a short light cord at the end (20' 16 gauge). This allows moving back and forth a moderate amount without having to move that heavy cord.

BTW, I don't think I really needed that 12-gauge; in retrospect a 14-gauge would have been better.

Comments on mulching mowers

(From: Jeff (kahlua53@aol.com).)Kahlua53

Mulching mowers are nice, you don't have to bag any of the grass that you cut. Mulchers do need a bigger engine, that's why if they are used to mulch make sure it is at least a 5 hp 21" or less (6hp for a bigger cut). Mulching adds moisture and acts as fertilizer for the lawn. The bad thing is that you need to cut the lawn every four to five days. If the grass gets too long the mower can't cut the grass as well as it should (also it's not good for the grass if you cut off more than a inch at a time that is when the mower is set at 3 inches). So for that reason it would not look that good if it was to rain a lot and you could not cut the grass. As for me I have both types that works out very well.

Comments on inexpensive lawn mowers

True or false?:

> "Throw away mowers will always cost you more in the long run. Murrays and MTDs are bargain basement mowers, and you most definitely get what you pay for."
>
> "The problem with Murrays and MTDs is that they use the cheapest engines and components available. If you manage to get the engine to last, the rest of the mower will fall apart around it. Remember, the reason K-Mart, Lechmere, Caldor, and other mass merchandisers sell these machines, is because they want you to come back every 2-3 years to buy a new mower from them."
>
> "Murray is a bargain basement brand sold by mass merchandisers who want you to come back for a new mower every 2-3 years, and Tecumseh engines at about the same. :-(If you manage to get the engine to last, the deck will fall apart around it. On the bright side, at least they are cheap."

Some responses:

(From: Jan Hickman (janry@ix.netcom.com).)

Yea!! My bargain basement (cost under $100 when new) Murray is over 10 years old and I'm cutting .4 acres with it. You can bet when it wears out (if it ever does) I'm gonna buy some mega bucks mower!! But if you do take that bet, let me in on the other side of the action. Keep the blade sharp, the air filter clean, topped up on oil and they will run for a looooong time.

(From: Don Sterner (No@junk.email).)

Well, my Murray has a quality Briggs & Stratton engine which is still running fine. My problem is that the deck has rusted and is now a shell of its former self. There is barely enough metal left to hold the blade shafts in place. The mower is only 2 1/2 years old, but we do live on salt water (next to it, really). All of our property is well above the water line - the mower has never been wet with salt water. I've made it a practice to always hose the mower down after use and I keep it under cover when not in use. The only replacement decks I can locate cost nearly as much as a new mower.

Our previous mower (a Craftsman) was returned to Sears within 6 months after it had lost much of its paint and was covered with rust.

(From: BELJAN E (lvpy67c@ix.netcom.com).)

My MTD mower holds up fine, and I have the killer lawn. It burns out virtually every lawn mower's engine, whether it is Briggs or Tecumseh. I bought my MTD and it is a self propelled with 3.75 hp Briggs & Stratton Sprint engine. I would buy the same mower again, the problem is I probably wouldn't need to! The mower is so durable, it is unbelievable (I should note it is last years front cog drive which now is 4 hp quattro, and it is still sold with the 3.75 HP engine as Lawn Chief.) It survived a year and still doesn't burn oil! That is a major accomplishment. The only trick is to put Marvel Mystery Oil into the gas and oil. I also have a 16 year old Snapper and it still goes. Regardless, MTD is well worth it. You get a cheap mower that in my estimate unless you abuse it will last 5 years or more with good maintenance. $100 or so for 5 years of use (and it isn't hard to maintain them) is an excellent deal. A $600 mower could last less than that.

(From: Floyd Reed (floyda@ix.netcom.com).)

If you take care of amy mower, you can expect a reasonable amount of service out of it, usually comparable to the price. True, Murray mowers are cheaply built, but they build an awful lot of mowers... with different name brands. Most still carry a substantial warranty. As for Tecumseh engines, years ago they were the more expensive engine, placed on the more expensive machines. They were the only engine of this type and size to incorporate an actual oil pump. I never did care much for them as they liked to burn exhaust valves and blow head gaskets. The carburetors left a little to be desired also. They were good for my small engine repair business. I am out of the business now and have not taken one apart for a long time and do not know how they are being made today, but I'll bet if you take care of them and change the oil regularly as well as keep the air cleaner clean, you will receive respectable service out of it.

(From: Jan Hickman (janry@ix.netcom.com).)

My Murray with a 3.5 HP Tecumseh engine is over 10 years old. The only parts replaced have been the wheels, the spark plug once and the blade a couple of times. The lawn area I cut is approximately 1/3 acre. Will I ever buy a $500 quality lawn mower? Not as long as I can get one to last like this. And by the way - it's not luck, it taking care of them. I know several people whose bargain basement brands last several years and they all have one thing in common. They take care of them."

(From: Patrick J. McQuiggan (PMCQUIGGAN@cardinalfinancial.com).)

I've had a Murray since 1990. No problems whatsoever. Also 1/3 acre. Use it regularly. Follow maintenance advice. Engine is Briggs & Stratton 5 hp and it is self propelled. A bargain.

(From: Bijan Mobasseri (mobasser@vu-vlsi.ee.vill.edu).)

I am amused with the high power recommendations here: Honda, Toro, Snapper, Lawnboy, some costing $600. In 1989 I bought a walk-behind Murray for $99. This morning, as in all Saturdays, I pulled it out of the shed, gave it ONE pull and as always it started. It is still running on the original plug (Tecumseh engine) and the only thing I have replaced is one $5 wheel.

Comment on high wheeler and wish list

(From: Edward Rice (ehrice@his.com).)

I've got a non-propelled high-wheel, it's okay. Nothing very exciting. My lawn is hilly but not bumpy, and I had gotten the high-wheeler to assist in shifting over edging and over flag walkways, and it's okay for that - but not so great that I'd bother with a high-wheel design in the future.

What I would *love* to get in the future, and maybe that 'weed whacker on steroids' is what I really need, is something that would let me go casually over edging, so the blade is cutting grass on one side and safely *not* cutting 1 to 2" river stones on the other side. This is made worse because the left-hand wheels on the stone (typically, with a right-throw mower) jiggle up and down enough that the occasional stone does get whupped.

I'd also be interested, if anybody makes one, in an *offset* mower, in which the left-hand wheels were not to the left of the mower housing. By increasing the wheelbase and putting one fore and one aft, I would love for the left side of the mower to be cantilevered out with nothing under it but the blade, to let me get really close for edging. I don't want a specialized edger - I want a mower that can do the job through the simple expedient of getting the left-side wheels out of the way!

Comments on plastic decks

(From: Joe Kowalski (builder@proaxis.com).)

I bought a new Honda with a plastic deck. I like it. The plastic is not like regular plastic; in fact, it has proven bulletproof. It is very lightweight. I mowed many rocks, keys, etc. with no problem. It was a concern of mine when I bought the unit ($660), but the salesman convinced me that it was 'put through hell' to prove its vitality.

Comments on Briggs & Stratton versus Tecumseh engines

These two manufacturers produce the vast majority of small engines used in low to medium priced yard equipment.

I have always preferred Tecumseh engines over Briggs & Stratton though perhaps this is more of a touchy-feely thing than representing any really fundamental difference between the two. The float carburetors (e.g., Craftsman) do tend to gum up if the gas is not drained at the end of the season but they are easy to clean and rebuild. (Also, I have picked up several mowers dirt cheap at garage sales where the only problem was a gummed up carburetor - 15 minutes work to remedy.) Change the oil regularly and Tecumseh engines will keep going for a long time.

(From: BELJAN E (lvpy67c@ix.netcom.com).)

> "What a JOKE!!! Try rebuilding a '72 carb sometimes, the floats are terrible, I finally slapped a '91 4 HP carb on the 4 HP '72 and it works now!!!! Some newer ones can be saved, but 10 years of sitting with *leaded* gas, that spells the end."

Hehehe... A guy just sent me a couple of carbs that were probably closer to '72 than '91. A new needle, seat, and hinge pin (in one case) was all that was needed (beyond the gallon of carburetor cleaner!). :-)

(From: BELJAN E (lvpy67c@ix.netcom.com).)

> "It depends on how the gas was in, if you drain the float, you should be able to get it clean. Another trick is to put Marvel Mystery Oil in the float assembly and let it sit there a week, in 99% of cases, that will get it running. On the '72 carb, The gas formed crystals around all of the parts, I put all sorts of carb cleaners in, and I replaced the rubber seal, float, needle, and all replaceable parts, it didn't work. I pulled the carb off (this happens to be a '72 Tecumseh off a Sears engine. My guess is that is was overhauled so I got it starting on one pull with starting fluid). I took a '91 Sears (Tecumseh) carb off and bolted it onto the engine, since this is a power reel mower, the engine isn't easily replaced, the new carb is from a primer type non-choke engine, so I made a rubber plug in the hose to the air filter assembly to spray starting fluid into the carb to start it. Now it works fine. It looks strange but runs great!"

(From: Thomas N. Harding (harding@coypu.cig.mot.com).)

> "I would like to add that Tecumseh engines are easy to rebuild. Most folks would be surprised how few parts are in them."

(From: Steve Ordinetz (steveord@xtdl.com).)

> "Several years ago I worked with a guy who rebuilt small engines as a sideline, and he was partial to Briggs & Stratton because parts tended to be pretty standard from year to year, while Tecumseh were less interchangeable between similar engines of different vintage."

(From: Terry Highley (terry.highley@daytonoh.ncr.com).)

> "I agree 100%!!!"

(From: BELJAN E (lvpy67c@ix.netcom.com).)

> "Ha! I have had no trouble forcing Tecumseh engine parts to fit on same horsepower engines, and they all worked fine, I had spent over 30 minutes starting one with stale gas once though!"

Comments on Honda overhaul

(From: Israel Kantorowicz (kant@sqi.com).)

I recently damaged the engine on my Honda mower, so here is my experience (Seattle area):

The engine is well built and fairly easy to work on. Their manual specifies a bunch of special tools, but I was able to take the engine apart and put it back together with just "ordinary" small engine tools. The only problem I had was with the flywheel. It has no threaded holes, and needs to be held around the periphery with something like a belt-wrench while torquing the center bolt. For the same reason, a large gear-puller is required to remove the flywheel from the crankshaft. I did not attempt anything ambitious like replacing valve seats, though. All threads on this engine are metric, of course.

The manual (available from dealers) is very clear and well illustrated. Carb rebuilding is not covered, however. Part numbers are listed in a special "parts manual", not in the regular one.

Note that Honda appears to have a policy of not letting anybody but their dealers get in touch with their central tech support. They don't publish their phone number, and there is no email address either. I could not find the timing mark on the crank, and the dealer could not or would not help, so guessing was the only option left... I don't know if other small engine makers are any better in this respect, but I am used to customer support meaning something entirely different in my line of work.

No trouble getting parts, but they all had to be "special ordered" from out of state, taking about a week to arrive. They seem very expensive to me. A rod was $50+, a set of piston rings, valve springs, or head gasket $20+ each, and the crank (which I luckily ended up not needing) was supposed to set me back about $185. My relatively minor repair ended up being about $125 in parts (taxes, oil, and band-aid for bruised knuckles not included).

The mower has served me well, and the only problem other than caused by my own fault was premature wear of the blade clutch lining. The plastic deck seems to take rock hits much better than an aluminum deck that I owned some time ago, and there is no paint to peel of from it.

Walk behind versus riding mower or tractor

(From: Stephen M. Henning (shenning@fast.net).)

The forward speed is about the same for a walk behind and a rider, about 3 mph. The main variable is the width of the mower. Let's say we have a 42" mower. If the overlap is 4", then we have 38" cut.

Then the time to do one acre with a 42" mower is:

220 ft. x 220 ft. / (3.17 ft x 4.4 ft/sec x 60 sec/min) = 58 minutes.

In summary:

- 24" mower is 110 minutes per acre
- 36" mower is 69 minutes per acre
- 48" mower is 50 minutes per acre

You can go faster with a rider, but the quality of cut degrades. The walker gets slower for a large lawn since one gets tired and takes more breaks and tends to slow down on the turns.

I would recommend only a tractor that had a cast iron engine and a rear discharge mower. I had a tractor with an engine with aluminum heads. The first engine failed and I replaced it and the second failed. They both warped and eventually failed. I got a tractor with a cast iron engine and it never quit. Eventually it got so old that when the fuel pump failed, it could not be replaced. Now I am using a WheelHorse/Toro with a 17 HP Kohler 2-cylinder cast iron engine. It is a great machine and has worked flawlessly over 12 seasons. The 17 HP is excessive for mowing or pushing snow, but the 2-cylinder engine is great. I can mow for 5 hours and not get the least bit fatigued. However, with 1-cylinder engines the vibration was so great that my toes and fingers would become numb in less than an hour. I had to take a break every hour to recover.

For the mower, get a steel rear discharge mower. The first mower I got was a cast aluminum mower. Every rock the mower picked up knocked a chunk out of the housing until there was nothing left. Then I got a steel mower, but the aluminum engine gave out and it was not prudent to get a third engine for the steel mower. I did get a tractor with a cast iron engine that could use the steel mower and this combination lasted 20 years.

Now on the WheelHorse/Toro I got a rear discharge mower because it does not throw objects like the side discharge machines. Also, when the grass clippings are too heavy to leave on the ground, I can collect them with a simple sweeper and not need a motorized collection system. Also, it doesn't throw clippings on the flower beds and walks or make passing motorists think they are going to be attacked. It is also easy to mow next to shrubs and trees on either side of the tractor. You don't have to always mow with the discharge to the mowed or unmowed side, depending upon what you are trying to accomplish.

A lawn mower for the security minded

Smarter (and lower maintenance) than the average cow...

> "This is a lawn mower that is solar powered and stays within a buried wire boundary. It also 'learns' the layout of your yard and will even put itself away at night. Does anyone have one of these devices? It sounds great, but at $1,500, I would like some real world product feedback."

(From: ranck@joesbar.cc.vt.edu).

I don't have one, but apparently the CIA has two. They use them in a courtyard that is completely surrounded by one of their buildings. The robo-mowers were seen as a better solution than having to have a security officer escort some person in/out and watch them mow.

The miracles of JB Weld

-------------------- OK, I have no idea of whether the following repair will actually hold up but I supposed there is nothing to lose by trying:

(From: Andrew Bowers (falcon_@geocities.com).)

I just did something cool!

My friend Dan gave me a 3.5 HP Briggs & Stratton horizontal shaft engine, which burned oil like crazy. I took it completely apart, (Dan had started to, but he hadn't taken the actual block apart, he had just taken the carburetor, muffler, and flywheel cover off) and found a _deep_ gouge in the cylinder wall. The rings were fine, except there was a chunk missing from the oil ring. Here comes the "miracle" part. Most people would have just chucked the engine, or kept it around for parts. I grabbed my thing of JB Weld ("the world's finest cold weld"), mixed some up, and filled in the gouge. The next day, I sanded the patch smooth, and put the engine back together. Started on the first try. Still burns oil (due to the missing segment on the oil ring; the auto parts store I went to didn't have piston rings, can you believe that?), but runs pretty good. (Well, the injectors in the carburetor keep getting clogged, and it won't start, so we're going to get a new, *plastic* gas tank).

Interesting lawn mower repairs

(From: Sean Smith (seansmith@racemark.com).)

When I was 17 and still living at home, mowing the lawn was part of my chores. Well, I didn't have a running lawn mower and my Mom insisted that I mow the lawn. She pretty much stated that she didn't care how I did it, as long as it got done.

So, I figured that I needed to get one of them running, and I couldn't for the life of me figure out what the exact problem was but I wasn't getting spark, so I figured that it had to be the magneto. Well, I didn't have the resources to get a new one, so I did the next best thing, I rewired it!

Mom comes out to find me mowing the lawn with a car battery and a coil strapped to the thing. Ran a line from the condenser to a spare coil I had for my VW Bug and strapped an AC/Delco to the thing and away I went. It was a bit heavy but it was better than nothing. I still wish I took pictures of it.

(From: Charles Gilley (gilley@bravewc.com).)

My coolest repair was rebuilding my B&S after letting the oil run out. After I put it back together and with great anticipation, I began to pull and pull and pull.... I was impressed. It was silky smooth, but the darn thing would not start. I sat down to rest, glanced at the bench... to see the valve lifters still sitting there.

Sigh.....

Importance of having the correct valve clearance

(From: Derrick Setchell (D.Setchell@eastman.ucl.ac.uk).)

My father-in-law owned a Flymo with a 3.5 HP Briggs & Stratton. He'd had it for nearly twenty years, but never used it much because it was "hard to start", especially when hot. He has other mowers and neither of us had found time to investigate it. Why he didn't return it for warranty investigation at the start is lost in the mists of time.

This year, he felt it was taking up space in his barn and was going to throw it away, so it was rescued by yours truly. I thought the motor might be a useful standby in case the even older Aspera (European Tecumseh) on my own rotary packed up. That's been a fine engine, by the way. The B&S was in a pretty good state considering, but sure enough took up to fifteen pulls to start when cold and would not re-start at all if fully warmed up. It did look like it'd been HOT, with the usual blockage of ventilation spaces by clippings, but otherwise well preserved.

I gave it a complete carb and magneto overhaul which improved cold starting somewhat, but not the hot. I also felt it was a bit "gutless", so then investigated the combustion chamber and valves. This poor machine had virtually NO valve clearance when cold, on either lifter. The valves were still in pretty good order, so my assumption is that it was shipped that way from the factory. Once it got hot, the compression must have been zero, though it didn't obviously seem to be.

A thorough clean, careful adjustment of the valve stems with a diamond hone (out of the engine !!) to provide the upper limit of the specified cold clearances and back together it went. What a contrast ! It now starts first pull, hot or cold, and runs like it should have done when it left the factory. My guess is the magneto and carb were fine all along in this lightly-used engine. Next time I'm going to look at those valve clearances earlier in the sequence, even if the engine isn't old....

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Internal Combustion Engines

Small engine technology

If you have some idea of how your automobile engine operates - or a Model T Ford for that matter - then you know the basic operating principles of your small engine as well. In fact, your Craftsman Eager 1 has a lot more in common with a Model T than a Honda Accord. However, strip off, the electronics, pollution control devices, and engine powered accessories, and the basic mechanical construction is very similar, though the lawn mower engine is not manufactured to quite the same tolerances and with the same quality materials as an automobile engine.

Nearly all small engines up to 20 HP or so are single cylinder affairs - one piston, one spark plug, no distributor, forced air cooled - about as simple and straightforward as it gets.

If you have never been under the hood of your automobile, then the description in the following sections may be of some help.

The next chapter: "Engine Diagrams" provides an explanation of each of the 4 strokes of a 4 stroke engine. However, if you cannot get the hang of my fabulous ASCII graphics, check out the following site:

The How Stuff Works Web site has some really nice introductory material (with graphics) on a variety of topics relating to technology in the modern world. Of relevance to this document is an article on "How Car Engines Work" which is really mostly about the basic principles but WITH some real animated graphics!

Types of engines

Unless otherwise noted, most of the descriptions and procedures in this document apply to both 4 stroke and 2 stroke engines. However, there are fundamental differences in the proper fuel and oil that is used with each type.

The small 4 stroke engine has a separate oil sump just like the engine in an automobile. Therefore, gasoline and oil are separate. Oil changes are also required.

WARNING: a new lawn mower or other piece of yard equipment will very likely be shipped without oil or just a minimal oil fill. Check it first and add oil if necessary. Running an engine without oil for a few minutes can cause serious - or terminal - damage. Even if your mower was assembled by the store where you bought it, don't assume they filled it with oil and tried it out!

The 2 stroke engine requires that the gas and special oil be mixed prior to use in specific proportions. Leave out the oil - or get your gas cans mixed up - and you will quickly ruin a 2 stroke engine due to lack of lubrication if plain gas is used by mistake. Clearly label the gas cans for each type and instruct anyone using them in the proper fueling technique.

Portable tools like chain saws, weed whackers, and backpack type leaf blowers use 2 stroke engines as these need to operate in a variety of positions.

Stationary or wheel-about equipment including most lawn mowers, rototillers, shredders, backup electric generators, and large blower/vacs, use 4 stroke engines.

Another distinction is that engines smaller than about 2 horsepower are generally 2 stroke while those larger than 2 horsepower are generally 4 stroke but there are exceptions. Lawnboy lawn mowers tend to have 2 stroke engines and there are some types of equipment with very small 4 stroke engines. Of course, if your engine has a cap marked 'oil' then it is a 4 stroke.

Larger pieces of yard equipment like riding mowers and lawn tractors use 4 stroke engines that are really very similar in most respects to their smaller cousins - much more so than to the engine in your automobile, for example. Similar servicing procedures apply. In fact, if you read the respective chapters in any of the engine repair books for engines (listed in the section: References) under 5 horsepower and those between 5 and about 20 horsepower, the only significant differences will be in the size of the various engine parts!

Parts of a 4 stroke engine

You may be surprised at the large number of individual parts which comprise the engine even on a $100 mower. The following description is for a typical single cylinder 4 stroke engine as would be found on most rotary mowers, rototillers, shredders, backup electric generators, larger snow throwers and leaf blowers, and even modest size riding mowers and lawn tractors:

- Fuel tank and fuel line. This may be on the side, above, or below the engine intake. A fuel pump may be present - either as part of the carburetor or a separate unit if it is not gravity fed. There may be a fuel cutoff valve and fuel filter and/or filter screen) as well.
- Shroud or blower housing. Since these engines are all forced air cooled, (no radiator, water jacket, or thermostat) the proper air flow is extremely important as air is much less efficient than water at removing the substantial heat energy generated by a running engine. This piece of sheet metal precisely guides the airflow. The engine should not be run for any length of time with the shroud or blower housing removed.
- Oil filler pipe. On many engines, this is just a hole near the base fitted with a screw-in plug. On fancier models, there is an actual extension tube with a dipstick usually fitting into that hole in the base and sealed with an O-ring.
- Starter. Like an automobile engine, some means must be provided to supply an initial rotation.
    - Pull or recoil starter. This is by far the most common on small pieces of yard equipment. A self retracting cord wrapped around a one-way clutch acts on the crankshaft directly. Less common variations include wind-up starters and a simple rope wrapped around a drum.
    - Electric starter. A small motor - usually powered from a wall socket - drives the edge of the flywheel via a self releasing gear. On larger equipment, as in an automobile, an on-board battery provides the electricity. The battery is recharged by an alternator while the engine is running.
- Air filter. The air used by the engine should be free of dust and larger particles. Most yard equipment will include one of several kinds of air filters - paper, foam, or oil bath. However, engines used exclusively in equipment used in low dust environments like snow throwers and outboards may lack an air filter. Types of air filters include:
    - Paper air filter. This is similar to the filter in a vacuum cleaner. The pleated paper element must be replaced when clogged.
    - Foam air filter. This uses a piece of foam rubber lightly coated with engine oil and can be washed in detergent or soap and water when dirty and recoated though replacement will be required if it is badly deteriorated.
    - Oil bath filter. This contains an oil reservoir and filter element. These can be drained and cleaned. Refill to the 'full' mark with the same type of oil as used in the engine crankcase. The oil bath air filter is much less common than the paper or foam type.
- Carburetor. The function of the carburetor is to provide a precise air-fuel mixture to the engine under a variety of operating conditions including:
    - Starting. A higher ratio of fuel to air is needed when starting and/or the engine is cold.
    - Idle. Just enough flow is maintained to keep the engine from stalling.
    - High. Full flow is provided with engine speed limited by feedback from the governor.

- Load pickup/acceleration. The proper air-fuel ratio and amount of fuel must be maintained when the equipment is placed under load or encounters an increased load and when switching from IDLE to HIGH, for example.

  Several functions are incorporated in a carburetor:

- Fuel control - float, diaphragm, suction. A variety of means are provided to maintain a nearly constant supply of fuel despite varying levels of gas in the fuel tank.

  Craftsman and Lawnboy carburetors use a float similar to the system used in automobile engine carburetors (when they still used this technology). A hollow float maintains a constant level of fuel in a reservoir called a float bowl by acting against an inlet needle valve. The fuel tank will usually be above the level of a float carburetor though a fuel pump could also be used. See the section: Basic operation of a float type carburetor for a more detailed description and diagram.

  Where equipment may be operated in any position, a diaphragm carburetor is used. A flexible disk (diaphragm) with atmospheric pressure on one side and intake pressure on the other is used to maintain the proper air-fuel ratio (this is a gross simplification!).

  Briggs & Stratton engines usually have a suction lift carburetor with a built-in fuel pump. Some simple ones don't even have a fuel pump but depend on suction alone to pull gas from the tank. In both cases, the fuel tank is usually below the carburetor. If there is no fuel pump, the fuel tank should generally not be less than 1/3 full for proper operation.

- Venturi. If you look into the air intake of a carburetor, you will see a narrowing of the passageway. This is called a venturi and results in higher velocity air flow and lower pressure at the center of the narrow section. Just as when you blow across a soda straw submerged in a liquid, or use a bug or lawn sprayer, this lower pressure will suck up the liquid and inject it into the moving air stream. In the care of gasoline, evaporation is almost immediate.

- Throttle. A plate that can rotate to close or open the outlet from the carburetor to the engine intake pipe controls the flow of the air-fuel mixture to the engine. When fully closed, the engine will stop. When slightly open, the engine will idle. When fully open, maximum power is developed. To limit rotation speed with little or no load and to maintain proper speed under load, a governor acts on the throttle plate to keep it at the proper setting under all normal operating conditions.

- Choke. A plate that can rotate to partially close off the air supply is placed in the air intake side of the carburetor. This is usually set manually when starting, particularly in cold weather, to make the mixture richer - more fuel with respect to air - as needed. The carburetors most newer equipment have automatic chokes or other methods of accomplishing the same objective.

- Flywheel. The flywheel in a small engine serves several functions:

  Provides some or all of the inertia so the engine can coast through the 3 non-power strokes of the full cycle (4 stroke). However, with rotary mowers in particular, the blade provides some of the inertia due to the use of a lower mass (lighter, so this is not all bad!) flywheel.

  - Provides the electrical energy for the most common magneto based ignition system. A powerful magnet mounted on the edge of the flywheel passes by a coil (and possibly other stuff) once per rotation. This is part of the ignition system and either provides the high voltage for the spark directly or charges a capacitor which is then discharged (by a solid state switch triggered by the flywheel magnet rotating past a sensor) into an ignition coil at the proper time to generate the spark.

- Includes the fan blades which provide most of the essential cooling airflow.

- Links to the starting mechanism. For recoil or other manual starters, the starting device attaches to the center of the flywheel. For electric start, the flywheel will have a large gear along the outside that is engaged by the starter motor gear (with an overrunning clutch).

- Engine/blade brake. Releasing the dead-man bar engages a brake pad that is usually applied to the outside of the flywheel.

  A soft metal key locks the flywheel to the crankshaft. This is designed to shear (break) to protect expensive engine parts should the engine stop abruptly (due to blade of a rotary mower striking an obstruction, for example). In this case, the flywheel inertia will attempt to keep it moving and it is better to shear the key than to fracture the flywheel or crankshaft.

- Blade adapter. This fastens the two ended cutting blade to the crankshaft. A key part (no pun intended, well almost) is the locking key. This may be a half circle (called a Woodruff key), rectangle, or part of the blade mount bracket itself. Its purpose, like the flywheel key, is to break cleanly should the blade strike an obstruction thus protecting - hopefully - the expensive engine parts from damage. However, see the section: Why you really don't want to attempt to move an immovable object for the reasons this isn't always successful and using your mower to trim rocks and curbs really should be avoided. Therefore, it is essential that the key be made of the proper material - a soft metal. Never replace a broken key with one made of steel 'because it is stronger'.

  For other types of equipment, various adapters are used to couple the driven device to the engine crankshaft. These may include gear reducers or multispeed transmissions, belt or chain drives, or a direct connection to a blower, vacuum, or pump impeller, or electric generator or alternator. As with the blade adapter, a soft metal key or shear pin will likely be used for protection.

- Spark Plug. The ignition source for all small gasoline engines is a high voltage spark. There is nothing magical about a spark plug - it is just an insulated electrode with a specific size gap poking into the combustion chamber. However, damage or fouling (gumming up with carbon or other combustion residue) is one of the most common causes of a hard or impossible to start engine. Not all spark plugs are created equal despite their simple function so the recommended replacement type should always be used. In addition, most automotive spark plugs have a longer reach - more threads - and will likely bash the piston at TDC.

- Magneto ignition. These used to use mechanical contact points - controlled by a cam on the crankshaft to determine the timing. Nowadays, most are fully electronic and require no maintenance.

  - Point type. The magnet mounted on the flywheel induces a current in a coil with pole pieces mounted in close proximity to the flywheel. When this current is near its peak, a set of contacts operated by a cam on the crankshaft - the breaker points - open interrupting the current and diverting it to a condenser (capacitor). The current drops abruptly and induces a high voltage in another coil wound on the same core. This coil is connected to the spark plug terminal. It will be 10 kilovolts or more to jump the spark plug gap even under the more difficult conditions during maximum compression. The exact time - angle of the crankshaft - at which the points open is the critical setting. This is usually adjusted by moving the piston to a specific dimension below Top Dead Center (TDC) or aligning timing marks on the flywheel and crankcase and setting the points to just open at this location.

  - Electronic type. These can be designed in several different ways but all must emulate the behavior of the point type ignition replacing just the magneto coil/pole piece assembly and without requiring alterations to the flywheel. See the section: What is inside a small engine electronic ignition module?.

- Engine block. The casting which includes the cylinder, crankcase, intake and exhaust ports and valve guides and seats. The other major part of the engine structure is the crankcase cover/oil sump.

- Cylinder. This is the, well, cylindrical component in which the piston moves. Most small engines are made of either aluminum (most common these days) or cast iron. In most cases, the aluminum type will have a cast iron liner for long life where the piston actually slides. With regular oil changes, there will be virtually no wear.

- Cylinder head (or just head). The cap which encloses one end of the cylinder. On most small engines, the only component mounted in the head is the spark plug which screws into a threaded hole. However, on the most modern (and expensive) small engines (as well as all automobile engines), the valves will also be mounted above the piston in the cylinder head. Fins on the head increase its surface area - absolutely necessary for these air cooled engines to keep their cool

- Crankcase. This encloses the lower working parts of the engine and also contains the oil supply. The flywheel/magneto end main bearing is mounted in one end of the crankcase. The crankcase cover/oil sump seals the crankcase and also includes the PTO/blade end main bearing. Also see the section: Bearings and bushings.

- Valves. These look like metal mushrooms and seat against metal rings mounted in the engine block casting. They are spring loaded in the closed position, slide in valve guides (bored holes), and operated by valve lifters from cams on the camshaft.

    - Intake valve. This valve is opened only during the intake stroke. It is subjected to less stress than the exhaust valve as it is cooled by the fresh air-fuel mixture. The intake valve may be stamped with an I.

    - Exhaust valve. This valve is opened only during the exhaust stroke. It is subjected to more stress than the intake valve since the hot exhaust gases pass out through its opening. The exhaust valve may be marked with an E.

  Note that in most small engines, the valves are not mounted above the cylinder (in the head) as they are in automobile engines. Rather, they are mounted on the side of the cylinder in the engine block. This is done for reasons of cost requiring fewer parts and simpler construction. The cylinder head is then just a casting with cooling fins and a threaded hole for the spark plug. The disadvantage of the side valve engine is lower efficiency and higher pollution. The newest (and currently most expensive) lawn mowers and other yard equipment are incorporating the better overhead valve technology. Eventually, environmental protection laws may force this on all small engine operated devices. However, both types can apparently be made to meet the emissions standards mandated for all new mowers sold after September 1996.

- Valve lifters (tappets). These also look like metal mushrooms with the wide part riding on the cams of the camshaft. Their ends press on the ends of the valve stems to open them during the appropriate part of the cycle.

- Compression release. This mechanism reduces the compression somewhat at low rpms (to make starting easier) by opening the exhaust valve slightly early. A weight disengages the compression release once the engine starts.

- Piston. The piston is a cylindrical close ended plug that slides in the cylinder and is acted upon by the hot gases during combustion. In small engines, it is usually made from an aluminum alloy. Power is obtained by the piston driving the off center crank pin journal on the crankshaft via the connecting rod.

- Piston rings. Springy split rings of cast iron (usually) which fit in grooves or slots around the piston. When the piston with rings is installed in the cylinder, the rings expand and tightly contact the cylinder wall forming a remarkably good seal.

- Piston pin (or wrist pin). The piston is attached to the connecting rod via a polished steel pin (actually a tube) which fits closely in a bearing in the connecting rod.

- Connecting rod (or just rod). A rod with bearings at both ends. Small 4 stroke engine rods are usually made of an aluminum alloy and have no special bearing inserts at either end. 2 stroke rods will have needle bearings due to the type of lubrication available.

- Crankshaft. The main rotating part of the engine. See the diagram in the section: Crankshaft anatomy.

    - Main bearings. The crankshaft is supported at each end by the main bearings. Most inexpensive 4 stroke engines use plain bearings without inserts - just the finely polished steel crankshaft surface rotating in equally finely finished surfaces of the engine block casting. 2 stroke engines may use needle bearings in these positions. Some engines use ball bearings.

    - Crank pin journal. The offset surface where the connecting rod bearing rotates. The is the bearing with the most stress as the full force of each power stroke is applied here. It is the location where damage will likely show up first due to contaminated oil or lack of oil.

    - Counterbalance weights. These two massive weights are part of the crankshaft casting opposite the crank pin journal. They help to reduce the vibration of the engine by partially counteracting the forces of the piston and connecting rod as they move back and forth. Larger engines may have additional rotating balancer shafts which can be designed to do a better job of minimizing vibration than just the counterbalance weights on the crankshaft.

    - Crank gear or timing gear. A small gear mounted on the crankshaft which rotate the camshaft at half the crankshaft speed to control valve timing. The crank gear has half as many teeth as the camgear.

    - A precision taper is located at the magneto/flywheel end for mounting the flywheel and starter components.

    - A cam (possibly removable) may be present under the flywheel location for operating the breaker points on a point type ignition system.

    - An auxiliary PTO gear may be present. This is a worm gear or other mechanism for providing a secondary, usually lower speed, higher torque, power output. A typical speed reduction ratio is 8:1. This may be used to power a front wheel drive sprocket, for example.

- Camshaft. This includes the two cams which operate the valves and runs at 1/2 the speed of the crankshaft. In addition, it may have a compression release mechanism to reduce starting effort and in the case of many Tecumseh vertical crankshaft engines, is part of the oil pump as well.

- Oil/lubrication device. Several types of mechanisms are used to distribute engine oil to all the critical parts in a small engine:

    - The piston rings (oil ring mainly) scrape oil off of the cylinder walls which passes through holes in the oil ring grooves of the piston to lubricate the piston pin at the top of connecting rod.

  All other important parts are lubricated typically by one of the following devices:

    - Oil dipper. An extension to the connecting rod dips into the oil sump on each rotation of the crankshaft and provides lubrication by literally just splashing oil onto where it is needed. (Horizontal crankshaft engines only.)

    - Oil slinger. A pinwheel like affair rotated off of the crankshaft or camshaft flings oil onto where it is needed. (Horizontal or vertical crankshaft engines.)

- Oil pump. A camshaft driven pump distributes oil to the important parts via various passages in the camshaft, engine block, and possibly the crankshaft and connecting rod as well. (Horizontal or vertical crankshaft engines.)

- Governor. This provides the feedback to the carburetor throttle plate to regulate the engine speed (usually for anything but idle speed). Thus, the speed is maintained relatively constant despite changes in load and a engine temperature

  - Air vane governor. The air flow provided by the flywheel/blower passes by a plate which is coupled to the carburetor throttle plate acting against a spring force.

  - Flyweight governor. A spinning gear assembly with a pair of weights is driven by the camshaft. As the centrifugal force of the weights increases, they move a sleeve which presses against a lever whose shaft passes through the crankcase. This lever then operates the carburetor throttle plate against a spring force.

  With both types, increasing the spring force will increase the engine speed.

- Breather. Since the crankcase is otherwise sealed with the piston moving up and down or in and out, some means is required to maintain a negative pressure or else oil might be forced out various places like the bearings an oil seals. The breather is a leaky one way valve which easily passes air out but is mostly blocked in the other direction.

- Muffler. The muffler mounts on the exhaust port and serves two important functions:

  - Noise reduction. As its name implies, the muffler muffles or reduces the loud noise resulting from the explosions of the air-fuel mixture.

  - Spark/flame arresting. The internal baffles of the muffler prevent most sparks or flame from existing the engine even if it backfires.

- Oil seals. These are spring loaded rubber rings which prevent the escape of oil through the main bearings to the outside.

Engine operating principles

These are internal combustion engines which means that the burning of the fuel-air mixture itself powers the engine. External combustion engines use the heat from combustion to expand or boil a working fluid as in a steam engine. Other examples of internal combustion engines are the rotary Wankel engine and gas turbines (jet engines).

The type of engine in your lawn mower or automobile operates on what is called the 'Otto' cycle (if you care). A complete 'cycle' is needed to supply one power impulse to the output shaft. All engines must provide the following regardless of whether they are 2 stroke or 4 stroke, rotary, or turbines (though turbines or jet engines operate in a continuous rather than pulsed manner):

For the following, refer to the section: The four strokes of a four stroke engine in living ASCII art.

1. Intake stroke. Air is mixed with fuel (gasoline for piston engines) and drawn into the combustion engine.

   4 stroke: The air-fuel mixture is sucked into the cylinder through the open intake valve as the piston moves downward on the intake stroke.

2. Compression stroke. The air-fuel mixture is squeezed into a smaller space. This heats it to some extent and prepares it to be burnt. (Note: in a diesel engine, this heating alone causes the mixture to ignite and there is no spark needed). Compression ratios for small engines are typically low compared to automobile engines.

4 stroke: Both valves are closed. The piston moves upwards thus reducing the space above it and compressing the air-fuel mixture.

3. Power stroke. The compressed air-fuel mixture is ignited at a precise time by the ignition system (spark).

   4 stroke: Both valves are closed. The heat produced by the rapidly burning gases to expand and drive the piston downward and because it is connected to the crankshaft, drives the load as well.

4. Exhaust exhaust. The burnt combustion products are driven out of the cylinder. These consist of carbon dioxide, carbon monoxide, water vapor, oxides of nitrogen, some unburnt hydrocarbons, and numerous other mostly harmful compounds.

   4 stroke: The exhaust valve is open. The piston moves upward and pushes the exhaust gasses out through the muffler. A relatively massive flywheel attached to the crankshaft provides the inertia to allow the engine to coast through the non-power strokes (1-3). However, this is not always enough by itself - the blade on a rotary lawn mower is often required as well and a rotary mower may not start easily if at all without the blade in place and tightened securely.

Note that the terms '2 cycle' or '4 cycle' are often used incorrectly when what is meant is 2 stroke or 4 stroke. The cycle is the entire sequence of events including intake, compression, power, and exhaust. The complete cycle for a 4 stroke engine is two complete revolutions of the crankshaft. The complete cycle for a 2 stroke engine is one rotation of the crankshaft. This means that a 2 stroke engine produces a power stroke on every rotation of the crankshaft while a 4 stroke engine does this only on every other one. Thus, a 2 stroke engine will be more powerful than a similar size 4 stroke engine. However, on the down side, 2 stroke engines tend to be less efficient in fuel utilization and pollute much more than 4 stroke engines.

Bearings and bushings

The shafts of rotating parts normally are mounted in such a way that friction is minimized - to the extent needed for the application. A bearing is any such joint with more specific terms used to describe the typical types found in lawn mowers - or small motors, automobile engines, or 100 MW turbines.

The bearings to be concerned with in a lawn mower or small engine are:

- Main bearings - supports the crankshaft at the blade/PTO end and at the magneto/flywheel end.
- Crank pin journal - links the bottom of the connecting rod to the rotating crankshaft. This single location is most critical as it is subject to the largest forces from the piston.
- Piston pin journal - links the piston to the connecting rod and is subject to the full pounding of the piston but only rotates back and forth through a small angle.
- Gear reduction - additional bearings may be used inside a gearbox. For example, a snow thrower or rototiller require lower speed high torque outputs to drive the auger and tines respectively.
- Auxiliary power takeoff - a lower speed output for front wheel drive or other secondary purpose.
- Wheels - although this is a must less critical application, higher quality bearings will make for easier and smoother operation and longer life.

A variety of bearing types are available. For most inexpensive rotary lawn mowers, plain bearings are most popular due to their simplicity and low cost.

- Plain bearings consist of an outer sleeve called a bushing in which a polished shaft rotates. The bushing may be made of a metal like brass or bronze or a plastic material like teflon. In the case of many small engines, the aluminum alloy casting of the crankcase and cover are simply then bored and reamed to a fine finish to accept the ground and polished shaft. There is no actual bushing. However, if these bearings ever need repair, the hole(s) in the casting would need to be enlarged and a bushing would then be pressed into place and finish reamed.

  The shaft of a small engine is made of steel though other materials may be found depending on the particular needs. Where a metal bushing is used, there must be a means provided for lubrication. In a small engine, this is provided by the engine oil via a variety of means. For example, a typical Tecumseh lawn mower engine lubricates the blade end/PTO main bearing by direct immersion in the oil sump, the magneto/flywheel main bearing via machined passage fed from the camgear driven oil pump, and the crank pin journal by oil sprayed or dripped from above.

  Under normal conditions, a plain bearing wears only during start and stop cycles. While the shaft is rotating at any reasonable speed, there is absolutely no metal to metal contact and thus no wear. With a properly designed and maintained bearing of this type, a very thin oil film entirely supports the shaft - thus the importance of regular oil changes to assure clean oil with effective lubricating properties.

  To put this into perspective, the clearance between the connecting rod and crank pin journal of a typical small engine crank pin journal may be 0.0005 inches or less - one half of one thousandth of an inch. This is roughly 1/10th the thickness of a sheet of computer paper! The same engine may be considered worn to its limit when this clearance increases to .0015 inches. Your automobile engine's crankshaft is entirely supported by these types of bearings as well - and the tolerances are even finer.

  If oil is lost even for a short time, serious metal-to-metal sliding contact results in significant wear and possible destruction of one or both bearing surfaces. Particles in dirty oil can get trapped and embedded, usually in the softer outer bushing resulting in scoring and additional wear. It is your responsibility to assure that your engine oil is maintained at the proper level and changed regularly. Any warranty is not likely to cover failure due to negligence.

- Frictionless bearings are usually of the ball, roller, or needle variety. An inner ring called a race rotates supported by a series of balls, rollers, or elongated rollers called needles inside an outer race. An optional 'cage' positions the rotating objects uniformly around the periphery. There is virtually no friction even at stand-still with these bearings. However, rolling metal to metal contact is maintained at all speeds so they are not quite as wear free as a properly maintained and constantly rotating plain bearing. Loss of lubrication, while not as immediately destructive as with a plain bearing, will still result in accelerated wear and premature failure.

  - Ball bearings may be found in the main bearings of yard equipment where significant sideways loads are encountered. Lubrication is provided by engine oil, gear oil in a separate gearbox, or by being packed with grease either as a maintenance item or for the life of the bearing at the factory.

  - Roller bearings may be used on larger engines where significant loads of all types are encountered. Since the contact between rollers is a line rather than a point as it is with balls, they can support much greater loads. Lubrication needs are similar to those of ball bearings.

  - Needle bearings are found in 2 stroke engines and may be used for the main bearings as well as the crank pin journal. The 'needles' are really just long rollers - a ratio of 5:1 to 10:1 is typical of length to width - and there is no cage to position the needles, they are packed in around the shaft as many as will fit. Due to the type of lubrication - oil mixed with the gasoline - plain bearings are generally not suitable for this application.

Crankshaft anatomy

The diagram below shows the major parts of the crankshaft:

- Main bearings support both ends and whatever is driven by the engine.
- The crank pin journal is the surface upon which the piston's connecting rod bearing acts to rotate the crankshaft.
- The crank gear drives the camgear/camshaft assembly which operates the valve lifters/valves and possibly the oil pump as well.
- The flywheel is actually mounted on a machined taper (not shown) held on by a large nut. The starter engages a clutch mechanism which may also be mounted with the flywheel. For point-type ignition systems, a cam to operate the contact points is usually located on the crankshaft under the flywheel.
- The blade or other driven equipment is mounted on the other end with an adapter (not shown) held on by another large nut.
- Auxiliary equipment like front wheel drive may be powered from a worm gear which is part of the PTO end of the crankshaft (not shown).
- The counterbalance weights help to smooth the operation of the engine.

```
                    Counterbalance weights
                         __   |   __
                        |  |  |  |  |
Threads for             |  |<-+->|  |           Threads for
Flywheel nut            |  |     |  |           blade adapter nut
      |                 |  |     |  |  __              |
      V     _________---|  |     |  |-|__|_______      V
     ...---/         |  |  |     |  | |__|       ----+...
     |||   |         |  |  |     |  | |__|       |   ||||
     '''---\_________|  |  |     |  | |__|_______----+'''
                  ^  ---|  |_____|  |-|__|  ^
                  |     |--|     |--|  ^    |
         Main bearing   |  |     |  |  |   Main bearing
        (Flywheel end)  |  |_____|  |  |  (PTO/blade end)
                        |__|  ^  |__|  |
                              |        +--- Crank gear (meshes
                                            with cam gear)

                          Crank pin
                           Journal
```

Basic operation of a float type carburetor

The diagram below shows a schematic of a typical float type carburetor with the engine running at high speed. The choke plate is fully open and the throttle plate is opened the proper amount be feedback from the governor to maintain the speed set by the user throttle control.

- Air is sucked through the venturi by the intact stroke of the piston. The lower pressure created by the faster moving air draws gasoline up through the main nozzle and into the air stream. This aerosol of gasoline vaporized almost instantly.
- The air bleed allows the pressure inside the float chamber to equalize as fuel it drawn off
- The float maintains a more or less constant level of liquid gasoline in the float chamber by opening the inlet needle valve when the level drops. The fuel supply is either above the level of the carburetor or there is a separate fuel pump (usually operated by crankcase pressure pulsations or a direct mechanical linkage).
- The main nozzle either has precisely machined orifices to set the ratio of air to gasoline in the mixture or has an adjustable needle valve for this purpose (not shown).
- Closing the choke forces more gasoline into the mixture and makes it richer.
- The throttle plate is used to vary the amount of the air-fuel mixture to the engine but maintains nearly the same ratio of air to fuel over a wide range of engine speeds.
- The user throttle (speed) control adjusts the spring force against which the governor must act to close the throttle plate. Increasing the spring force increases the engine speed.
- Operation at idle speed depends on a separate system of an idle nozzle and idle speed adjustment (not shown) and does not depend on governor feedback to control the throttle - which is kept open just a small amount.

```
         Air filter       (Air: -->, Air+fuel: ==>)

       _____________
      /             \  Choke plate               Throttle plate
       | ||||||||| |  (Fully open) Venturi      (Partially open)
       | ||||||||| |______________    v   _______________________________
       | |||||||||                \______/
       | ||||||||| -> -> -> -> ->           ==> ==>      /  ==>  Intake
       | ||||||||| ->  ----O----  ---> ===> ==> ==>    O    ==>  pipe to
       |           -> -> -> -> ->  __||__   ==> ==>  / |    ==>  cylinder
        \____________________  ___/  ||  \_____________|__________________
                             ||      ||                |
 Fuel __________ Air bleed ->||      ||<- Main nozzle  o---------+
Inlet ______    |____________||______||__                        |--> Pull
         |  |_ _|                    ||  \       Speed <--/\/\/--+    from
Needle ->|  __A_______________       ||   |     control   Spring    governor
Valve    | |o__/              \      ||   |                          closes
         |-----|     Float     |-----||---|                         throttle
         | . . |               | Gas || . |<- Float bowl              plate
         | . . .\_____________/. . . || . |
          \______________________________/
```

The four strokes of a four stroke engine in living ASCII art

You will just love the most excellent, accurate, and to-scale (:-).)ASCII renditions below but at least it will display on any computer using a fixed width font and not require half your disk space allocation for storage!

Note that the valves, normal operated by a camshaft driven off of a small gear on the crankshaft, are not drawn in their usual position for a common small (side valve) engine to improve the superb clarity of these drawings.

Intake stroke (1)

Air-fuel mixture is sucked into the cylinder by the by piston moving down driven by inertia of flywheel (and blade).

- Intake valve: open.
- Exhaust valve: closed.
- Piston: moving down sucking in fresh air-fuel mixture from carburetor.

```
    From ignition/magneto coil >========
                                       ||
                                      ||||
                           Spark Plug ||||
                                      /||\
            _________________________| || |________________________
           |  _______________________| || |______________________  |
           | |                          =="                      | |
           | |   ______   ->  ->  ->  ->  ->  ->  ->  ->  ->     | |
           | |__ \____/ ___   ->  ->  ->  ->  ->    ___ ______ __| |
           |____\  ||  /   | _____________________ |   \\____//____|
Air-fuel           ||  |   ||                     ||   |  ||
mixture from --->  ||  |   ||=====================||   |  ||
carburetor  ______ || /    ||=====================||    \ || ______
           |  ____||||___  ||=====================||  ___||||____  |
           | |     ||    | ||        |            || |    ||     | |
           | |     ||    | || Piston | O          || |    ||     | |
           | |           | ||        V  \         || |    ||     | |
           | |           | ||  _ _ _ _ _ \ _ _ _  || |           | |
           | |   Intake  | ||/           \       \|| |  Exhaust  | |
           | |   Valve   | |              \        | |  Valve    | |
           | |   Open    | |              \        | |  Closed   | |
           | |           | |          Rod  \       | |           | |
           | |           | |               \       | |           | |
                                            \
                                        ---> O  Crank pin journal
                                            /
                                          /
                                        /
                                       O
                                 Main bearings
```

Compression stroke (2)

Air-fuel mixture is compressed as piston rises in sealed volume of combustion chamber driven by inertia of flywheel (and blade).

- Intake valve: closed.
- Exhaust valve: closed.
- Piston: moving up compressing air-fuel mixture.

```
From ignition/magneto coil >========
                                   ||
                                  ||||
                      Spark Plug  ||||
                                  /||\
        _________________________| || |________________________
       |  _______________________| || |______________________  |
       | |                          =="                      | |
       | |               ^ ^ ^ ^ ^ ^ ^ ^ ^ ^ ^               | |
       | |__ ______ ___  | | | | | | | | | | |  ___ ______ __| |
       |____\\_____//  | _____________________ |   \\_____//___|
               ||  |   ||                     ||   |  ||
               ||  |   ||=====================||   |  ||
        ______ || /    ||=====================||    \ || ______
       |  ____||||___  ||=====================||  ___||||____  |
       | |     ||    | ||            ^        || |    ||     | |
       | |     ||    | ||  Piston  O |        || |    ||     | |
       | |     ||    | ||         /  |        || |    ||     | |
       | |           | ||  _ _ _ / _ _ _ _ _ _ || |           | |
       | |   Intake  | ||/       /           \|| |  Exhaust  | |
       | |   Valve   | |        /              | |  Valve    | |
       | |   Closed  | |        /              | |  Closed   | |
       | |           | |       /  Rod          | |           | |
       | |           | |       /               | |           | |
                              /
          Crank pin journal  O
                              \
                             ^  \
                             |    \
                                   O
                             Main bearings
```

Ignition

Compressed air-fuel mixture is ignited just before piston passes Top Dead Center (TDC) and starts down again.

- Intake valve: closed.
- Exhaust valve: closed.
- Piston: just short of Top Dead Center moving up.

```
                                ZAP!
From ignition/magneto coil >========
                                   ||
                                  ||||
                      Spark Plug  ||||
                                  /||\
        _________________________| || |________________________
       |  _______________________| || |______________________  |
       | |                          =="                      | |
       | |                       - X -                       | |
       | |__ ______ ___  _____________________  ___ ______ __| |
       |____\\_____//  ||                     ||   \\_____//___|
```

```
        ||   |   ||=====================||    |  ||
        ||   |   ||=====================||    |  ||
 ______ || /     ||=====================||     \ || ______
|  ____||||___   ||                     ||  ___||||____  |
| |     ||     | || Piston   O          || |     ||     | |
| |     ||     | ||          |          || |     ||     | |
| |     ||     | ||  _ _ _ _ | _ _ _ _  || |     ||     | |
| |            | ||/         |         \|| |            | |
| |   Intake   | |           |           | |  Exhaust   | |
| |   Valve    | |      Rod  |           | |  Valve     | |
| |   Closed   | |           |           | |  Closed    | |
| |            | |           |           | |            | |
                       ---> O
                            | Crank pin journal
                            |
                            |
                            |
                            O
                      Main bearings
```

Power stroke (3)

Heated expanding gases drive piston downward and apply power impulse to crankshaft via connecting rod (clockwise rotation).

- Intake valve: closed.
- Exhaust valve: closed.
- Piston: moving down driven by combustion of air-fuel mixture.

```
From ignition/magneto coil >=========
                                   ||
                                  ||||
                      Spark Plug  ||||
                                  /||\
  _________________________| || |________________________
 |  ______________________| || |______________________  |
 | |                         =="                      | |
 | |             | | | | | | | | | | |                | |
 | |__ ______ ___  V V V V V V V V V V V   ___ ______ __| |
 |____\\_____//   | ______________________ |   \\_____//____|
        ||   |   ||                     ||    |  ||
        ||   |   ||=====================||    |  ||
 ______ || /     ||=====================||     \ || ______
|  ____||||___   ||=====================||  ___||||____  |
| |     ||     | ||       |             || |     ||     | |
| |     ||     | || Piston | O          || |     ||     | |
| |     ||     | ||       V  \          || |     ||     | |
| |            | ||  _ _ _ _ _ \ _ _ _  || |            | |
| |   Intake   | ||/           \       \|| |  Exhaust   | |
| |   Valve    | |              \        | |  Valve     | |
| |   Closed   | |              \        | |  Closed    | |
| |            | |         Rod   \       | |            | |
```

```
           | |           | |               \       | |           | |
                                            \
                                             O  Crank pin journal
                                            /
                                          /  |
                                        /    |
                                       O     V
                                 Main bearings
```

Exhaust stroke (4)

Exhaust gasses pushed out of cylinder by rising piston driven by inertia of flywheel (and blade).

- Intake valve: closed.
- Exhaust valve: open.
- Piston: moving up pushing out exhaust gasses to muffler.

```
    From ignition/magneto coil >=========
                                       ||
                                      ||||
                          Spark Plug  ||||
                                      /||\
            _________________________| || |________________________
           |  _______________________| || |______________________  |
           | |                          =="                      | |
           | |     ->  ->  ->  ->  ->  ->  ->  ->  ->   ______   | |
           | |__ ______ ___    ->  ->  ->  ->  ->   ___ \____/ __| |
           |____\\____//   | _____________________ |   \  ||  /____|
                   ||  |   ||                     ||   |  ||         Exhaust
                   ||  |   ||=====================||   |  ||    ---> gases to
            ______ || /    ||=====================||    \ || ______  muffler
           |  ____||||___  ||=====================||  ___||||____  |
           | |     ||    | ||            ^        || |    ||     | |
           | |     ||    | || Piston   O |        || |    ||     | |
           | |     ||    | ||         /  |        || |           | |
           | |           | ||  _ _ _ / _ _ _ _ _  || |           | |
           | |   Intake  | ||/       /           \|| |  Exhaust  | |
           | |   Valve   | |        /              | |  Valve    | |
           | |   Closed  | |        /              | |  Open     | |
           | |           | |       /  Rod          | |           | |
           | |           | |       /               | |           | |
                                  /
              Crank pin journal  O --->
                                  \
                                    \
                                      \
                                       O  Main bearings
```

5. Back to Small Engine Repair FAQ Table of Contents.

Service Information

References

The best reference is the manual that likely came with your engine. This will have the specific information needed to service it as well as the recommended preventive maintenance tips. Many engine manufacturers now have the user and service manuals for specific engine/equipment models on-line as well as extensive general maintenance and troubleshooting information, and parts identification and ordering.

- Briggs & Stratton
- Lawnboy
- Kohler
- Tecumseh

- Sears has many of its mower diagrams and other information on-line. For servicing of Sears/Craftsman equipment, this may be more then adequate. You may need the complete model number to access them. Here is a road map to get through the Sears Web site (at least as it configured now, Summer 2001, provided by: Frank Clason (patdc@nts-online.net).)

  - Start at Sears Home Page (same link as above).
  - Go down the left hand side of the page and click on PARTS.
  - Go down to item #2 and input the model number - make sure it is complete.
  - Click on GO and then on CONTINUE.
  - Go down to the diagram that says "OR select the area...".
  - Click on the item under the column that says VIEW DIAGRAM for your area of interest.
  - Click on CONTINUE.

  This should bring up the schematic (diagram) of interest. I was really surprised to find the diagrams - they appear to be quite useful and could come in real handy in the future.

- LAWN-MOWER-SHOP.COM has a variety of information on basic maintenance and troubleshooting including: Tune-up procedure and checklist, starter repair, a troubleshooting guide, links, carburetor diagrams, and more.

The Lawn-mower-shop.com Web site has a great deal of useful information including diagrams of popular carburetors, rope starter repair, and links to small engine manufacturers. There is even a "slide-show" illustrating complete disassembly of a typical small engine. This may be all you need for many popular engines.

The following are good for general information but may not have the specific information for your equipment. However, the combination of the original user or service manual and a small engine repair book is probably all you need.

1. Small Engine Repair, 2-12 HP
   Richard J, Rivele, Ed.
   Chilten Book Company, 1993
   Radnor, PA 19089
   ISBN 0-8019-8323-1

   (There are also several other versions of this book covering small engines up to 20 HP. For the most part they

are very similar with some additional information provided where appropriate for each size range.)

2. Chilton's Repair and Tune-up Guide for Small Engines, 1-1/2 to 20 HP
   Chilten Book Company, 1979
   Radnor, PA 19089
   ISBN 0-8019-6810-0 (Paperback: ISBN 0-8019-6811-9)

3. The Complete Handbook of Lawn Mower Repair
   Paul Dempsey
   TAB Books
   Blue Ridge Summit, PA 17214

4. Small Gas Engines: How to Repair and Maintain Them
   Paul Weissler
   Sterling Publishing Company
   Two Park Avenue, New York, NY 10016

5. Simple Gasoline Engine Repair
   Ross R. Olney,
   Doubleday and Company, Inc., 1972
   Garden City, NY

6. Walk-Behind Lawn Mower Service Manual - Third Edition
   Intertec Publishing Corporation
   P.O. Box 12901, Overland Park, Kansas 66212

7. You Fix It: Lawn Mowers
   Carmine C. Castellani & Clifford P.Seitz
   ARCO Publishing, Inc., 1975, 1976
   219 Park Ave. South, New York, NY 10003
   ISBN 0-668-02705-3

8. My Lawn Mower Hates Me - An Original Manual for Hand and Power Mowers
   Tom Cuthbertson and Rich Morrall
   10 Speed Press
   Box 4310, Berkeley, CA 94704

9. Handbook of Lawn Mower Repair
   Franklynn Peterson
   Emerson Books, Inc., 1978
   Buchanan, NY 10511

10. Repairing and Maintaining Yard Equipment and Power Tools
    Mort Schultz
    John Wiley & Sons, Inc., 1994
    605 Third Avenue, New York, NY 10158-0012
    ISBN 0-471-53500-1 (cloth:acid-free paper), ISBN 0-471-53501-X (paper)

11. The Repair & Maintenance of Small Gasoline Engines
    George R. Drake
    Reston Publishing Company, A Prenice-Hall Company, 1976
    Reston, VA 22090
    ISBN 0-87909-724-8

12. Small Gasoline Engines: How to repair and maintain them
    A Popular Science Book
    Paul Weissler
    Times Mirror Magazines, Inc., Book Division, 1975
    ISBN 0-06-014564-1

13. Fix It Yourself - Power Tools and Equipment
    Time-Life Books, Inc., 1989
    Alexandria, VA
    ISBN 0-8094-6268-0, ISBN 0-8094-6269-9 (lib. bdg.)

14. Small Engines - Mowers, Tillers, Chain Saws
    The Editors of Time-Life Books
    Time-Life Books, Inc., 1982
    Alexandria, VA
    ISBN 0-8094-3910-1 (retail ed.), ISBN 0-8094-3911-X (lib. bdg.),
    ISBN 0-8094-3912-8 (lib. bdg.)

15. Small Gas Engines and Power Transmission Systems,
    A Repair and Maintenance Manual
    Walter E. Billiet
    Perntice-Hall, Inc., 1982
    Englewood Cliffs, NJ 07632
    ISBN 0-13-814327-7 (hardback), ISBN 0-13-814319-6 (pbk.)

16. Garden and Yard Power Tools - Selection, Maintenance, and Repair
    Walter Hall
    Rodale Press, 1983
    Emmaus, PA
    ISBN 0-87857-446-8 (hardcover), ISBN 0-87857-447-6 (paperback)

17. How to Repair Briggs and Stratton Engines, 3rd edition
    Paul Dempsey
    Tab/McGraw Hill, 1994, $14.95

    (From: Jim Nelson (jgn@ameritech.net).)

    This is an excellent book about B&S engines.

    I don't know any old galoots who can teach me this stuff, so I always end up at the bookstore. This book I had to buy to identify the missing controls on a B&S driving a mortar mixer I bought cheap.

Links to engine and equipment manufacturers

The Doc System Small Engine and Power Equipment Resource site has links to most of the major companies as well as some detailed procedures for basic maintenance and tips on purchasing replacement parts.

On-line small engine discussion group

This is a free (well sort of, it is advertising supported which presumably means you probably have to tolerate banners and such but hopefully no SPAM).

From the charter:

> "Small Engines is an open forum intended as a resource for individuals studying small engines, business owners, home owners or anyone for that matter. The basic purpose of the list is to serve as a forum for discussions and distribution of information. Subscribers are encouraged to post questions, comments, or announcements of interest to the list about small engines and which pertain to work or theory or ideas about the current development or past of small engines. Discussions include: electrical systems on equipment, what works and how to do things, the effects of small engines on the environment and a lot more."

Check out: Yahoo Groups: Small Engines Discussion Group.

Mower and engine parts sources

Most of the common maintenance and repair parts that are likely to be needed are readily available and relatively inexpensive. Your place of purchase may be most convenient but not necessarily the cheapest.

Many engine parts are fairly specialized and non-interchangeable unless the replacement part really is identical. However, even different model engines may use the same parts. For example, the identical connecting rod, piston, piston pin, camgear/camshaft and oil pump, valves, valve lifters, ignition components, and flywheels are used in several different 3-5 HP Tecumseh engines. Even the same crankshaft may be used in multiple models but slight variations like whether there is an auxiliary power take-off or not can complicate matters.

Carburetors, magnetos and other ignition components from similar sized engines from the same manufacturer may be substituted in many cases. I have even heard of people adapting a larger carburetor to a small engine (with varying levels of success).

Here are some of the alternatives for obtaining replacement parts:

New parts and supplies - walk-in

- Home centers: 2 stroke and 4 stroke engine oil, spark plugs, mower blades, wheels, some front wheel drive components. They also have tune-up kits as well as other service parts like air filters, mufflers, and flywheel keys. These seem to be mostly for Briggs & Stratton engines but I did find some Tecumseh parts at a Builder's Square. Home centers are also a good source for name-brand tools. Stay away from the bargain tools as their quality is often mediocre.

- Auto supply stores: engine oil, carburetor cleaner, anti-seize, sealer, hardware, some tools.

- Sears retail stores: 2 stroke and 4 stroke engine oil, spark plugs, mower blades, wheels, front wheel drive components, air filters, mufflers, and blade adapters for Craftsman equipment. However, all the general items like oil and spark plugs can be used on most other engines and the repair parts will be compatible with much other equipment powered by Tecumseh engines.

  Sears is, of course, where you get Craftsman tools which in the past have been of very high quality. All hand tools also come with an unconditional lifetime warranty.

- Sears parts centers: these are separate from the retail stores and generally serve an entire region. They will have all engine parts for Craftsman and other Sears equipment down to the last nut are available but you will have to have the complete equipment model number (134.XXXXXX) for non-engine related parts and/or the complete engine model number (143.XXXXXX) for engine parts so they can look up the part numbers.

Having samples of the parts you need is a good idea as well.

Sears now has a Web site: Sears PartsDirect which allows direct ordering of over 4 million parts (so they claim) based on the parts list (which they provide on-line) for each product model number.

Parts availability is guaranteed for something like 15 years for most Sears brand equipment. Since the Tecumseh engine design has really not changed substantially for a lot longer than this, parts will likely be available even for an old mower. However, the person at the parts counter may look at you as if you are from Mars if you are interested in some of the very low level engine replacement parts like circlips or rod bolts. It would appear that not many people do this sort of stuff anymore.

- Yard equipment dealers and service shops: most parts for brands of equipment they sell and repair. Complete equipment model and engine identification information and samples of the parts you need will prove essential.

  For Sears/Craftsman products in particular, the first 3 digits of the Sears part number identify the actual manufacturer of the equipment. With these in-hand, you may be able to bypass Sears entirely and buy parts directly

New parts and supplies - mail order/Web

An increasing number of small engine manufacturers are providing on-line sales of repair manuals, general maintenance items, and "how to" books and videos. One example is Briggs and Stratton. However, they may not have more specialized items like head gaskets and connecting rods.

There are a large number of parts supply companies. Only a few are listed below. (I have absolutely no affiliation with any of the following companies. Some of the descriptions are from the company's site or what they emailed me. Listed in alphabetical order, more-or-less.)

- Battery and Electric Co. (BECO) has a secure online catalog featuring some of the most popular lawn mower and small engine parts, and we do offer consumers a form to request information on any parts not found online, including hard-to-find McCulloch parts. BECO is a distributor of all major OPE parts lines, and also offers a lower cost alternative in quality aftermarket Prime Line parts. We also offer new engines by Briggs and Stratton and Tecumseh in our online catalog. Online orders are by credit card (Visa, Mastercard and Discover). BECO has been in business since 1920 offering quality parts and service to the Carolinas, and we have now been on the Web for about a year.

  - Voice phone: 1-864-242-6480
  - Fax: 1-864-235-6465
  - Email: sales@becoparts.com
  - Web: http://www.becoparts.com/
  - Payment terms: Visa, Mastercard, and Discover

- Manufacturer's Supply lists all kinds of parts and accessories including those for small engines, lawn mowers, snowmobiles, logging/chainsaws, ATVs, and other engine powered equipment.

  - Phone: 1-800-826-8563
  - Fax: 1-800-294-4144
  - Web: http://www.mfgsupply.com/
  - Email: webmaster@mfgsupply.com

  The site has an on-line catalog (under construction) and search capability. A free 200 page print catalog may be requested as well. (I have been informed that they are currently out of these (May '97) but you will be put on their mailing list for a summer release.) They also have a 600+ page catalog (major portions of which will be put on their web site in the near future) with all sorts of fabulous replacement parts, tools, and other maintenance items - for the princely sum of $3.

- M & D Mower Repair. Product lines include those from Briggs & Stratton, Tecumseh, MTD, and others. Their web site provides access to the following:

  - Safety information.
  - Monthly tips, FAQ-like help, and an 'ask the mechanic' service.
  - Original engine service manuals and special tools.
  - Equipment and engine parts including complete engines and shortblocks. - After-market replacement parts for most popular brands of engines and outdoor power equipment.

  - Web: M & D Mower Repair: http://www.M-and-D.com/

  Orders are accepted via secure email, Fax or snail mail. Payment may be made using MasterCard, Visa, or Discover. The minimum S&H fee is around $4.

- Oscar Wilson Engines & Parts, Inc. has a web site which indicates that they are distributors for a large number of companies including Briggs & Stratton, Kawasaki, Kohler, McCulloch, MTD, Tecumseh, and others. There is no on-line catalog. I do not know if they will help with parts identification or whether you really need to have an exact part number to order.

  - Voice phone: 1-800-873-6721
  - Fax: 1-800-873-6720
  - Web: http://www.oscar-wilson.com/
  - Email: oscar@i1.net
  - Payment terms: cash, check, Mastercard, Visa, Discover, Open Account.

Used parts

It doesn't make a lot of sense to search the countryside for a clogged air filter or slightly worn engine oil :-) but it may be possible to save a substantial amount of money if you can locate a previously owned replacement for that bent crankshaft!

- Salvage yards: these are probably the most reasonable priced sources for major engine components if you can locate a compatible model and are willing to do the necessary leg work. Since only a hand full of really different engines are used on the majority of rotary mowers, this may not be that hard. Of course, the condition of such parts can be quite variable. And, it will likely be your entire responsibility to locate exactly what you need! Buying a complete engine by the pound to obtain a rod or piston may end up being cheaper than buying just a new part and just about as good in many cases. For internal parts, take along a copy of the Chilten or other engine repair book which lists engine cross references so that you will be able to determine if a part will be compatible without stripping the engine! (Of course, if the previous owner neglected the routine maintenance, the engine had a long hard life, or oversize repair parts were installed, you may be out of luck anyhow.)

  Yard equipment dealers may take old (non-working) mowers as trade-ins and be happy to sell or give away the remains for parts. Of course, if all you need is a bolt, you will have to dispose of the rest of the carcass!

- Garage or yard sales: if you are in no hurry and enjoy this weekend pastime, mowers in various stages of decay and disrepair are often available. I have paid $2 to $10 for non-functional mowers requiring relatively little in the way of repair - usually this is carburetor cleaning or perhaps a tuneup. The beginning and end of the mowing season are probably the best times for this search. At the beginning of the season, people discover that their mowers won't start, shove them in a corner, and go out and spend big $$$ for a brand new mower that will be in the same sorry state in a couple of years. (They, of course, have not read this document.)

(From: BELJAN E (lvpy67c@ix.netcom.com).)

> "About 10 minutes, replace the points, spark plug and a spritz of starting fluid and 90% are fine after that!"

At the end of the season they say "never again" and move to an apartment or hire a landscaper.

I paid $35 for a Sears Craftsman mower in perfect condition (I guess grass mowing was not something the seller enjoyed) about 17 years ago and it is still going strong with only minimal maintenance.

Comments on buying used mowers

Caution: Mowers older than about 20 years or so will not have the safety features of modern ones (dead-man bar for engine kill and/or blade-brake clutch). Therefore, it may make sense to avoid really old mowers without these safety features even if they are in perfect condition.

Garage and yard sales, tag sales, flea markets, and auctions, are also excellent sources for tools. Very high quality tools often show up at reasonable prices but there is a lot of junk out there so know what you want and how to distinguish an easily salvageable tool from one that is a pile of congealed rust.

(From: Mark Manville (manville@vega15.cs.wisc.edu).)

What I did when we bought our first house was to just go around to garage sales and look for an inexpensive used mower. I figured I would need to cut the lawn for a while before I was really sure of what I needed anyway. Besides, after the down payment, closing costs, and other expenses, there was not much free cash to speak of. Such a mower could perhaps take you through the first year or so, until you have more experience, time, and cash. You may even get lucky like I think we did and get one that you can stick with for a while. We got a 22" Sears self propelled that works pretty well - it's old, but at $30 I count it as a bargain, even if breaks down after one year."

(From: Erik Beljan (lvpy67c@ix.netcom.com).)

I would like to comment on buying used lawn mowers. Do not trust what you are buying. You never know what the quality of the engine is and there is no way to guarantee it. I found a Roper Rally 22 inch lawn mower last fall, and had an interesting ordeal which shows what you might be getting. I took it home only to find the engine was seized (found by attempting to pull the starter cord). I took the sparkplug out and put a mixture of Duralube All Purpose Spray, Marvel Mystery Oil and Liquid Wrench into the cylinder. I put the spark plug in and let it sit a few minutes. I took the plug out and yanked the blade from the underneath. It snapped free. I then cranked it about 10 times, to clear the cylinder (if fouled the old plug that was in the mower) I cleaned the plug off with some carb and choke cleaner, sprayed some into the cylinder and carb. I proceeded to start it again. It kicked to life with a huge cloud of smoke. It blew smoke everywhere for about 5 minutes. I shut it off and parked it under a tree overnight so I could take a closer look the next day.

The next day I took a better look at it only to find that the top of the flywheel was full of poplar tree cotton, which I removed. I looked at the oil which was a dark thick black color. I poured a large dose of Marvel Mystery Oil into the oil and started the mower. I ran it for a few minutes (it burned considerable oil), shut it off and changed the oil. I dumped the old oil out and filled it with a 50 50 blend of SAE 30 oil and Nu Lube oil stabilizer (a thickish oil treatment like STP thins out more though). I filled the gas tank and put about 4 oz of Marvel Mystery Oil in the gas. I started it and ran it for 10 minutes. No smoke, sounds like new. I am using it now this spring with the only modification of a new spark plug and air filter. The thing runs fine, but it is likely that the engine is in terrible shape internally (I am not bothering to take it apart, but can it can be seen by the excessive oil burning if I don't put some Nu Lube in the oil).

If I sold it to you today without telling you what I did to it, you would never know, there are no outward signs of what it was like. The Nu Lube seals the clearances nicely, stops the oil from burning, keeps the spark plug from oil fouling, keeps the oil looking clean and quiets the engine quite a bit. If I were the purchasing party I would not want to receive this engine if I would have known its condition. This story goes to show that for minimal work you can make an engine run in so it seems to be in decent shape, even though it might not be.

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Small Engine Specifications

Typical mechanical specifications

The following are some of the key dimensions and other specifications for several common Tecumseh engines. Where two numbers are listed, they are the upper and lower service (wear) limits as appropriate. One of these will be close to the expected dimension on a new engine; the other represents the point at which you are supposed to replace the part due to wear. All values are in inches unless otherwise noted.

```
        Specification        LAV/H30   LAV/H40   LAV/H50    V/H70    VM/HM100
-------------------------------------------------------------------------------

Horsepower:                     3         4         5         7          10

Displacement (cubic inches):  7.75      10.5      11.5      15.0      20.2

Bore:                         2.3125    2.625     2.75      2.75      3.187

Stroke:                      1-27/32   1-15/16   1-15/16   2-17/32   2-17/32

Timing Dimension:              .060      .035      .035      .050      .070
(before TDC)

Point setting:                 .020      .020      .020      .020      .020

Spark plug gap:                .030      .030      .030      .030      .030

Valve Clearance:               .010      .010      .010      .010      .010

Valve seat angle (degrees):    46        46        46        46        46

Valve spring free length:     1.135     1.135     1.135     1.462     1.462

Valve seat width:              .035      .035      .035      .042      .042
                               .045      .045      .045      .052      .052

Crankshaft end play:           .005      .005      .005      .005      .005
                               .027      .027      .027      .027      .027

Crank pin journal diameter:    .8610     .9995     .9995    1.1865    1.1865
                               .8615    1.0000    1.0000    1.1870    1.1870
```

Connecting rod bearing diam: (crank pin journal end)	.8620 .8625	1.0005 1.0010	1.0005 1.0010	1.1880 1.1885	1.1880 1.1885
Crankshaft diameter: (cover/blade/PTO)	.8735 .8740	.9985 .9990	.9985 .9990	.9985 .9990	1.1870 1.1875
Main bearing diameter: (cover/blade/PTO)	.8755 .8760	1.0005 1.0010	1.0005 1.0010	1.0005 1.0010	1.1890 1.1895
Crankshaft Diameter: (flywheel/magneto)	.8735 .8740	.9985 .9990	.9990 .9995	.9985 .9990	.9985 .9990
Main bearing diameter: (flywheel/magneto)	.8755 .8760	1.0005 1.0010	1.0005 1.0010	1.0005 1.0010	1.0005 1.0010
Camshaft bearing diameter:	.4975 .4980	.4975 .4980	.4975 .4980	.6230 .6235	.6230 .6235
Piston diameter:	2.3090 2.3095	2.6260 2.6265	2.7450 2.7455	2.7450 2.7455	3.1817 3.1842
Piston pin diameter:	.5629 .5631	.5629 .5631	.5629 .5631	.6248 .6250	.6248 .6250
Width of comp. ring grooves:	.0955 .0977	.0925 .0935	.0795 .0815	.0795 .0805	.0955 .0975
Width of oil ring grooves:	.125 .127	.156 .158	.1565 .1585	.188 .190	.188 .190
Ring end gap:	.007 .020	.007 .020	.007 .020	.007 .020	.007 .020
Top piston land clearance:	.0105 .0145	.0165 .0215	.024 .027	.023 .028	.029 .034
Piston skirt clearance:	.0025 .0040	.0045 .0060	.0045 .0060	.0045 .0060	.028 .053

Typical torque specifications

For proper operation and long life, you cannot just tighten critical nuts and bolts by feel. You really don't want the connecting rod cap to come loose while the engine is running! The following are just samples - check your engine manual for exact values!!! The most critical are the connecting rod bolts or nuts and the cylinder head bolts.

Location	Torque ---> Inch-pounds	Foot pounds
Cylinder head bolts:	160 - 200	13 - 16
Connecting rod bolts (Durlock rod bolts):		
2.5 - 4 HP small frame:	96 - 110	7.9 - 9.1
5 - 6 HP medium frame:	130 - 150	10.8 - 12.5
7 - 10 HP medium frame:	150 - 170	12.5 - 14.1

Cylinder cover or flange to cylinder:	65 - 110	5.5 - 9.0
Flywheel nut:	360 - 396	30 - 33
Spark plug:	180 - 360	15 - 30
Magneto stator to cylinder:	40 - 90	3.3 - 7.5
Starter to blower housing or cylinder:	40 - 60	3.3 - 5.0
Housing baffle to cylinder:	48 - 72	4 - 6
Breather cover to cylinder:	20 - 26	1.7 - 2.1
Intake pipe to cylinder:	72 - 96	6 - 8
Carburetor to intake pipe:	48 - 72	4 - 6
Air cleaner to carburetor (plastic):	8 - 12	1
Tank plate to bracket (plastic):	100 - 144	9 - 12
Tank to housing:	45 - 65	3.7 - 5
Muffler bolts to cylinder:		
1 - 5 HP small frame:	30 - 45	2.5 - 3.5
4 - 5 HP medium frame:	90 - 150	8 - 12
Electric starter to cylinder:	50 - 60	4 - 5

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-- end V2.18s --

Interesting Repair Related Stories and Anecdotes

Version 1.27

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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These are the Runners Up

Well, not really. The articles in this document are based on email I have received about other people's experiences while troubleshooting, repairing, breaking - and learning, as well as random comments about the FAQs, repair in general, or the state of the universe. They have not become "Assorted Repair Briefs from OTHER sources [than Sam]" for one reason or another, mostly obvious, but that is no reflection on their significance or the lessons to be taught by their content. For the most part, I have only made editorial changes and have retained the original flavor of each of these interesting and sometimes amusing articles.

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Repair Story #1: MacGyver-In-Training

Author: Norval F. T. Tennant, Copyright © 1996,1997, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or valten_f@toj.com.

Happy Holidays

Hope you had an enjoyable Christmas and that the approaching new year will see the fulfillment of all your dreams. I discover Sci.Electronics on the web about a week ago. Since then I have downloaded and read most of your articles. Presently I am reading your repair briefs. I am finding it very informative and hilarious too (ha ha heh heh).

I have been fiddling around electronics for sometime now and earlier this year started a course with N.R.I. Schools in Micro Processors and Micro Computers. Presently I am an Information Systems Manager at a hotel but I really love electronics. I have fix quite a few equipments. (Have not had any complaints of fire after my repairs either) . However I am still a novice - Pro Wannabe and I believe that with guidance from guys like yourself and others someday I too might become a pro.

Hey any chance of me renting your knowledge for a month or two?. Oh well I didn't think so either but just checking. Man, I have quite a number of appliances laying around the house. Mostly for friends. Well you see they seem to think that whatever broken equipment they have, MacGyver can fix it.

MacGyver - Yeah thats what they call me. That was from a television series some years ago staring Richard Dean Anderson or was it Robert Dean Anderson, Well lets just say "Something Dean Anderson". Now he was something else. I once saw that guy broke an egg and empty its contents in a car radiator to stop a leak. Well Thats television for you.

Oh about that equipment - Yeah I do have quite a few. VCRs, televisions, computer monitors, CD player and even an electronic scale.

Well a part of my problem is that unlike you I cannot go to the library to get a copy of a Sams'. What are you inquiring about .... Service manual for a Panasonic PV2822?. What the hell is that. You see I am living in Jamaica. Where? Oh that's a little Caribbean country about 90 miles south of Cuba. Its total area is about 4411 Sq. Miles with a population of around 2.6 million. Home of the now famous reggae music. Also produces world renown Blue Mountain Coffee. Has produced some world class athletes in track and field the likes of Herb McKinley, Donald Quarrie, Bert Cameron. Did I say has produced?. That was a slip of the tongue. We are still producing - Merlene Ottey, Deon Hemmings etc. etc. Hey we even have a bob sled team, but listen it has never snowed in Jamaica. Ha. Ha. Well there are quite a few achievements to make us proud but to have Sams' Photofacts in the library, We are not there yet. Still a third world country....perhaps one day.

Probably when we have become close friends then we can work something out but for now - grope grope in the dark. Do you think if I share some symptoms you might be able to help? Well I do not own a scope. Have never seen one except in magazines. I have download something from Sci about them thought, will read that later. I have a DVM, pliers, screw drivers, etc. The basic tools really. Well let me tell you about a patient:

Panasonic PV 2822 Video

Complaint - Good sound but no picture. Snow on T/V (local term - T/V snowy). Tried cleaning video head - no change.

Well that sounds like the video heads might have done its days I thought. First thing I did was to remove cover. Lift main board to get to head. Close scrutiny shows head appears to be worn and the color seem sort of brownish not shiny bright. I wonder what they use to clean head. Some of those cassette cleaners not any good. How about some manual cleaning. Some isopropyl alcohol and tissue from the bathroom and some gently rubbing on head, tape guides, pinched roller, etc.

Now to test. Circuit board not screw back in position but set so that nothing will short against any metal parts. Connect to TV. Plug into A/C line. No Variac or Isolation transformer that Sam refers to so often. Need to address that but for now .. .Power switch press. Display lights up. Channel 2 on display. No local station uses that channel and cable is not attached. Menu appears on TV, "Numeric key to set date and time etc. etc.

Now for a cassette. That is inserted. Safety tab on cassette is removed so play come on automatically. All mechanics seems okay, tape properly wraps around drum and alas picture, best I have seen on this TV since I fix it 2 years ago. I was attempting to tweak it then, when I use a minute metal screw to adjust - what is that part called .. IF or RF transformer for cleaner picture I reasoned. Well the darn screw driver crack the core or was it the person using the screw driver? Well the picture has been somewhat snowy since perhaps one of these days I will fix that but back to video at hand.

Picture cool, sound awright just screw it back together and hook it to the better working TV and watch a movie. Just got 2 movies to borrow from my cousin. Well Stop, Eject and power. Off goes connector to tv and out goes power cord. Oh did I mention a small spark from the socket the first time I plug in into the ac line. I have seen that every now and then I wonder if the socket terminals are somewhat corroded well I will check that one of these days....

Time to screw up (no pun intended) VCR. Enter my 4 year old stepson and his 5 year old uncle. "Hi dad You said you were going to allow us to help you fix video". Man why do young kids have such good memory. This I told them earlier on when they were refusing to go for their bath. "Well your time now" I said go get two phillips screw drivers. Well they know were the tools are kept sometimes I have to ask them were my tools have disappeared to.

Well it is a good thing they only visit during holidays or I think I would be mad by now but then again probably I already am. Well they are back and they look ready to screw. No No Not that type of screw Sam. These are kids, oh boy!. Well I carefully inserted the the main board back into its position making sure all wires are intact. I inserted all the screws putting about two turns on each with my finger. Okay guys your turn. I showed them how to finish inserting screws a few minutes later they were through. No No I did not leave them to do it by themselves another few years perhaps but for now I was right there. Well with the main board out the way I replace the cover and with the boys help screwed it in place.

Now to go watch the movies. Movies in a few minutes I announced to the rest of the household. I hooked up Video to properly working TV, plug into A/C line again that little spark - different socket this time - Well this is an old house. Power, display lights up and menu comes up on t/v well now insert cassette. In goes cassette, on comes play, sound but wait NO PICTURE. FAINTLY detected ghost wiggle but NO PROPER PICTURE. EVERYONE NOW TAKING THERE SEATS. Wiggling of cable bring no change. Well I must have missed something when WE WERE SCREWING it together. Well off comes cover, up comes board, close visual inspection reveals nothing amiss. Well what the &$#@ went wrong. By now I am back to snowy Tv set still no picture. Gently prodding of circuit board yields no change. Another quick clean of head - Nothing. A hour and a half later still nothing. By this the theater - I mean the living room is empty. Someone making a wise crack about me working on the projector. Well What am I not checking. When Power is applied the startup menu is displayed - Set date time etc on t/v. Did I check the channels from the video No. Well antenna is attached to video and local channel is selected on video, vcr/tv switch is check vcr selected. Well what do you know still no picture. Whenever a channel is selected for which their is no signal there appears to be horizontal lines on t/v however once one with a signal is selected good sound put faint ghost and lots of snow. Did I say it never snow in Jamaica.

Well it is getting late and I have to be up early for work in the morning so I not going to stay up with Mr VCR anymore. Why did you have to do that to me I ask?. Well now I know that I am really tired because I sure I hear it mumble something about me allowing kids to poke around in his belly. Well just my imagination probably.

Well Sam that was yesterday. Have not looked at it today. But I have been thinking - That fact that there is no picture at all neither from the tuner circuits or from the video circuits then the problem is in a circuit that is common to both could it be power problem?.

Knong Kong Heht Hett - Now what is that. Ah my little 15 months old niece. Heh heh Hoh hah - Sam she is wearing her Mother's Shoes. Well I think she is here to continue her computer class we started the other day.

Sam I have to say bye for now. Hoping to here from you soon. Anxiously awaiting your advice. In the meantime I continue to read your articles. This young lady is pulling on my pants trying to get on my lap. Now where did I put that Dr. T's Sing-A-Long CD. "Raat raat" - No baby, Not a rat. It is call a mouse, Kids .....

Samtron SVGA monitor model SC441V

Well well!. Today is the start of a new year so after awaking, yawning and stretching I decided to check my mail and what do you know - Heh Heh there is a reply from Sam. Now I know why they call that other service SNAIL MAIL.

Sam it was nice to hear from you. I have noted all your recommendations and will be posting a few questions to Sci.Electronics shortly. Well after reading your chapter on "Incrediblely handy widgets". I decided to construct the Visual Load Indicator - . Like yourself I wired a dual outlet box in series so both the equipment under test and the lamp can be plug in. My problem now is understanding what wattage bulb to use for what equipment.

You see I constructed it last night - NEW YEARS EVE - Well who cares, I was doing what I like. I was at my own New Year's Eve Ball. The equipment I was testing it on was a 14" Samtron SVGA monitor Mod# SC441V. This patient was busted up somewhat, but I will tell you about that some other time. For now I had just replace a voltage regulator - STR 58041 = ECG 7078 (Yeah I have an ECG Cross Reference manual 96 version). This had a short between pins 2 & 3. Base and output if I remember correctly. I also replace two C1008 transistors with 2N2219A, A 1K resistor 1/4 watt and a RPG15G diode - This is rated at 600 prv 3amp so I used one rated at 1000 prv 3amp. This was only for test purpose as I will try to located a original or one of similar ratings.

No I have not noted any shorted are open capacitors as yet. Well time to test. The monitor is rated at 70 watts 0.5 - 1 amp. My newly made visual indicator is connected and I am using a 40 watt bulb. My bulb holder is one of those with a switch on it. Am I wearing rubber boots? Yes and one hand struct deep down in pocket. Wait Wait What is this?. A huge hole in my pocket - On so that was how my $500 bill escaped. Sam 500 Ja.$

is about $15 in Uncle Sams currency. Well you gain some, you lose some, that's life. Still I will show this torn pocket.....

Now back to the matter at hand. Burr Rum Burr bum (Is that how a drum sound Sam). Well drum roll and all and POWER. Now what do you know?. Awright Sam Awright - I am just learning not as experience as you but one of these day .... Yes bulb shines brightly. Well Sam did say If bulb glows bright then shorts probably exits - now what could that be. Now give this a little thought and ... Okay if degausing cable is still connected then that might provide a low resistant path for current back to bulb... One way to find out. Power Off, degausing coil disconnected. Power on. No glow from bulb, no wait there is a faint glow on the filament. Now what still no sign of life from my patient SAM err err I meant My patient SAMTRON. Now what would Sam the man with Gold in his name have done. Well I remembered him changing the wattage of the bulb a few times I wonder if.... . Can't see any harm in that. Well I do have a 100 watt bulb. Now that is fetch and quickly replaces the 40 watt. Power. Ahah bulb is glowing but not brightly AND THERE IS A HORIZONTAL LINE ON MONITOR THAT IS SLOWLY OPENING VERTICALLY. AND there is also letters on the screen. Not quite legible but there. Oh I did hook the monitor to a old 386 PC that had no hard drive or key board. Yes is has memory. About 2 mb. The rest will be added later. You know me one of these days ......

Well I suppose this monitor needs more current so I will just disconnect this visual tester and plug it in ac outlet. My Next gadget must be an isolation transformer and also a variac. I already have a few transformers and also a line conditioner. I could probably convert that to a variac. I could asked on Sci about a circuit diagram or perhaps Sam can help. Back to monitor. Degauss is connected and monitor plug in to ac. Power. Yes Yes monitor lights up beautifully. It i s a bit bright but that is soon corrected with a little adjustment to the brightness control on the front of monitor. Now I see the booth up and error message on monitor as 386 tries to booth without a hard drive or floppy drive. Now to let this run for awhile. How about rebooting computer. Okay. Power Off. BUZZZZ Buzzz. Now What the hell is that. The back of monitor is still off so visual inspection is easily done. Power Off. Plug pulled from a/c. That sound seem to be coming from somewhere in the vicinity of the newly installed regulator and that many legged transformer that it is close to. In fact in is connected to a heat sink that have a portion hovering over the transformer. A quick check using a finger as heat detector on newly install parts - CAREFUL NOT TO TOUCH ANY METAL PART - FILTER CAPACITOR NOT DISCHARGE ALSO STAYING FAR FROM HV CIRCUIT - revealed nothing until i came to the newly install diode. The one with the 1000 PRV Instead 0f 600. Well that is rather hot. Well what does this supply. From tracing the circuit I saw 24 volt written on PCB and it goes to quite a few components. Well I suppose one of them has a problem that is causing my little silicon friend to over work and sweat - I mean heat up too much. Well let me just check this voltage. All connected and power up. Monitor lights up. With my DVM I checked - 23.9 volts after a few seconds buzzz buzzz. Power off. Diode is quite hot. Well it is almost midnight now. My fiancee seems to be asleep and hey she is hugging a pillow. Well I've got to start the New year right - think I better get to bed and replace that pillow. She did say she wanted to be up when the New Year arrived so she won't mind if I wake her Plus Sam did say NOT TO WORK WHEN I AM TIRED - Well at least not on any thing electrical. Well that was last night and the rest is history. This morning I got your letter and now I reply. Later I will attend to patient SAMTRON. NO Success then to Sci.

How do I determine what wattage bulb to used on equipment under test?. Gotta say bye for now. Looking forward to hearing from you soon. All the best for New Year.

Now what is that sound. Oh Oh 15 month old niece. Sam I have not fully recovered from that last lesson. Gotta find somewhere to hide , Gotta find somewhereeeee ....

January 3, 1997

Hey Sam - How about under a section entitled "NEVER DO THIS" - Ha Ha. Well as one of my mentors whatever you chose to do is okay with me. I have taken a little break from repairs for a couple days. I have to keep Mr. Mantzanas (Director of Education - N.R.I.) happy, so I am catching up on a few lessons. I am presently studying Logical Operations and Functions. You know all those logic gates - AND, OR, NOT, NAND, NOR etc etc. Sam these Boolean Algebra are really a brainful. Do you know any EASY WAYS of remembering all these various laws? - Commutative, Associative, Distributive, Laws of Absorption etc.

About your comments on that diode!. Well the only difference between the original and the one I installed is the PRV. Well this is based on data in ECG Manual. I check on the original and also the replacement. It is in the secondary supply. On the other hand - Would a problem arising from the switching function of this diode results in that buzzing sound that I am hearing?. Sound only appear after unit is turned on for a few seconds. In fact the first time I heard it was when I disconnect the signal cable from PC to monitor. Well I guess I could double check that.

Until I hear from you "TEK CARE AND WALK GOOD" - (Jamaican dialect) - Means "Be careful and watch your step".

MacGyver

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Repair Story #2: Watering a TV

Author: Andrew Bock, Copyright © 1997, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or abock@mars.ark.com.

I just wanted to pass on thanks for info on monitors. I read your 'Why I do This' note and agree with your philosophy.

I have fixed countless VCRs, TVs etc just to stop them from going into the dumpster. Todays society is so much a toss it in the bin generation. If people don't want it back when I give them an idea of its cost I fix it anyway and donate it to charity or some poor starving student. If I can ever help you proofread or sort info let me know as I have time at work between trouble calls. I too have tried just about everything (cars, motorbikes, lawn mowers, built a house). I work as a tech maintaining air traffic radar and navigations systems.

In exchange for your info I offer this story:

One of the guys I work with brings in his brothers big screen TV that's belly up. When quizzed he doesn't really want to talk about it or whats wrong with it. So now we are really interested. It turns out that it has had water spilled in the back. Well we had all ran across this before so after much guffawing and insulting of his lineage the story comes out. His brother had the customary spider plant on top of the TV. Well sometime not long after he bought it the bottom third of the screen folded over and left a black bar at the bottom.

Because of the size of the TV he just left it that way for more than a year. Then one day he watered the plant a little too exuberantly and smoke came out of the back. He quickly unplugged it and left it wisely to dry out. Well when he plugs it back in several days later it is cured of its fault! The TV works perfectly for a month. Then the fault comes back, but he knows what to do. You guessed it, he gets out the watering can and pours water! In the back of his LIVE TV set. Why he didn't end up as a pair of smoking sneakers was only luck. Needless to say the comments on his genetic structure flew fast and furious.

Enjoy and keep up the good work.

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Repair Story #3: Chinese CD Player with an Attitude Problem

Author: Mark Kinsler, Copyright © 1997, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or kinsler@bobcat.ent.ohiou.edu.

Patient: RCA model 1050 M-F (maybe that means it only is guaranteed to work on weekdays? :-).

Symptoms: Ejects discs instead of playing them.

Testing: Same behavior with multiple discs.

So we finally bought the world's cheapest CD player, which is an RCA model 1050 M-F. Fabrique en Chine, as one would expect. Worked fine until I decided to horse around and try to play the free CD that came in the mail from Microsoft the other day. Not surprisingly, it didn't play. Lots more surprisingly, our audio CD's won't play now, either, and Natalie won't believe that I didn't wreck the thing by trying to play a computer CD in it.

The symptoms are: You put a CD in and push the button to close the drawer. CD starts to spin up and then the drawer opens. The drawer never, in normal use, opens automatically. So I took the cover off and lugged machine over to the kitchen table, where it worked fine. Put cover back on, still worked fine. Re-installed it to Natalie's ancient Montgomery Ward receiver and it started with the music critic act again: put in a CD, it pushes it out again.

I didn't think that the fool drawer motor was connected into the microprocessor circuit. Does anyone have any ideas? Help?

(From: Vlad (vlad@chaos.bme.ohio-state.edu).)

> "I'm also a happy owner of a similar CD player.

> When I was inside it :), I noticed that the drawer is kept in locked position with a tiny plastic hook, and instead of metal spring to move the hook to locked position, they used plastic. At first, I could not believe this thing could work at all. The cover (or drawer?) is pushing a little switch, when it is locked. It has no other connections to anything important. If you can locate this little switch, you could try to press it and play the CD. Or try just to keep the cover closed with a hand ant try to play. Perhaps, this stupid cover locking mechanism does not functioning right."

The situation has progressed as follows: With the deck on the kitchen table and playing normally, I poked and prodded everything with the power on and the cover off. I noticed that one of the ribbon cables from the CD mechanism to the circuit board was sensitive to my prodding: when I'd push it with my finger, the sled would start to search and focus and stuff. Solder joints and everything looked fine, and the problem seemed to clear up after I removed and replaced the ribbon cable plugs. Plugged it back into the amplifier, and out the drawer comes--the machine won't play a thing. Back on the kitchen table, the thing plays fine.

I notice that the ribbon cable seems sensitive again. I don't know how long it took me to figure out that it was sensitive when I poked it with my finger but not when I poked it with a pen. (Not that long, actually--I used to be fairly accomplished at audio repair before CD's came out, and I'm suspicious of everything.)

To make a long story shorter, I've got an rf shielding problem. We have, it turns out, a strong AM radio station near the house, and the problem showed up after I plugged the power wiring of the stereo system in somewhat differently. In fact, the CD player works like a loop antenna. If I rotate it 90 degrees in its location on the shelf, it works better--hesitantly, skipping, but still trying.

The drawer mechanism is presumably involved because this thing has a remote control and simple pushbuttons to control things like the power and the drawer. These buttons activate interrupts to the microprocessor, which then executes the desired command. Apparently the rf is getting to the microprocessor and scrambling things.

I noticed late last night that the machine had settled down remarkably, and that the ribbon cable wasn't particularly sensitive to my massage techniques. I'm very glad I also noted that the radio station had gone off the air for the night as well: this morning, the drawer was up to its old tricks again.

I will discuss the problem with the dealer, but I don't expect much help in that direction. Then I will get at it with various remedies like 0.05 uF disk capacitors from power and audio cables to ground.

I haven't put the steel case back on the machine yet, though it's apparent from the construction of the player that they paid considerable attention to shielding and that they expected the case to be in place. I will apply my capacitors and maybe some ferrite beads and then put the case back on.

Sheesh.

Natalie was convinced that what I should do is to move the thing the next shelf up, away from the TV set. I had to explain to her that that wouldn't do any good because the TV set wasn't affecting the CD player by its unplugged presence. Back to work:

Having determined that the problem was shielding and bypassing, I checked my cabinets of little plastic storage drawers. Only the faded labels on these give evidence that they were once organized. They're now filled with random junk of a vaguely electronic nature. However, I found some 3-legged ceramic disk capacitors with ferrite beads on two legs. These were from a Radio Shack surplus capacitor assortment and were obviously meant for rf suppression purposes. I put one on each of the audio outputs, grounding them to the board ground. I also stuck one on the audio cable shield. Just for good measure, I stuck a big old 2kV 150 pf ceramic disk capacitor across the power line, which was already equipped with series inductors. I tightened everything that looked like it had anything to do with shielding and checked the continuity of everything thereof.

Stuck the case back on, paying particular attention to the single screw that connected the case to the ground. Set it on the shelf, plugged it in, put in the test CD. Spun right up!

And two seconds later, the drawer pushes open. Did it again, and again.

So what the hell. I took the books off the next shelf up and put the CD player up there. Plugged it into receiver and power.

That's the Bach Double Violin Concerto playing in the background.

From Sam:

> So, you are saying the TV picks up the AM radio station and does something to affect the CD even though the TV is unplugged????? Did unplugging the audio cable have any effect? Yes, I know it would be tough to listen to it that way but maybe the drawer would stay shut :-).

Could have been anything, actually. Among other things, I just rebuilt Natalie's closet. It shares a wall with the living room, and I put in two long pieces of 3/4" steel electrical conduit for her to hang her stuff upon. These could change the radiation pattern effectively. I also re-routed the TV cable under the floor. With the hills in this area, you can get the strangest rf on earth. Apparently I stuck the CD player in a local Bermuda Triangle.

Natalie is delighted, I must say.

Plugging the cables in did indeed affect the symptoms. A bit of experimentation showed that the cable shields seemed to be carrying in more rf than the core conductors: no effect when just the center pin of the RCA plug was inserted, but we got hunting and stuff when the shield made contact. Just touching the plug shield to the jack shield without the pin's being inserted caused disturbance.

BTW, I tried the Microsoft disk again. No sound, but no skipping.

From Sam:

> Right, the CD player is too new to gobble up CDROM discs or else the company has ties to Sun Microsystems instead of Wintel.

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Repair Story #4: Magnavox Portable CD Player

Author: BELJAN E, Copyright © 1997, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or lvpy67c@ix.netcom.com.

Well, I just wasted nearly half my night on this piece of junk. Problem was that it wouldn't read CDs, but if you turned it upside down it would. The pickup would then slip out of alignment and start clacking. It took me an hour to get it apart (This is a Magnavox AZ6822) because of the stupid screws, I couldn't find screwdrivers to reliably get them out. When I got it apart, the design inside was simple enough, and I decided to take out the transport. I removed the transport, which is nicely supported by springs that fall all over the place. Well, I got the thing out, and you cant even tell what is wrong with it, because it isn't related to the circuitry. Well, I figured out that as you know, the lens slides along a metal bar, well at one end, a little plastic clip was missing. I figured this was logical since the unit was dropped about 5 times on concrete. Well, there I was, No clip, pickup mechanism out, what was I to do. Well, I found a seemingly unlikely solution. A piece of a broken Rod Antenna, the end was crimped, so I cut it off with tin snips. Well, what do you know, same thickness and width of the clip. I cut it to size, and put it in. Reassemble, and Bingo works like a charm, reads the CDs, plays fine. This was absolutely the worst CD player design I ever saw. Easy to scratch discs, eats batteries, but it took 5 falls on concrete to break it.

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Repair Story #5: Toshiba TX-902 Car Radio/CD Player

Author: Peter Strezev KJ5CN, Copyright © 1997, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or jup001@airmail.net.

Editor's note: This one is a great example of persistence despite what would appear to be a hopless cause - a piece of equipment that has been previously butchered!

This car radio I bought at a garage sale in a hope to install it in my daughter's car if I could fix it. Evidently somebody had worked on it before because I could see signs of sloppy soldering job here and there, a few burned traces jumpered with wire, and also the 2 flexible wires between the LCD panel to the CD mechanism were not there at all. I fixed the obvious damage and used flat ribbon cable to hook the CD mechanism up.

At this point, the radio part started working. Attempts to play a CD did not succeed though: the disk gets "sucked" in normally, just sits there without rotation for a few seconds and then is ejected.

The laser is working: to check that I took a junk CD and sanded out a small portion of it where the pickup is located to make it transparent. This method works great by the way: I could easily see from a safe angle the tiny deep red spot inside the disk material without even having to turn the lights off.

From the following, I came to the conclusion that the the YM7121 chip was bad. I spent hours carefully checking everything else step by step (by the way, thanks for the great web page that you maintain: I found plenty of very useful information there).

Check on the focus search signals showed that none are generated. This led me to checking the IC in question, which is the main CD controller. I have the schematics, so I was able to compare the voltage levels on the pins of this chip to the ones indicated on the diagram. Only the VDD (no wonder) and some of the input signals are within the expected values. Rest are wildly off mark. But this is not all. The VCO test pin shows no oscillation at all (yes, I used a scope), and even the 16.9 MHz XTAL oscillator is not running. I checked every of the few components around the crystal and the crystal itself, everything is fine, so evidently there is something wrong with the oscillator amplifier inside the chip.

My last experiment was to take the crystal off the board and put together a quickie 74LS00 oscillator around it. Once I had this working, I tried to feed the 16.9 MHz signal into the XTAL IN pin of the YM7121. My hope was that if something went bad with the feedback in the OSC amplifier in the chip, I might get the chip to work by feeding it an external clock. No such luck :-{.

The output of my oscillator gets quite heavily loaded, everything else remains the same. At this point I accepted the grim fact that the YM7121 is fried. I agree with you, this is the last thing to happen, but I can suspected that whoever worked on this unit before might have burned it by accident.

So I need to replace a Part Number is YM7121C, 80-pin PQFP package.

I have not quite given up yet, so I will keep playing with it until I either return it to life, or say to myself "enough is enough". I placed an order for the replacement chip with Fox International Ltd (yes, I was surprised myself to find a place where you can actually order something like that).

It is an 80 pin WFP surface mount part. Yes, I do have certain experience with SMT rework which I have done on computer boards, so replacing the chip is not gonna be a problem.

But the best experience I had was with the hybrid metal/glass CRTs. That is, the ones which had a bare metal cone as the 2nd anode, and the glass parts (the screen and the electron gun assembly) welded to the metal on each side. Great way to learn about the safety issues when you have one third of the set having a dozen of kilovolts on it :-) :-). Just to add to the issue, most of these sets had a transformerless power supply. Nasty...

Let me update you on the CD player status. First, my determination to fix it was not because I want it so bad, but because of the great learning experience I have been getting in the process. Also, I am sure you are familiar with that feeling of satisfaction when you bring a seemingly hopelessly dead thing back to life.

You probably already figured out that I had some major progress. Yes, the thing is now working, flawlessly.

I got the replacement chip last week ($27 plus shipping, to answer your question) and replaced it on Sunday. Sure enough, it did not start to work right away. Even though the 16.9 MHz oscillator seemed to be doing something (remember, with the old chip it did not oscillate at all), the frequency was somehow 2 times higher (33.8), and looked very noisy on the scope. Nothing else worked, the DC voltages on most pins were still wildly off the expected values. After fighting with it for some time, I suddenly remembered the golden rule:

"if too many things seem to be so wrong, that you fail to even understand, how they could be so wrong, check the ground connections".

I started testing the pins on the YM7121, which were supposed to be on VDD and GND. Surprise: pin #77, which should be at the GND according to schematics, in reality is not. So are a few components around this pin which used the same PCB trace.

After rechecking my diagnose, I bridged the trace to the nearest ground, and turned the thing on. Viola! The VCO came on. Quick adjustment of the PLL free run frequency to make it 4,35 MHz, power off, reconnect the pickup, power back on. Yes, the disk starts spinning, I hear the buzzing of the focusing coil and even bits and pieces of sound start coming through. Next adjustment: E-F balance, brings only a marginal improvement.

OK, let's see what we have on the RF test points. The scope shows an eye pattern, but very shaky and jittery one. Suppressing my doubts I start tweaking the optical alignment screws. At some point the inner tracks start playing much better, but with lots of skipping and re-search attempts. The outer tracks are much worse no matter how carefully I try to find the proper alignment.

OK, maybe this is because all this time I had the CD mechanism upside down (this is the only way to reach the PCB and all adjustment points).

Turning the mechanism the right side up makes matters a lot worse: even the disk index search fails 100%, alignment screw does not help at all.

This tells me that something is wrong with the turntable adjustment.

Accessing the turntable requires a lot of disassembly (all these tiny screws and springs), but finally I am able to measure the turntable height. Yes, there is a problem: the manual shows that the height should be 5.0 +/- 0.05 mm, while I measure only 4.7 mm. Figuring out how to adjust the height takes quite a while, but finally I am on my way back assembling the thing together.

Power on: this time everything starts playing just great even before I re-adjust the alignment. Final adjustments on the first and the last tracks: great, the eye pattern is now clean and stable, the player works great the right side up, and even turning it upside down does not change anything.

Conclusion: Obviously, the chip I cruelly cut out and replaced, was not guilty at all, but hindsight is always 20/20. The fault in the PCB trace underneath the chip is probably a microscopic one, since I did inspect this part of the board when I removed the old chip and did not find anything unusual.

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Repair Story #6: Sony TV with Power Problems

Author: David Klementovic, Copyright © 1997, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or djk@trsvr.tr.unisys.com.

Editor's note: The following is an excellent example of methodical, logical troubleshooting, taking appropriate precautions, and monitoring behavior leading to a successful diagnosis.

BTW, the gradual deterioration of performance/change in current is a good indication of a component drifting. This is going to most likely be a capacitor - bad solder connections, coils, and transformers don't drift but usually change their characteristics suddenly.

Good work!

My client asked me to repair his 5 year old Sony television which failed to power on. I put it up on the service cart, plugged in the line cord and tried to power it on. I heard a tic-tic-tic sound coming from the switching power supply board F. A quick check of the power supply was done with the ohmmeter but nothing obviously shorted or open.

Then I removed plug F61 from the power supply board, pressed the power on button on the set and the switching power supply began to work, I could hear the audio amplifiers working through the speakers. Something in the television chassis was loading the power supply down. I metered the brown wire on plug F61 (B+ supply) and found it shorted to ground. Then I tested the horizontal output transistor Q503 and it was shorted.

I inspected the flyback and other high voltage components and seeing nothing else shorted replaced Q503 (2SD1941) horizontal output and Q502 (2SC2688-lk) horizontal driver with exact replacements. Now, I know that frequently horizontal output devices are over-stressed by some other defect in the chassis so I prepared for this possibility by removing B+ jumper wire JW-41, inserting a 5.6 ohm 10 watt resistor in its place and clipped my voltmeter leads across the resistor. This gave me the ability to monitor the current being consumed by the flyback transformer.

I powered up the set slowly using a variac and an isolation transformer, the picture was good. I adjusted the variac for 125 volts AC, set the customer picture controls on the Sony to midway, (brightness, sharpness) and the Trinitone to LOW. I tuned to a music video channel on cable in order to observe the raster changing frequently from dark to light, and recorded a voltage drop across my 5.6 ohm resistor of 2.2 volts with a dark raster to 3.98 volts with a white raster.

After 10 minutes of operation, the voltage across the resistor began to climb even though the raster was fairly dark at the time. At 5 volts the right side of the raster began to shrink, and after about the loss of 3 inches of raster from the right side I powered the set off, alas there was more trouble in this set for me to debug. I inspected for problems with the scan-derived B+ voltages, pin cushion correction circuitry, deflection yolk and retrace tuning capacitor, nothing found defective! The trouble- shooting breakthrough came when I replaced a 0.47 mfd electrolytic capacitor (C525) which coupled the horizontal drive signal into the base of the horizontal driver transistor and C537, a 4.7 mfd electrolytic capacitor in the horizontal driver circuits. These two capacitors had weak- ened and had resulted in the eventual failure of the horizontal output transistor. I checked the horizontal waveform on the base of the horizontal output transistor and it looked OK. So I removed the 5.6 ohm resistor, soldered B+ jumper JW41 back in the circuit and tested the set for 6 hours.

The Sony worked fine and has continued to work for my client for 3 months now. Thank you for listening.

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Repair Story #7: Beware the Nasty High Voltage!!

Author: Zapper, Copyright © 1997, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or zap@mhv.net.

I had to replace all three crt's in a mag projection TV. The "new" crt's were rebuilts. I usually do the blue and green first. Remove one, drain it, new crt, fill, reinstall,, fire up the set and "rough-in" the alignment, then move on to the green...do all the same then the red last. Yeah I know, should do the green last, but I have had both blue and green out before to change the fluid so red was really my reference....

so anyway.... I the green jug is in and the sets fired up... I reach up to grab the yoke to position it and WHAM-SNAP I get bit by HV. right from the anode cup... Not just one snap mind you, but snapa-snapa-snapa-snapa !!!!

Shit, I have done this the same way for years....Well you never know when its gonna getcha, heheheheheheh

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Repair Story #8: The School of Hard Knocks!!

Author: A. R. Duell, Copyright © 1997, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or ard12@eng.cam.ac.uk.

The only way to learn is to make mistakes. I've been learning electronics for over 25 years now (!), and I still make mistakes. I fact, the last mistake I made when repairing something was last night - I unsoldered and replaced a 40 pin chip in a Tektronix computer before realising the fault was simply bad keyboard contacts (!).

Of course, as my skills have progressed, I make fewer mistakes that cause more damage to the equipment. I learned years ago never to overrate a fuse unless there were _very_ good reasons, and I learned somewhat more recently that it was a good idea to test a PSU into a dummy load before connecting the rest of the machine. I learned both those things the hard way. If I'd simply read them, I'd probably still be making the same mistakes.

People who are learning often make things a lot worse. I think most regulars here will agree with that. But that doesn't mean they shouldn't learn. Yes, it does mean they shouldn't (IMHO) 'be helpful' and try to fix other people's stuff for money. What they should do instead is obtain old stuff that would be thrown out anyway (and there's a heck of a lot of it about), and have a go at fixing it. If you make it worse, you've not lost much (and you've probably added a lot of spares to the junk box, and learned what not to do next time), and if you fix it, well, you've learned something as well, and got a working whatever.

I have lost count of the perfectly repairable VCR's and Stereos that I've written off because of secondary damage caused by well-meaning 'buddies'.

The worst one of those I ever saw was a Solartron DMM. The real fault was simply bad contacts on the switch-bank, but the idiot who had it before me had randomly replaced FETs with bipolar transistors ('the old ones didn't test right'), zeners and constant-current diodes with 1N4148s, etc. The result was that the _very_ expensive custom chip had died. Yes, it was worth repairing, but only just.

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Repair Story #9: Chris's HeNe Laser Adventure

Author: Chris Chagaris and Samuel M. Goldwasser, Copyright © 1997, All Rights Reserved.
Comments or Suggestions to: Sam or pyro@grolen.com.

This is a on-going project on finding information and restoring a strange HeNe laser acquired by: Chris Chagaris (pyro@grolen.com). Research to determine the specifications and requirements involved postings to sci.optics, email correspondence, and a bit of luck - seeing a photograph of the mysterious laser in a book on holography.

Here is the original description (slightly reformatted):

(From: Chris Chagaris (pyro@grolen.com).)

I have recently acquired what I have been told is a 35 mW Helium Neon laser head. However, it is unlike anything I have ever seen before. (See the diagram, below.)

```
                Capillary tube/external starting electrodes

   Starting pulse  o-------+----------------------+
                         _|_                    _|_
    ||     //===================================================\\     ||
    ||   //=====. .==================. .=================. .=====\\   ||
                |||                  | |                 |||
  Mirror        '|'  25K             | |           25K   '|'        Mirror
         Anode 1 +---/\/\---o +HV    | |   +HV o---/\/\---+ Anode 2
                      .---------------' '--------------.
                   ---|-+                            +-|---
                      |  ) Main                Spare (  |
                   ---|-+                            +-|---
                      '---------------------------------'

              Gas reservoir with heated cathodes and getters
```

Jodon Laser Head shows the construction in more detail.

- It has no external markings except for "CAUTION LASER LIGHT" on one end and "DANGER HIGH VOLTAGE" on the other end.
- The exterior is a grayish/green rectangular metal box 4" x 4" x 32" long with a ventilated top and bottom. It has four adjustable metal feet on the bottom and a 1-3/8" dia. x 7/8" long silver bezel on the output end.
- The resonator tube itself consists of a 2 mm I.D. capillary tube approximately 27" long (with about 12 wiggler magnets along the axis).
- Attached in the center is a glass reservoir that is 30 mm in diameter and about 13 inches long mounted underneath.
- This large glass tube has what are some sort of filaments at each end with four electrodes on each. Only one side is connected to the input power wires (black and green) using only two of the electrodes.
- The only other markings are on this reservoir, and from what I can make out are "SM-7225-2 HN-7175 10-15-6".
- A white input wire (anode?) runs to ballast resistors (25K) connected to electrodes near each end of the capillary tube.
- A red input wire is connected to what looks like some sort of trigger transformer - one inch in diameter by 1-1/4 inches long with a 2-1/2" long x 3/8" core in the center (ferrite?).
- The other two input terminals of this transformer are connected to the black input wire which is also grounded to the case.
- The output of the trigger transformer is connected to two fuse clips externally attached 4-1/2 inches from each end of the capillary tube. There is about 300 ohms resistance between the input and output of this device.

Here is one reply Chris received by email from someone else named Marco. As you will see, this turns out to be a dead end.

(From: Marco.)

> "Hi Chris,
>
> This seems to be a really old one, or from other location than west Europe, Japan, and the USA.
> The 'SM' could be an abbreviation for Siemens, they had manufactured lasers from 1966 to
> 1993; until last year Zeiss/Jena has taken over the production; and since 1997 Lasos has

overtaken the production by a kind of management buy-out. You can send them the number, it will be possible that they know it. Contact Dr. Ledig. I will also look around if I can help you further.

HeNe lasers with a heated filament are no longer built. To see if it still runs you can attach a 3.3 V supply to the filament and see if it glows red, not more, to much heat will destroy it. You could use transformers from tube amplifiers for the filament and an old HeNe laser power supply for the anode.

This laser will need around 5,000 V and 10 mA I think. If you could only get a smaller power supply, you may not see any laser beam, but you can see if it will trigger."

(From: Sam.)

Here are my 'guesses' about this device. (I have also had email discussions with Chris.)

I agree with much of what Marco had said.

- This IS likely quite old. Unlike modern HeNe lasers, it uses a heated cathode instead of the common aluminum 'can' cold cathode. Perhaps the last number is a date code: 10-15-6. The '6' could either be the first part of a date that is rubbed off (e.g., '68) or the last digit ('66, '76). It is almost certainly before the mid seventies as HeNe tubes I have seen from that era were very similar to modern ones in construction.

- I expect the anode voltage (on the white wire) to be in the 2 kV to 3 kV range. Based on the diagram, the actual discharge length is about 12 to 14 inches in two sections, not the entire length of the capillary tube. The current may be higher than a modern tube because the bore is wider (2 mm). Perhaps, 10 to 15 mA for each section (20 to 30 mA total).

- With the wide bore, it may be multimode, not TEM00.

- A microwave oven transformer would be ideal for the main supply if it were not so dangerous. And it IS - don't be tempted. A voltage doubled boosted tube type TV power transformer should be able to provide 1,000 VAC resulting 2,800 V DC - this may be enough. At the expected current, an inverter might be tricky (at least for testing) as up to 100 W may be required.

- The trigger transformer probably operates like one for a large photoflash or flash lamp pumped laser. I would guess discharging a capacitor of a few uF at several hundred volts into it will work. However, if I were building the power supply, I might just ignore the trigger transformer and use a more conventional approach - a voltage multiplier or HV inverter. One less unknown to worry about. However, each of the two anodes would need to have its own feed from the starter.

- With too small a power supply, there would likely be at least a flash of laser light at the instant that the discharge was initiated - if the tube is still functional. This would occur even if the power supply was inadequate to sustain the discharge.

- I would power the filament from a low voltage transformer using a Variac and, as noted, not push it!

Unfortunately, Chris has determined that regassing will be required and he is equipped to do this but there will be some delay in the results.....

(From Chris (a few months later).)

Well, tonight while looking through the "Holography Handbook" I spied what looked suspiciously like that elusive laser I have. It said it was made by Jodon Engineering Associates of Ann Arbor, MI. I immediately called them and was fortunate to have the engineer (Bruce) who has built their tubes for the last 18 years answer the phone. I told him of my plight and read off the numbers that were on the plasma tube. Sure enough, it was one of their early lasers. They have been manufacturing HeNe's since 1963. He provided me with many of the details that I had been searching for.

- The laser is rated at 15 to 25 mW output.

- The capillary tube is 2 mm in diameter.

- The heated cathode requires 6.3 volts at 2.05 amps, (and, there are two sets, one is the spare), the getter assembly (a spare here too) can be fired using a variable supply rated at 6 VDC @ 10 amps.

- He wasn't sure about the operating voltage but assured me that my variable 4,000 volt supply would be more than sufficient. The current requirements are 9 to 11 mA on each leg (two anodes).

- The optimal fill pressure with a 7:1 mix should be 1.85 torr.

- He also explained the reason for the wiggler magnets along the capillary tube. These are used to suppress the 3.39 um line which competes with the 632.8 nm line and can rob up to 25% of its power.

I explained that I planned on trying to re-gas this antique and he offered to help with what ever information I needed. It is truly refreshing to find someone in the industry that is willing to help the amateur without an eye on just making a profit.

I finally located a small supply of HeNe gas, just yesterday. While visiting North Country Scientific to purchase a pair of neon sign electrodes (in Pyrex), I mentioned my need for a small amount of laser gas for my laser refurbishing project. (This was formally Henry Prescott's small company that supplied all the hard to find components for the Scientific American laser projects.) Lo and behold, there on a shelf, covered with dust, were a few of the original (1964?) 1.5 liter glass flasks filled with the 7:1 He/Ne gas mix. He let them go at a very decent price!

(Hopefully, those tiny weeny slippery He atoms have not leaked out! --- sam)

Now, about the magnets:

The magnets are of rectangular shape, one inch long, 3/4 inch in width and 3/8 inch thick. There are a total of 26 magnets placed flat against the top (14) and flat against the bottom (12) of the plasma tube as viewed from the side. All but the ones on the very ends of the plasma tube are attached exactly opposite from one another, top and bottom. (See Jodon Laser Head for placement and field orientation).

They are placed with the long side (1") parallel to the plasma tube with the north and south poles along this axis.

They appear to be of ceramic construction and not very powerful. Sorry, I don't have any means of measuring the actual field strength.

The current status of this project is that the laser needs to be regassed. Chris is equipped to do this and has acquired the needed HeNe gas mixture.

To be continued....

Photos of a similar but much larger Jodon HeNe laser (3.39 um IR in this case) can be found in the Laser Equipment Gallery (Version 1.41 or higher) under "Jodon Helium-Neon Lasers".

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Repair Story #10: Paul's Sony 27XBR15 Saga

Author: Paul Grohe, Copyright © 1997, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or rohe@galaxy.nsc.com.

Prolog:

Date: Thu, 20 Nov 1997.

Hi All,

Sony experts...help!! I'm puzzled! Any hints???

The details:

This is a circa 1990 27" Sony with dual-tuner PIP, "ANU-1" chassis (same basic "guts" as the non-PIP 27XBR10's).

Last weekend I was flippin` channels when the screen just went blank between flips. The set seems to be functioning completely normally..except no picture! Tuner works, sound okay, PIP seems functional, video inputs switch, high-voltage okay, filament lit, remote works, "sleep" lamp is off and I could hear the H & V scan change as the channels changed.

Wrestling the set up on to the bench, I narrowed down the "bottleneck" to the Y/C/J "Jungle" chip.

After convincing myself that the chip was bad, I ordered another one ($30!). To make a short story longer....It did not help.

The suspect was the 48 pin "IC301" (CXA1313S) Jungle chip on the main "A" board. The chip contains the H & V stripper circuits as well as all the digitally adjusted Y/C to RGB conversion and switching circuitry. The RGB outputs of the chip then go directly to the neck board drivers.

There are three video inputs to the chip, the Y/C input, the RGB input for the OSD and another "ext" RGB input for the PIP circuitry. I can see correct tuner/aux video signals at the Y/C input pins, and good OSD and PIP video RGB signals. However, the RGB output pins just show a positive going ~50uSec pulse. No "video" at all.

The problem is that all the usual video "adjustments" are performed by multiple D/A's in the chip. There are no coils or pots to adjust.

The sync sections of IC301 seem to work, as I can see it "lock" as a video signal is applied. All the sync signals are there and look okay. Voltages and waveforms around the Sync and Video *inputs* of the chip are very close to what the manual shows.

The neck board and CRT seems okay, as applying appropriate voltages *directly* to the neck-board inputs results in the expected Red, Green or Blue rasters (with retrace lines). The raster appears at about 3.8V and is full-brightness by about 5.5V. Going too-far trips the X-ray protection (as expected).

The biggest error is the DC level at the chips RGB outputs. The manual claims 3.9VDC. Right now the outputs are 0V with a 3.5V, 50uSec positive going pulse (V-rate). There should be 1.5Vp-p of video signal on these outputs. I am assuming that I should see the video signal between 4 and 5.5V.

The manual claims 2.4V for the "ABL" input, and I measure 2.5V. More discrepancies:

- The "filter" pin #27, measures 0.6V, instead of the 7.8 V claimed (can anyone confirm this? Could it be 0.78 V?).

- The three "AKB-R, G & B" pins should be 6.1 V, but measure 3.9 V.

  I'm getting the feeling that the chip is being "told" to misbehave.

Questions:

- Would there be any failures *anywhere else* that would cause this chip to blank the screen? The protection circuits (X-Ray & ABL) do not seem to be activated and the "Sleep" light is off.

- Is this chip, IC301 (CXA1313), known to fail?

- The "VM" mute lines shows a 7.5mSec, 2.5V "fuzzy" square wave - is this normal??

- EEPROM failure??? All the channel settings are correct.
- Anybody else seen this problem???

Any thoughts appreciated!

Help!!!

Here is update #1

Date: Sat, 22 Nov 1997 09:30:36 GMT

I want to thank everyone who has responded!!

First off; NO, it is not the regulators. Been there, dunnit months ago.. All supply voltages are "normal" and steady.

Alan Harriman sent me a copy of a previous post from "cyberchaos" about "IK Shutdown". It hit the nail-right-on-the-head. There *is* a reason why the chip would shut off the video!

This is a copy of the earlier post by "cyberchaos@aol.com":

-- begin quote --

> "Other than power supply problems, this is the second most common circuit to give people problems on our sets made in the last 5 years. If you have high voltage and vertical deflection (as you indicated) the unit is probably in what we term as 'IK blanking'.
>
> The jungle IC sends a 60us pulse in the vertical blanking area in order to monitor CRT cathode current, thus maintaining white balance. Each color drive output has its own pulse in this area (Red=line 17, Green=line 18, and Blue=line 19. These pulses are them matrixed and returned to the jungle IC to be monitored. If one or more of the pulses does not return (or is very low) the jungle IC will keep the video off. Bad video drivers, weak CRT cathodes or faulty IK pulse return circuits will cause this symptom".
>
> Here's how to find the cause: Even though the video is off, the Jungle IC is sending the pulses to the CRT board. Measure each of the cathodes with a scope. At vertical rate you should see a 60us pulse at each cathode about 20-50 volts in amplitude. What we're looking for is one of the cathodes to either have an extremely large pulse (in comparison to the other two) at about 150 Vp-p or having no pulse at all".
>
> If one cathode has no pulse, troubleshoot the driver circuitry for that color.
>
> If one cathode has a very large pulse, the cathode is weak or the return pulse is not making it back to the Jungle IC. To tell if the CRT is bad, turn up the screen control and see if you get a raster with one of the primary colors missing. It should be the color that you saw the large pulse

on. If the raster is white or is slightly dominant in one of the primary colors, the CRT is probably OK. Troubleshoot the IK return buffer transistor and associated components for that driver.

If all 3 cathodes have a large pulse (150VPP) Then check the following:

1. The IK buffer transistor which is sending the combined pulses out of the CRT board (all three must be present here and at least 700mvpp).

2. The screen control is turned too low.

3. G1-G2 short or leakage. this will be evident by G2 voltage dropping drastically while the CRT board is mounted on the tube and raising when removed."

-- end quote --

It looks like this is what is happening, but it is the result of another odd problem on the neck board.

The green cathode shows a "normal" pulse, but the red and blue show a strange 11 cycle pulse train where the "IK" pulse should be.

Cathode waveforms:

"Good" green cathode:

```
----+    <- 60uSec ->   +------------- 200V
    |                   |
    |                   |
    |                   |
    |___________________|           ___80V


______________________________________ 0V
```

The red and blue cathodes show a really "weird" pulse train during their "IK" interval.

```
    |-| 5 uS apart, 1 uS wide.

----|-|-|-|-|-|-|-|-|-|-|------------- 200V
    | | | | | | | | | | |
    | | | | | | | | | | |  (11 pulses)
    | | | | | | | | | | |
    | | | | | | | | | | |           ___80V
```

```
______________________________________ 0V
```

The eleven narrow pulses are triangular, stable, 5uSec apart and 1uSec wide. They roughly occupy the same "area" as the "normal" pulse.

Simplified output stage:

```
        +200V
          o
          |
          /
          \ 8.2K
          /
          |           B     1K
        A +----|>|----+----/\/\-----o To cathode
          |           |
          +----||-----+
          |  680 pF   |
          |         |/ E
          +---------|    PNP
          |         |\ C
        |/ C          |
 9V o---|    NPN      |
        |\ E        __|__
          |         _\_/_
          |           |
        |/ C          |
  In o--| NPN        E \|  (PNP)
        |\ E            |--o gated 173 V
          |          C /|
          o            |
       to 'I'          o
       source    to protection
                 summing node
                  and buffer
```

Here is where it gets weirder.... On the driver transistor collector, there is a "normal" 200-80-200V pulse at point "A". But on the "CRT" side of the diode (point "B"), the "weird" pulse-train appears. The waveforms remain the same even if I isolate the CRT cathodes; so it does not seem "load" dependent.

Removing or bridging the 680pF cap makes only a slight difference. The transistors and diodes look "okay" on a curve tracer.

The IK feedback pulses reflect this "pulse train" waveform. The green interval shows a 0.6Vp-p level, but the "pulse train" shoots up to 3.5V. I can also see the amplitudes rise as the load of the scope probe is applied to the cathode.

Here is an example of feedback waveform at the "IK" pin 25

```
|||||||                                - 3.5V
|||||||
|||||||         | 1.2V "spikes"
|||||||_________|_______               _ 0.6V
                        |
                        |
"R"      "G"      "B"     -------   - 0V
```

I discovered this late last night, so I left it at that, saving the "digging" for later.

Tonight, I was in the middle of tracking down the cause of the "weird" pulses, when I pulled a "bonehead" stunt. I accidentally clipped the scope ground clip onto the 1000V "G2" line, instead of the ground next to it. This stunt blew the 1000V rectifier diode and flameproof resistor. So until I get some new parts, I'm "SOL" for now. Hopefully I can pick some up replacements tomorrow.

So, Stay tuned! (If your %#@%!# TV works!)

Here is update #2

With a quite possible happy ending.

Date: Sun, 30 Nov 1997 01:43:02 GMT

Now that the Holiday Hoopla is over, I had time to take another crack at the set.

I was going nuts trying to track down the source of these funny "pulse trains" in the video circuits. I did not want to call them "oscillations, because the pulses were too regular and did not "vary", as you would expect a feedback-type oscillation to act.

Suspecting "flakey" parts in the neck board, I swapped parts between the "good" channel and the "funny" channels. No difference - no better, no worse. I was stumped!

I then began to suspect the Jungle chip and it's associated parts again. I began swapping/bridging the various components around the chip...again. When I bridged C309, the "AKB-R" capacitor, the strange "pulses" for that channel went away. So I did the same for the other two "AKB" capacitors. When I touched in the last cap, BINGO!, the picture came back on! Yippee!

The three caps (C309,310,311) are 0.1uF film caps hanging off IC301 that are used as integrating capacitors for the "IK" sampling circuit. It seems a little strange that two of the three caps would go "bad", but stranger things have happened!

The removed caps all measure the same on the bridge (C & ESR @ 1kHz). Unfortunately, my "junk" box is out of similar 0.1uF film caps, but I will get some next week. Right now I am using ceramic "bypass" capacitors. I cannot announce "success" quite yet.

So, If you have no video, and see set of thin "pulses" on *any* of the RGB input lines, "IK" line and cathodes, try bridging/replacing C309, C310 and C311.

Hopefully I will be able to button-up this set by next week.

Cheers, Paul Grohe

Date: Mon, 1 Dec 1997 04:31:18 GMT

(Indented text from: Michael Caplan (cy173@freenet.carleton.ca).)

> "As you noted, the three caps are at IC301, in the same area as the video outputs to the RGB. I believe the caps are on pins 19, 21 and 23, and the RGB outputs are pins 20, 22 and 24."

Yep. That's it. The caps are 0.1uF to ground.

> "I am puzzled by the causal relationship -- I wonder how or why the defective capacitors caused the IK pulse at the CRT cathode to be a train of pulses while, as I recall, at the collector of the first video amp on the CFT board the pulse was "normal"."

I believe I was looking at the good, green channel. Subsequent tests showed the pulses on both sides on the blue and red channels. Should have' mentioned that!

The "current detection" circuit outputs are all summed into one junction, and all three video amplifiers share a common current source. It could be feed through.

However, each color is "pulsed" individually, not at the same time, so the "runt" pulses from one color can't simply feed-through to another....strange.

> "Perhaps there is someone more familiar with the SONY IK system who might enlighten us."

Please do! Or, does anyone have a datasheet for the Sony CXA1313S "Jungle" chip?

When I did the initial checkout of the jungle chip, I *did* bridge each cap *individually*. Because I was not aware of the function of the "IK" system at the time, I did not know what to watch for! It finally took bridging ALL THREE caps at the SAME TIME to restore normal operation.

More puzzling to me is why the caps went bad at the same time. Any spike big enough to kill the caps should have killed something else! If IC301 was "zorched", the new one should have worked.

"Sometimes a little "break" and lots of perserverence help."

Or, a more powerful force: "Honey...Isn't the TV fixed YET!?!?!?"

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Repair Story #11: This Throwaway World - a Telephone Tale

Author: Ron Dozier, Copyright © 1997, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or dozier@udel.edu.

Problem: Callers and callies complaining about excessive noise on telephone line.

Diagnosis: Noisy Radio-Shack phone

Possible remedies:

- Buy another phone.
- Fix phone.
- Have phone fixed.

Constraints: Cost, holes in wall accommodating that phone.

Experience buying another Phone:

- Retails for $50.
- On sale for $30, salesman doesn't immediately know that.
- Salesman tries to sell another phone.
- He also tries to sell extended warranty: 3 years $15.

Conclusions about buying another phone.

- Sale - got lucky.
- One year of phone service for $50.
- Three years of phone service for $50+15 (retail prices).
- Buy a schematic - I refer to them as insurance policies $10.

Have phone fixed:

- $35 + parts. Guarantee - unknown

Fix phone myself:

- How does one fix phones?
- Buy a service manual - $10.
- Ah Ha - Good ideas for testing phones, bad component values 10H choke? - Na.
- Buy Xformer 600-600 100 mA DC, LM317THV and 43 ohm resistor,
- Wire as 30 MA current source and add 40 VDC power supply. Neat. $15.00
- Try on passive phone, Observe on scope. Can't blow them up as easy. Works. Touch tones work. Can see dirty contacts, etc.
- Try bad phone. Yea! Great! Noise!
- Use troubleshooting chart - oops - noise not listed as a problem.
- Use brain - determine TEA1062A IC is bad.

Time passes (next day)

- Try to order part from local Radio-Shack. Can't e-mail RS and ask why they don't want me to buy their products.
- Last item I bought only 15 items were available for replacement part on a currently sold item. (mini cassette recorder)
- Went to IC distributor down the street - NO luck.

Internet search:

- Chipdir - Chip made by Phillips, distributed by Marshall.
- Listed at Marshal as not in stock and costs $1.00. $10.50 seems to be added to all orders. Backordered no more than 182 days (so the site tells me).
- Look at data sheet: Radio shack phone missing 100 uF CAP on power supply to blown IC. (Probably missing on purpose: expensive part, makes phone break). More protection is needed for pulse dialing, but you need to order publication X to find out what it is.

So for $30 (sale phone) + $10 (insurance policy a.k.a. service manual) + $15 (testing gizmo) + $12.50 (ordered TEA1062A) + unknown wait, I now have:

Total: $62.50

- New phone that needs a CAP that would void warranty.
- An education in troubleshooting phones without a phone line.
- An old phone that contains all the parts that won't go bad on the new one. (remember I bought an Insurance policy)

All I really needed was:

- A service manual - With the phone would be nice.
- A part that costs $1.00.
- Know how to test a phone.

My nature forces me to puzzle solve. It's fun. It's entertainment. It's frustrating. It's my nature.

It's no wonder why you throw it away.

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Repair Story #12: AIWA Model RX-N373U Mini Stereo Repair Tip and Comments

Author: HA11747ANT and Jerry G., **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or ha11747ant@aol.com or jerryg@total.net.

(From: HA11747ANT (ha11747ant@aol.com).)

Patient: AIWA RX-N373U mini stereo receiver.

Symptoms:

When you turn on the power, the receiver comes on and immediately shuts off, blanking the digital display. After about 10 seconds, the display comes back on flashing "12:00 AM" (if clock was set in receiver). When the display comes back on, pressing power will repeatedly do the same thing over again.

The cause:

I found (after about 3 hours of troubleshooting the power supply and microprocessor) found the main power amp module IC203 (STK-4162II) bad. How I found this was not easy. I finally resorted to jumpering the relay's driver transistor (Q108) between the emitter and collector, energizing the relay, which switches on the main power amp's supply rails. The display went black immediately, and did not come back on until 10 seconds after I removed the jumper. While the relay was energized, I went to the speaker outputs and checked for DC offset, low and behold, the left channel was at the full negative supply rail (-39 volts)! The right channel was OK. I haven't put in a new module (I wont be able to do that until Monday), but hopefully that will repair this receiver. If I went to the module itself and disconnected it's speaker outputs from the main board, the receiver would come on normally.

My Comments:

This one was definitely a strange one. I was rather upset (learned more words to my vocabulary which I won't repeat here), after going for 3 hours to find a bad STK module. What kills me is the rather strange protection circuitry used in this receiver, if there's a fault in the power amp, the damn receiver won't even come on properly to reveal the fault. It kind of pi**es me off to see stupid circuitry designs like this. I thought the Pioneer RX-series "blow line" was stupid, but this one takes the cake. In my 25 years of repairs, I've never seen something as retarded as this. I would have to call it an "overdesigned circuit", yet the simple speaker relay protection I've seen in many units would suffice.

(From: Jerry G. (jerryg@total.net).)

Do you think that if the receiver was allowed to stay on, and the speakers were left connected, they would be destroyed? If the STK chip is putting out DC to its output, this is very dangerous for the speakers!

When I troubleshoot these types of units, I never connect the speakers. I use a sample and hold voltmeter. I get a full DC from the supply for a bit less than a hundred milliseconds if the chip is shorted...

Technics has a few receivers that don't have a protection at all for the DC outside of the chip itself. I have had a few cases where the speakers actually caught fire!!! One model that I had a few cases on was the SA 350 series. I have been told it is know for this!

In fact I have one here at the moment that destroyed a pair of expensive Tanoy speakers. The customer went to the manufacturer and got nowhere with them. They didn't want to know about it! She dumped the receiver on me. I fixed it, but I later on will be adding some very large non-polar coupling caps on the output. This will fix the DC problem if the chip blows again!!! Then the receiver should be safe for speakers if the output chip blows again...

Most of the time these chips blow when the user tends to put the volume too high for the rating of the receiver, and there is some distortion. This makes it run too hot, and will eventually break down. Another problems is when the customer goes and buys 4 ohm speakers for a unit that is designed for 8 ohms only. And, the classic problem that causes breakdown is that people sometimes don't connect the speakers properly. Some of the strands may touch each other, or the wires are not on properly.

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Repair Story #13: JVC 7300U VCR -- Fixed (Almost)! And Adding Remote Control

Author: Joe, Copyright © 1997, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or pichej@shaw.wave.ca.

I'm providing this for anyone else as a few pointers which might help fix a senior VCR :)

Problem #1 -- Tape play would abort in mid stride.

> Closing one of the switches on the bottom would start the machine in playback mode. Tracing the mechanicals back led me to the tape transport motor and belt. If I hand cranked it through, it would complete the cycle. Simple fix.. Replace belts with better ones from my old toasted VCR.

Problem #2 -- No RF out.

I had all the signals in, but no output. I scrapped the old RF converter, and inserted one from an old Sega Master system that half worked. Now RF out worked.

Problem #3 -- No video, from either RF or video in.

Problem traced to a wire that had sheared off of the circuit board. Simple resolder job.

Problem #4 -- Scrambled video out.

Lucky guess. I had an approximate idea were video was being processed because of the last problem. 3 pots were in the area. I found that I could adjust them to get a washed out red hazy picture that was viewable (best). Figuring that my finger would do something to the picture,

I found that putting it across one of the pots improved the picture to perfect state! Then I tried a 1k resistor, same effect. Soldered it on, works pretty well.

If some one would like to explain why it worked, I'd love to hear why!!

Problem #5 -- Uneven record speed.

Replaced a magnetic pickup on the video head with one out of my old JVC VCR. I probably buggered it up when I was tracking down problem #1, with the head spinning, and screws out of the transport.

Sh*t happens :-)

Problem #6 -- No RF in (did work before).

Channel selector flickers on and off, no RF in signal. Probably won't fix it either. I use a cable box to pick stations. (57 channels and nothings on).

Likely a loose wire, broken connector.

Problem #7 -- Won't record.

Records scrambled, and aborts. Like it used to look in #5. If I play back, get a good video signal off of the tape (good picture), then record, it works. Not straight off. Probably one of the pots I screwed with is off. Picture is a bit overly bright.

Project #1 -- Add a remote control to a dinosaur.

I found a radio electronics magazine (Aug 1995) that covers building a remote control unit using a PIC. I think I'd like to add this to the VCR. Use the IR remote control and module from my old VCR, and add remote play, stop, fast forward, rewind, pause, and record. A latch, and a transistor or two, and it might be real practical :-).

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Repair Story #14: Quasar VCR Problems and Service Center

Author: The Tooth Wrath, **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or nelsonr1@means.net.

This is my mother's VCR, a Quasar VH400.

I took it to Zap-City (true name suppressed) TV and Electronics after it started refusing to load tapes. I was quoted a $25 non refundable diagnosis fee, and was told that given the symptoms the repair would likely run $25 in addition to this fee. A few days later, they call my mother and tell her the repair will be $125.

Since I can buy a new VCR for that, she wasn't going to pay that, but I wasn't going to let Zap-City have the VCR for free so I went and picked the carcass back up. I set it on a shelf when I got back home, and it sat there for a couple of months, and then one day I decided to see if I could diagnose and repair it myself.

I can fix most mechanical VCR problems if I can find the trouble, but this had appeared to be a sensor problem, so I had thought it better to leave the repair to a VCR shop, and chose Zap-City, a factory authorized service center for this Quasar VCR.

I thought the repair quote from Zap-City was obscene, and told the joker there that I believed I was at least entitled to a detailed diagnosis for my $25, and he refused. He made some remark about the trouble being in the tape transport was all.

So two months later, when I hauled it out to take another look at it, I suspected I might have made an error in my assessment of the problem being a sensor problem, and I decided to examine the tape transport.

I was thinking I would find a stripped or broken gear somewhere, since the joker at Zap-City had said the problem was in the transport. I figured I could find the problem gear and make a new one with fine sand casting and curable clear plastic epoxy.

The only way I found to move the tape transport from full disengage to full engage was to turn a worm gear by hand. It took 72 turns, which was a pain in the butt. This is one reason I gave up so easy the first time.

Then it hits me, I can hook up a big 6 volt flashlight battery to the tape transport motor, and use that to drive it back and forth so I could do a full gear inspection. Worked pretty well, too. I removed the entire transport and ran it back and forth about 50 times, looking for the problem gear. But all the gears appeared to be working perfectly.

Then I noticed it.... There is a little return spring that carries the tape to the sound head, and it had been bent, (The VCR started acting up immediately after it ate a tape.)

All I had to do was to remove this spring, use a needle nose pliers to bend it to give it more tension. I reassembled the unit, and it has been working perfectly ever since.

Damn, Zap-City wanted $125 to replace a bent return spring, I guess they think their time and 'expertise' are far more valuable then the rest of you normal people's...

Anyway, since I got it back, when it records the sound on playback is really low, pretty near inaudible when an older used tape is used for he recording.

Prerecorded tapes and tapes it made earlier play back at normal volume. The picture and tracking are perfect, and I aligned and centered the sound head.

I notice there is a resistor to the right of the tape transport which has obviously been overheated, to the point where I cannot read the value to be able to replace it. Could this be the problem component? At any rate, I would appreciate it if someone could tell me the value of this resistor, and/or give me any input on what the problem might be.

I would also appreciate it if someone who knows Matsushita's email address would give it to me. I would like to narc on Rite-Way, but I can't find any email links on Matsushita's worthless Web pages.

(From: sam) In all fairness, Zap-City, like you, probably didn't have any idea what the problem was when they issued the quote. They just knew that it wasn't obvious and thus they didn't want to deal with it!

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Repair Story #15: What a Nice VCR

Author: Paul Jones, Copyright © 1998, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or pjones@caltel.com.

A friend gave me a nice VCR.

It had a fried SMPS. I spent $15 on a kit from SK. It didn't have the 82 uF cap which of course had blown its top! I finally got it working even though the test instructions were erroneous.

Fired it up and the video head bearing is really noisy. I went to a bearing house figuring $10 at most. Nooooo! "Yes, we have them at our Tracy, CA warehouse at $38 each", he mumbled something about precision bearings. I said I didn't think the VCR maker had paid that much. They checked some more and said they could get them out of Atlanta, GA for only $7.81 ea plus shipping and gouging. I said thanks and left. I then tore apart a swap meet machine I paid $10 for and lo and behold same bearings. I gently removed them and then installed them in the other machine. No more picture!

Read FAQ (should have before!) I didn't mark position of motor.

Lots of tweaking, finally got it back. Whew! I guess it was worth it....

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Repair Story #16: Now I Wonder Where Those Parts Went?

Author: Charles N. Horton, Copyright © 1998, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or carolus@mit.edu.

Here's one that should be right up your alley, if you can get past my lousy description of the problem. A girl I know wanted me to fix her combination TV/VCR, which had eaten her tape. I agreed, somewhat reluctantly, to open the case. So we managed to get the VCR out (score one for Zenith -- they made the board with the VCR assembly easily removable; whether this is good engineering or cynicism I'm not sure :) and looked at it.

Oh yeah, the symptoms: When plugged in, the machine would power up (sometimes without even needing to be switched on!) for a short time, maybe a few seconds, then turn itself off. The VCR made a rather unhappy sound during that time, as though it were trying to eject the tape. The tape was quite mangled; the heads were away from it and the tape door was closed, but the tape had gotten caught in the door and crumpled.

Secondary goal: fix the VCR. Primary goal: get the _____ tape out :)

Back to the story... So the only thing about the VCR assembly that didn't look fine, aside from the unspeakably cheap Third World construction (one metal piece was attached with TAPE!) was a capacitor. Around the base of this capacitor was some hard white stuff. It looked like it might have come out of the capacitor, although given the general care that went into assembling the VCR I thought it could have been insulation. What do you think? This capacitor was in the general region of the power supply, BTW.

Now, to vent for a moment: This TV reached the ripe old age of 2 years before dying. When we opened the case, there were already 2 pieces free inside it: an anonymous piece of clear plastic, and some sort of little metal piece that had liberated itself from some mechanism. The person across the hall from this girl has a VCR, also two years old, that has stopped recording. I have a Sony tape deck that I've had for a couple years, and one of the two tape bays doesn't work.

We also have a Panasonic VCR circa 1980 that still works fine (no repairs in its 18 years, except one lamp that burns out every few years -- which is user replaceable with a soldering iron), a BiC tape deck from before I was born that works better today than my Sony did when it was *new*, and so on...

From sam:

The white stuff may just be adhesive especially if >it is dry and hard. Though, that glue (when it turns brown) is known to >short stuff out! The little prism thing may be THE problem - part of the tape-in sensor or one of the end sensors. Figure out where it goes and at least some of the VCR problems may be solved. I am waiting for the next installment.....

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Repair Story #17: Where the VCR Saved a Computer Monitor

Author: Paul Millington, Copyright © 1998, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or pm@digitalnebula.com.

Please help!

Problem: Broken VCR circuit board from shock of computer monitor landing on top of VCR while moving electronics in car during rush-hour traffic (sudden stop.) Plus, it is my friends $1400 VCR that I broke. Circuit board broke into 2 pieces. Copper tracers(?) broke. Need to reconnect tracers.

Status: I have etched away all the green stuff, and epoxied the 2 halves together.

Solutions: The only things I have found so far to fix it are "Pretinned solid bus wire", 24-gauge, $1.79 from Radio Shack, or a "Etch your own PC board" kit, $13.99, from Radio Shack also.

Available tools: Radio Shack solder gun, wire strippers, and about $50.

Questions:

- What is the best way to repair it?
- What is the most economical way to repair it?
- How should I do it?
- Is there a good Web site or manual out there that would help me?

(From Sam: After several replies to this plea for help on the newsgroup sci.electronics.repair, we have the following mostly success story.)

Update: May 14, 1998

The VCR is fully functioning again--well almost. The only thing not working is the channel up and down front panel control and also the channel up and down controls through the remote. However, channels can still be selected directly by using the remote to input it, such as "11." Usually the best way anyway. I figure it is just a lose connection somewhere else on another board, but I didn't see anything.

The procedure used in repairing the VCR:

First, the broken circuit board was epoxied together, which ended up looking like it had never been broken. I made sure that when i epoxied it together, that i could still see the traces well. Next came the long, tedious part. In all, i had to make about 25 broken trace jumps. I used #30 wire-wrap from Radio Shack, 0.022 silver bearing solder, Rosin Soldering Paste Flux, and a 15 W solder iron. I probably should have used a magnifying glass too, but didn't have enought money to get one. I just followed the broken traces back on each side of the break to the closest soldered pin (please note i don't know the proper technical definitions) and placed a very small dab of Flux on the point with the end of a paper clip. In most cases, i just re-heated the old solder and placed the wire-wrap end into that, so i hardly used any of the solder i had purchased. This was mainly due to the fact that the pins were so close together that i didn't want to risk shorting anything. Finally, to add strength to the epoxied joint, i cut up one of my old credit cards, and epoxied a small piece to each side of the board.

When i was finished, it kind of looked messy with all the wires, (25 of them or so) going in various directions over the circuit board. I tried to flatten them out as good as possible and then applied some electrical tape over a couple locations to help hold the wire in place. I wouldn't call it a work of art, but at least the VCR is working again. I noticed that the point where the break occurred also had a small plastic support going from the front panel display to the circuit board. I had to break this off (well, i tried to shorten it but is broke) because that was the same place the credit card support was added. I figured that was also a cause for the break in the first place--over 10 years of use, this location probably became weak whenever someone pressed the eject button. And there is no eject button on the remote, so this probably had caused small stress fractures in this area, which eventually broke when the 17" computer monitor landed on it in the car.

All in all, I probably spent 12-15 hours to get to this point. It turned out to be a good decision for me to repair it because it would have cost anywhere from $600-$1500 to replace it (it was a top-end Hitachi from 1988, with digital effects, Picture-in-Picture, S-VHS, Hi-Fi, Level control, and many other hard to find features that most current VCRs don't have.) Not to mention that I probably would have just been playing Jedi Knight with that time anyway. So it was a good learning experience. My friend has his VCR back and is satisfied with its condition, although i would like to get the channel up/down buttons working for him. Boy, am I lucky (or unlucky for breaking it in the first place.) Wish me luck in Saturday's $110,000,000 Powerball.....

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Repair Story #18: The Saga of the Mini-Scope

Author: Stephen J. Conner, Copyright © 1999, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam s.j.conner@strath.ac.uk.

A while ago I was presented with a mini battery-powered scope, an irresistible toy by any accounts. 'For the engineer who has everything'...

Made by a British firm in the Seventies, it had dual traces and 20 MHz bandwidth. The whole thing ran off six 'D' size nickel-cadmium batteries. It had a cute 4" screen and was about 9" by 14" deep by 5" tall. Like most British instruments of that era, all the transistors were in sockets!

The previous owner was a scrounger like myself, and he had given up on it as a bad job. But it was such a dinky piece of equipment it might as well have worn a T-shirt saying 'Please Fix Me.' I made up my mind to do whatever it would take to get the thing working. I didn't know it, but I was in for an epic battle!

Act One

Before getting stuck in I inspected the service manual. (Yes, it came with a service manual.) On one of the schematics pages, a large arrow had been drawn on the EHT tripler, with the helpful legend 'Burning here!' Further down the margin was a note; 'Replacement EHT unit costs 75 pounds!' Uh-oh! (US readers; 1 pound = about 1.5 dollars)

Opening the scope, I was greeted with a grisly sight. A square inch of insulation on the EHT multiplier had turned into brown bubbly crust, and black streaks were burnt along the EHT lead. Out of a sense of morbid curiosity I attached a bench power supply to the battery terminals and applied power. A miniature lightning storm broke loose inside the scope and the current meter shot up to a silly number of amps. Horrified, I pulled the plug.

This proved that the power supply was healthy, so I decided to continue. I unscrewed the multiplier unit, a potting-resin brick with flying leads, and dangled it as far away from conducting objects as its leads would allow. Then I repeated the experiment.

This time, apart from a bit of crackling as the EHT built up, nothing nasty happened. Actually, nothing happened at all. The thing was obviously live though; the heater was glowing and the multiplier was sizzling away nicely. I turned brightness up as far as it would go; nothing. Consulting the manual, I tweaked the sub-brightness and blanking trimmers on the tube base board. Bingo! A trace! Unfortunately though, it didn't blank during flyback. Nevertheless I was able to verify that the Y amps and timebase were working. Things were looking better by the minute. For the present though, something needed to be done about that EHT unit.

As far as I could tell, the components inside it all seemed to be working. So I decided to repair the insulation. I had vaguely heard of a substance called 'conformal coating', a clear rubbery resin that would withstand high voltages. Perfect! Unfortunately I didn't have any. With the impatience of youth I ransacked the chemical cupboard until I came across a tube of the clear, rubbery sneaker repair compound, Free Sole. Yes! Free Sole looks just like conformal coating, I reasoned, so it must be able to withstand high voltages! Oblivious to the flaw in this logic I applied a generous coating of Free Sole to the destroyed insulation. As I waited for it to cure I pondered how I could check its insulating properties. Maybe if I plugged my brother's hiking boots into a socket...

Next day I re-assembled the scope. The Free Sole had developed a lot of air bubbles and it didn't look good. Would it hold up when the 8,000 volts kicked in? I threw the switch. For a few seconds there was silence. Then a vicious crackling developed. Bummer! I must have got a bad tube of Free Sole. Still it was better than before; the power supply wasn't actually being overloaded. Seizing a roll of electrical tape I wrapped the EHT unit until it was mummified. I still wasn't too confident, but I had heard that oil was a really good insulator. I couldn't fill the scope full of oil, but grease! That would do the trick. Applying a generous coating of Carlube around the damaged area I screwed the EHT unit back in, and the crackling eased off to the occasional tiny click.

Now the EHT was working I could mend the blanking. Using another scope I found that the blanking signal went into a transistor buffer stage... but never came out. The transistor was obviously history. It was near the EHT unit, so it was probably zapped to death. I didn't have an exact equivalent, so I replaced it with a 2N2222. (The service manual mentioned 'high frequency'.) Now the trace unblanked, but only at the beginning of the sweep. Afterwards it faded out.

The blanking was dealt with on the tube base in two ways; a small capacitor fed the start of the unblanking pulse straight to the grid, while the rest of the pulse went down a resistor chain and was amplified up again. This complex coupling was necessary because most of the tube base circuitry sat at an impressive -1,600 volts relative to chassis. Yikes! How would I troubleshoot that? My multimeter could only stand 1,000 volts. But - the display went up to 1,999. Surely, I thought, 1,000 V would be a worst-case value, and the 'average' multimeter could take more. In any case I'd be careful not to apply the test leads to any points more than 1,000 V apart. Suddenly one of my probes slipped... and for a split second the meter showed 1,720 V. Then there was a bit of a bang. Not bad though, the last one exploded at only 750 V when I was working on some tube equipment. From then on I resolved to work on the tube base only when unpowered. (The moral of this is - not all battery-powered equipment is safe to work on!)

Eventually I tracked down the fault to two 0.1% resistors on the tube base which had failed open-circuit. It was the first time I had ever seen that. In a bizarre coincidence, the dead digital multimeter contained exactly the right values of resistor to replace them. They weren't 0.1% but so what, I figured. (I would regret this later.)

Now the scope was ready to go into service. It worked fine for a few days, and then suddenly it began to crackle and the screen flashed. The scumbag had already cost me one multimeter! I gave it a few ill-tempered bashes with Mr. Fist but to no avail. Then the trace disappeared completely.

Opening it revealed that a little piece of metal filings had got into the tube base. Sitting on the chassis, its pointy end stuck out towards the circuit board. This created a lovely spark gap. I only noticed this because it lit up! The transient voltages caused by the sparking had obviously fried something. In disgust I hurled it to the darkest corner of my junk pit.

Act Two

2 years passed, and I finished university. I now had an honours degree in electrical and mechanical engineering! 'That' oscilloscope would not defy me now!

Before I started I made a x100 high-voltage probe for my latest multimeter. Foolishly I used 10M 10% carbon resistors which are non-linear at high voltages. I also modified a scope probe by taping a 4n7 5 kV ceramic capacitor to the end. I then investigated the tube base again.

After a few evenings of exploration I tracked the problem down to the most expensive component on the board... a high voltage, low-power FET. It didn't appear in any of the data books, and with its white ceramic case and gold pins it looked like an antique. The manual said that it 'formed a long-tailed pair with the CRT to regulate supply current' - great. Since the characteristics of a MOSFET and a CRT couldn't possibly match anyway, I wouldn't have to worry about finding the exact equivalent. Picking a device with suitably high breakdown voltage and low leakage I hurtled to my local electronics store.

Back in the workshop I bent the thing into a pretzel shape to get the Gate, Drain and Source leads in the right holes. After a bit of adjustment the blanking worked perfectly. Now, I had to deal with that monstrous collation of Free Sole, electrical tape, grease, and burnt plastic. I ripped it out and took it down to the basement. With a PCB drill and a burr, I machined off all the Free Sole and burnt potting resin. I kept on drilling the resin away until I came across the internal connection for the EHT lead. Then I cut off the lead, chopped out the burnt bit, and soldered it back on. To help it out I stuck a piece of 10,000 volt GTO sleeving (I think it stands for 'Gas Tube, Outdoor') over the lead. I then made a cardboard-and tape pot for it and potted it up again. It looked as good as new!

Firing it up again I was greeted by more sparking, and a flickering screen. My potting job was bombproof, so I suspected something else. Turning all the lights out, I peered into the guts. Now this scope had an unusual EHT lead arrangement. Instead of the single captive length of cable ending in a big sucker, it had a cable attached to the EHT unit and another cable coming from the tube. The leads joined in a plastic connector - and blue flashes were coming from deep within! Gotcha! I switched off and, opening the connector, I stuck a screwdriver in to discharge the EHT. Blam! Yikes! Being the suspicious type I waited a minute and did it again. Blam! Yikes! That's dielectric memory for you. The EHT lead to the tube had come adrift inside the connector, and the tube current was having to jump the gap. Soldering it back on I fired up again.

Now a sinister frying noise came from the innards. Apart from this, the scope was fine, but I didn't like it... the noise reminded me of that scene from 'The Taking of Pelham 123' where the bad guy steps on the third rail. By just waving a scope probe near the guts I could pick up spikes of interference from the discharge. Using this method I tracked it down to that plastic connector again. I cut it out, soldered the leads together and ran them through a thick plastic tube which I zip-tied in place. Silence!

The scope is still running, and I now use it as my main oscilloscope. Sometimes when it gets hot the blanking won't work, because of those resistors I put in that weren't 0.1% - but so what. I still love to play with electronics. To save you some hassle, here are the lessons I learnt;

- Free Sole and conformal coating are not the same substance.
- Do not hit things if they don't work.
- Resistors sometimes blow - even if they don't run hot.
- Don't replace close-tolerance components with rotten ones.
- Don't do metalwork and electronics on the same table.
- When you exceed the maximum voltage rating printed on your DMM - it blows up.
- Always discharge HT circuitry twice before touching it.
- Battery-powered equipment can zap you too.

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Repair Story #19: MGC XGA Multisync Color Monitor

Author: Bill Lahr, Copyright © 1999, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or mr.bill@pcmagic.net.

I was given this monitor by a friend. It was a good one, would support 1024x768 which was a far cry from the plain vanilla VGA monitor I was using on my CDROM burner. (It was an old Compaq that was salvaged from a dumpster. A $2 video output IC had fixed it.) When turned on, with no video input, the MGC made a loud noise, kind of a hiss or crackling sound, like frying bacom, coming from the Switchmode Power Supply transformer. The display was also unstable unless the brightness was fully on. If I plugged it into the video port on my notebook, it would quiet down. It was also quiet when plugged into the video card in my CDROM burner, but only if the brightness controls were set as high as possible, and if a light background was on the screen. Bring up a darker page, or lower the brightness, and the hissing noise would reappear and the display would jiggle and show noise in the horizontal.

I suspected a problem in the Switchmode Power Supply, but they can be rather complicated and difficult to track down without a schematic. I subscribe to Electronics Now, and Sam had included a schematic from a "no-name" monitor in an article on the SM power supply. I examined the schematic, and my monitor, and as luck would have it, they were identical!

I took some oscilloscope readings, and with video present, and all signals appeared normal. With no video, there was evidence of ringing (oscillation) in the positive half of the waveform on the drain of the power MOSFET. I checked all the capacitors and diodes in that section of the board, but everything was fine. Next I put the scope on the gate of the MOSFET. With no video, the gate drive signal went crazy. I knew the Pulse Width Modulator IC was okay, because the monitor worked. The DC output voltages were okay when there was video signal, but with no video signal, they increased. The B+ would go from +92 V to +133 V.

I removed each of the electrolytics on the secondary side of the SMPS transformer. All the ones in the higher voltage sections were fine, but when I got to the 6.3 V line, one of the two 470 uF electrolytics, the one nearest the diode rectifier, was bad. Looking at the schematic, I could see what happened.

There is an opto-isolator used to control the Pulse Width Modulator top regulate the output voltages. The DC supply for the LED in it comes from the 6.3V line. Since one of the capacitors was open, some 45 kHz AC ripple was present on the LED. This "signal" was passed through the opto-isolator to the PWM, which in turn amplified it and fed it to the gate of the MOSFET. The MOSFET generated noise in the transformer, which passed even more of it to the 6.3V line, eventually making its way back to the PWM until the SMPS transformer was nearly saturated. I replaced the bad 470 uF capacitor and the monitor works perfectly again.

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Repair Story #20: Saved from the Deep Six

Author: Bill Lahr, Copyright © 1999, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or mr.bill@pcmagic.net.

A friend of mine, who lives on a small boat, noticed the new owner of the boat next to his putting boxes of "junk" on the dock. He struck up a conversation and was told the "junk" was on its way to the dumpster. My friend asked if he could have it for me, since he knew I like to repair electronic equipment, or scrap it for parts. There was no objection, so he showed up at my door with a large, wet cardboard box. Inside was an

RCA VCR that didn't work. It was a fairly expensive one, where half of it slid out and could be powered by a battery pack for use with a camera as a camcorder. Somebody had spilled varnish on it and the buttons were stuck on the front panel. I took it all apart, cleaned it up, replaced one drive belt, and it worked.

In the bottom of the cardboard box was a rectangular box made from metal. It was brown and disgusting looking, and was wet from being left out in the rain. I didn't know what it was, but noticed an embossed area near the bottom that said "IBM" followed by a number. I examined it and noticed a handle on one end. There were two small buttons on the sides near the handle end, so I pushed them and the front section of the case lifted up to expose an LCD display, two 3.5" floppy disk drives, and a keyboard! It said "IBM PC Convertible." It was a notebook computer!

It was in sad shape, and I poured seven ounces of water out of it. Most people would have given up at that point, but I wanted to see if I could fix it. It took a few minutes to figure out how to take it apart. The battery pack was no good, but was composed of 8 nicad "C" cells, so I knew I could rebuild it if necessary. The keyboard lifted out, and I could unplug the ribbon cable. The LCD panel lifted out of a socket. Two screws held each of the disk drives in place, so I removed them and pulled the drives out. Once they were free, I was able to lift the rear portion of the case to expose the motherboard and three smaller cards. I unplugged the boards, then removed the stiff paper insulator under them. I dried the keyboard, circuit boards, disk drives and case with a heat gun. One of the drives was frozen, so figuring I had nothing to lose, I squirted some WD-40 in it and worked the motor back and forth by hand until it loosened up. When everything was dry, I put it all back in the case and plugged in the display.

There was an IBM power supply in the cardboard box. It was wet, but looked okay. It plugged into a socket on one side of the computer case. I noticed a red button next to it and pushed it, but it didn't make any noise so didn't think anything happened, until I looked at the LCD display. There was a drawing of the computer showing a floppy disk moving toward the left hand drive! It worked! It was waiting for me to put in a disk with the operating system!

The next step was to make a boot disk for it. Since the CPU was an 80C88, I knew the drive would have to be only 720K. Luckily my main computer at that time was a 486-100 running DOS 6.22 and Windows for Workgroups 3.112E I had a few spare low density floppy disks, so I made a boot disk with 6.22 to try it. The notebook booted right up, no problem. Knowing that the kernel for 6.22 is larger than DOS 3.3, I dragged out an old 5.25" floppy with the older OS on it. I popped in the boot disk with 6.22 on it and turned off the attributes for the three boot files. Then, I copied the three boot files from the 5.25" disk to the 3.5" floppy. Finally, I ran Norton Speedisk on the 3.5" floppy to remove any blank spaces between the files. Put the 3.5" disk into the notebook and it booted up perfectly in DOS 3.3. (This little trick for creating boot disks comes in handy sometimes.) Once I knew it worked, I made a few disk copies and set them aside, then went to work finding software that would run on it. It could not handle much in the way of graphics, but I did find a word processor, some utilities, modem program, database, spreadsheet, etc., that would run from dual floppies.

Since the notebook worked, I invested $20 in some surplus nicad C-cells and rebuilt the battery pack. It would run for 30-45 minutes on a full charge. The keyboard was filthy, so I pulled all the keycaps off and washed them. The mechanical keyboard switches were okay, so I didn't have to remove and clean them. The case was filthy from years of diesel fumes and cigarette smoke, but "409" cleaner, some Q-Tips and a lot of soft rags did a nice job. When I finished it, the case looked almost new. It was hard to believe it even worked, given the condition it was in when I got it. It even had a port adapter and a video adapter, plus a small printer, that snapped onto the back of the computer. I even got a 9" monitor with it, but it was DOA. The printer was no good, all rusty inside and not repairable. The video adapter didn't work either, but the port adapter did. I was able to print with no problem, and the modem port worked with my old ISP, using text mode, so I could use it for e-mail if I needed to. It is only an 8088, so it is really slow, but it works, and makes a neat conversation piece.

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Repair Story #21: About the Caps in Those Panasonic VCR SMPSs

Author: Ray Chandos, Copyright © 1999, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or rchandos@ivc.cc.ca.us.

Re: Repair Brief 97 (See: Sam's Repair Briefs.) I've got you beat!

How about a 1 week repair time to locate the same bad capacitor in a Panasonic PV-4700. After reading your account, just for the pure entertainment value, and studying your reverse-engineered schematic, I thought "this sure sounds familiar" and went back to the bench to review my reverse-engineered schematic, and check the two filter caps on the 5-V (measuring 3.9 V) output. As I had done previously, I applied the LCR meter (B+K digital) across each one and, as previously, measured about 700 uF. Great, I thought. Each cap is 330 uF, and they're in parallel (except for L3, the horizontal element of the pi filter--like a short, right?--in between) so that's about right, if they're both a little high, I thought. Then, for the heck of it, I unsoldered one lead of C16 and found it was low (under 300 uF) and had a high dissipation factor. I next did the same on C15 and found it was completely open! Replaced them and the regulation came back and the VCR ran. Apparently, that inductor drives the LCR meter nuts. I'm guessing it works by measuring reactance, and the inductor had plenty of that.

I had scoped the outputs, but that didn't help me, for some reason. What I saw there was the 5-V output going up all the way to +5 V for a second, at which point the colon on the display would give one blink and one of the motors would whirr, then the 5 would drop down to 3.9 and everything would go dark until you unplug and repeat. The switcher would continue to switch, but the voltages were off, so it was a problem of regulation.

No blown zeners, but a $24 SAMS VCR facts on the way...(VCR-256) If you ever need to borrow it, let me know. When it arrives, I'm going to see what's inside IC2. Unlike the model you sketched out, this one has one of those stick-of-gum type modules between the regulated output voltages and the opto-coupler. But there's inputs to it from both sides of the above pi filter, for some reason. So the filtering must be critical to the regulation, although, again, I didn't see any obvious ripple or hash on the 3.9-V output, although I didn't switch over to AC coupling and crank up the scope sensitivity to look for anything. (I will next time.)

I found two other crappy caps on the hot side and changed them earlier. I'll probably do the kit and change them all, or the @#$% thing will be back in a month.

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Repair Story #22: Uncle Jay Comes Through Again

Author: Jay Vickery, Copyright © 1999, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or jmv@digitalexp.com.

One of my best friends in the world brought over his kids' CD player the other day. A 1990 Pioneer, model PDM630. I gently explained to him that he could get a new one cheap and I'd even go in halves on it and make it an early Christmas gift or something. The only problem was, his kids had given it to him and told him to: "Take it to Uncle Jay. He can fix it, he can fix anything!". I don't know where they got that idea. All I have ever done, was fix their Tvs, Nintendos, VCRs, satellite receiver, hot water heater, pool pump..... Anyway, now I was under the gun.

I put a disk in the single cartridge, upside down, but I caught it. :) The machine loaded the disk, waited a couple of seconds, and unloaded it. Pulled the cover off, looked for obvious problems, didn't see any. Put the disk in again, it loaded, the carriage moved down, but the disk did not spin! AHA!.

Along about then, I remembered the S.E.R FAQ and started digging. I downloaded the entire CD Repair FAQ.

I skimmed the text, found the Pioneer Test Mode part. Great! I entered test mode, loaded the disk, turned on the spindle, ran great. Ok, now we are getting somewhere. Must be a bad switch not telling the machine that the disk is loaded. Nope, all switches check out good. I check a few other things, finally sit back to think about it for a while. Figured I would clean the lens while I was thinking. Removed the four shoulder screws from the rubber grommets, and laid the assembly back.

Looked carefully for the lens. And looked and looked and looked. Finally realized that that round hole in the plastic behind which I could see the "speaker voice coils " was the hole that the lens was supposed to be in.

On the plus side, I can look down through the hole, and see the mirror real well. :)

There's no sign of the lens in the machine, of course, so I'm heading to the Pioneer site to get a number to order a new assembly.

It'll probably cost me more than a new machine, but by God, Uncle Jay will come through again!!

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Repair Story #23: Rob's Experiences

Author: Robert Dvoracek, Copyright © 2000, All Rights Reserved. **Edited by**: Samuel M. Goldwasser

Comments or Suggestions to: Sam or lgtngstk@uti.com.

I have been reading some of the electronic horror stories at your Website and got inspired to relate a few of my own. You could say that I'm a junior technician, being only 18, as a point of interest.

1. My neighbor across the street had heard that I could fix stuff (lawn mowers, cars, electronics, computers, bicycles, doors, fax machines, furnace blowers, halogen lamps, predict weather, etc). So she decided to loan me her brand new TV that had no picture. I immediately took it over to the deck (I was outside) and plugged it in. The picture was compressed into a horizontal line. So, I tried my first line of troubleshooting - hit the damn thing from various angles - and presto, the line would expand to the whole screen and quickly turn back into the horizontal line. I promptly unplugged it and took off the cover. With the nearest ^wooden^ rake handle, I began to prod the mainboard in various places to try and localize the problem. It seemed to be the worst around an inductor or transformer or something near the flyback and HOT, probably the one for the horizontal driver. So, it began to tap the mainboard with the rake handle using much finesse until the picture "stuck". Then I hit it some more until I couldn't get it to screw up again. After zipping it back together I returned it to her. The whole shebang took all of 15 minutes, and she's been enjoying her new TV for several months now. I figure that the transformer or inductor had a loose connection inside and that the arcing from being jarred heated the loose connection until it fused itself back together.

   In short, I fixed a TV with a RAKE HANDLE while simultaneously breaking the all time record for shortest TV repair (arguably).

2. I received a small thermal FAX machine from my stepfather with a paper feed problem. After a few lines, the paper would stop and it would make a ticking sound. After I opened it up, I found the gear for the platen had a missing tooth. Solution - get a new gear? What? Not a chance. It was a manufacturer that I'd never even heard of before and there were no phone numbers on the machine. So the solution - splice in a gear tooth. Anyone out there ever heard of this being done before? Me neither, but here it goes. I had some styrene sheet lying around that I got at a hobby shop. I took the old gear and, using a small file or hacksaw blade, made a notch in it about the width of the styrene sheets as close to dead on center of the missing tooth as I could get. Then, I cut a piece of styrene to fit in the notch that was a little taller than I needed it to be (excess can be filed off) and JB Weld/Krazy Glued it in place. Don't worry if the styrene piece doesn't fit perfectly, because chances are that you screwed up the notch like I did and ended up with a rounded off bottom, just fill in the gap with JB Weld. Reguardless, make sure the piece sticks straight out from the gear hub. After the whole mess dried, I got a really small file and CAREFULLY filed down the new gear tooth as close as possible to the others. To assure of smooth operation, I test fitted the adjacent gear and rolled it over the new tooth and then filed it accordingly until the gears meshed more or less perfectly. After reassembling the FAX machine, needless to say, the thing worked perfectly. If you try this, make sure to use a stronger plastic for higher stress gears, like high density polyethylene (HDPE) or something.

3. THIS ONE'S GOOD!!!!! (the former statement reflects the author's opinion and is in no way intended to sway opinions or other o words) Do NOT read the following if you have a sensitive stomach or just got back from Old Country Buffet or something.

   I found a complete Macintosh Performa 631CD in the garbage, including monitor, keyboard, CDROM, etc (no mouse). Just one problem: The entire thing was full of cat pee! :^() Was I going to let that stop me? Hell no! I know macs suck, but I needed the practice, being a computer technician. Besides, I had a little theory to prove: You can wash a mainboard in soap and water and the thing will still work, as long as you let it dry thoughly. Did it work when I was done? Stay tuned to find out. So, I commenced the dirty deed, making sure to wash my hands !VERY! !WELL! before meals. I started on the case top and all that (you know, those macs are a real pain to take apart). The plastic parts came out smelling like roses, but the metal parts had started to corrode from the action of uric acid. After tedious scrubbing, they came out reasonably clean. The disk drives were pretty much shielded from the cat's vile spray, but the mother board took a direct hit to the processor via the cooling fan. Those Apple engineers put the blasted thing right on top and the cat's aim was true. After removing the mother board, I discovered a puddle in the bottom (I hope you haven't just ate lunch :o). The power supply's heat sink was sitting right in it. Yet another qualm about the mac design: the power supply isn't a separate module like in the ATs. Anyway, to make a long story longer, I carefully washed the heatsink in soap and water, being careful not to wet any transformers or coils that will probably retain the water and short out - why take a chance, they weren't peed on anyway, fortunately.

As for the cooling fan, I basically just drenched it in water numerous times - this is one of the parts that took a direct hit, remember - to make sure and rinse out any pee residue. Okay, okay, on to the good part: mainboard. I pryed out the processor with a screwdriver as there was no zif socket (mac strikes again). I washed the processor twice with soap and water without a care, knowing all processors are hermetically sealed. I then ran the mainboard under a stream of hot running water for about a half hour and soaped it up several times, making sure to get all the little crevices - there are a lot of little crevices. I then let it tumble dry overnight in the clothes dryer (just kidding about the dryer part). The next day (yes, the whole ididerod took two days), I took apart the monitor, which wasn't too bad, and washed the outer shell. I don't know what i'd have done if the monitor board was full of pee. After letting it dry, I commenced reassembling the whole mess (it was quite a mess, it took up the whole bathroom and part of the living room (those darn macs have so many odd parts crammed in there - that's why they're so heavy)). - another big section cut out here - After it was together and after hooking everything up and finding the power switch, yet another annoying thing about macs, it's in the back and feels just like a nearby piece of plastic so you end up pushing on a useless piece of plastic every time you try to turn the thing on, UGH!, I finally arrived at the moment of truth. With its famous elevator music type of startup sound, it came on!!! :-) :-) :-) :-) :-) :-). That is the first and last time that I was happy to see that insidious smilyface icon staring back at me from out of the deralict void (gosh I feel dirty:-). So, to sum up, you can actually wash a computer with soap and water, when you know what you're doing. If anyone else out there has done this before, I have $20 waiting for them.

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Repair Story #24: Sione's Blown VCR

Author: Sione Vaka, Copyright © 2000, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or sione.vaka@ttil.to.

Patient: Emerson VCR model VCR3002A, American system. A friend of mind said he was going to dump the machine and I asked if I can have it.

Background Information: Here in our country, Tonga, (in the South Pacific) our main electricity is 240 VAC, 50 Hz just like New Zealand, Australia, etc. Since there are so many Tongan people in the States they tend to send electronic equipment such as TVs, VCRs, Hifis, and many many more. The bad thing is that they have to be used with a stepdown transformer since USA only uses 110 VAC. This is one of the major causes of equipment failure here in our country is that sometimes people forgot to use the transformer!

Fault Symptom: My friend told me that his wife accidentally plug in the VCR straight to the 240 VAC and smoke coming out from the back of the VCR. The VCR is completely dead.

Testing: Plug in to the mains using step down transformer but completely dead.

I removed the top cover and found the fuse has blown. One leg of the rectifier has been burned. I checked the power transistor with my DMM and confirmed there is permanent short between B-C-E. I also check for open fusable resistors but none of them were bad. Off to the electronic shop and buy one rectifier type S6056 (cost $3.00 = US$1.74) same type as the burned one, a power transistor type (cost $5.00 = US$2.91). I connected up these two components and ready to test. Plug in mains with the top cover off and still the VCR completely dead. Expect for any smoke but none. Turn power off and check the fuse is not blown so as to the rectifier. I measured the power transistor while it is still connected in the circuit board and I come up with something strange. The B-E is shorted. I remove the power transistor out of the circuit and measured again. I found B-E is no longer shorted (high resistance). Now I am confuse If this is normal or not. I emailed Sam and asked for his assistance. He replied with some helpful information saying that normally testing the power transistor in-circuit on VCR SHOULD NOT be shorted. Now I suspected a component in the vicinity of the power transistor is shorted that causes the B-E shorted. I measured a small transistor which drives the base of the power transistor but confirmed to be OK. I finally found out a zener diode just around the power transistor which was shorted. I removed the Zener diode and test and still confirmed to be shorted. While the zener Diode is still out of the circuit board, I checked again the B-E of the power transistor and confirmed now is no longer short. This brings me good luck on this problem. I replaced the Zener diode with an identical one and now ready to test again. Hold my breath, cross my fingers, turn the power on and bingo!! The VCR comes alive.

I connected the VCR to a TV and loaded a tape. Everything was just fine except some adjustments on the audio head and the cleaning of the video head. Now I have a working VCR!

Comments: This is a great experience for me to come across such kind of problem. As I mentioned before this kind of problem is usually happen here in our country due to voltage difference but I am more confident if I meet this kind of problem again.

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Repair Story #25: Alan's First Monitor Repair

Author: Alan Pearson, Copyright © 2001, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or alanp@linux.pearson.uk.

Patient: Mag MX17 in good physical condition.

I am experienced in electronics and repair, but never TVs, monitors etc. I had been away from it for a year or two and got back in with this beautiful monitor. It had been lying round for 2 years because I didn't have a chance to look at properly.

Symptoms:

It lit up its LCD dislay, said no signal, and after 5 secs powered down.

So, first thing to examine was the power supply. I found no -7V. So, I traced the circuit board traces and found an open resistor. Then put a meter on where the -7 V went to and ground and found a short. Further tracing located a shorted transistor, a 2SD799 (Q506) main board.

I replaced it and powered the beast back up. Still the same symptoms. I removed the PS from unit and metered output voltages. Mistake 1: The PS should have been loaded by a light bulb or something. With a light bulb load, the PS was indeed power cycling. This eliminated a short on the main board or something (well mostly). Metered again (Mistake 2: Used a highly inaccurate DMM which read +210V for a +185V source). So, I thought the voltages were very high.

After taking a lot of advice from Bill (MANY THANKS!), I was told to check the 91K resistor in the PS. It was open. Replaced and metered again. Voltage still high. My crap meter! Anyway, days later I dug out my trusty AVO 8 meter, and it gave ACCURATE readings that showed the PS all okay!!

So I put it back together and all I got was a very bright vertical line in middle of screen. Consulted the FAQ (thanks Sam!! big time) and discovered this was due to the horizontal deflection not working. I traced the yokes back from the tube and found a blown transistor, 2SD4924 (Q503). Bill also enlightened me on this and told me to check R514 on the main board as well. Surprise, it was open open! Replaced this and the transistor and checked the other power transistors, and all common faults for this unit. Found Q909 short as well (2SD799) and replaced. Bill many thanks for pointing me at that resistor. Saved me days of heartache.

I reassembled the unit and powered on. Just a very bright white screen. (Well, that's progress, first nothing, then a line, now a white screen. :) --- Sam) At this point it is worth mentioning that this unit had been in for an estimate of repair years earlier, (not by me) and someone else had been inside. So, I turned down main brightness of flyback transformer, and got a picture (not much of one but one). Check all PS voltage again and correct.

It took hours to discover the correct location of about 5 plugs in the unit which the previous tech had put back in the wrong places, and 2 I couldn't remember. When the brightness was turned up, the unit clicked a relay and then said no signal. This turned out to be the brightness was connected to the place for the input selector switch. Then the convergence was messed up, and a lot of other stuff. Eventually figured out the correct connections (I don't have a service manual for this beast) through, logic and common sense.

Then I got a picture. But I had to go and realign every POT on the beast to get the picture right (focus, pincushion, convergence, position, brightness the whole bloody lot).

Now she runs beautifully with one exception: A line was burnt in the middle of the tube, where the horizontal had failed. I only had the unit on for max 10 secs at a time when it was like this (and then only 3 or 4 times), so I conclude it wasn't me. Apart from that I am the happiest man alive ! Successful repair, and I learned a bucket load.

Some recommendations based on my experience:

1. See if some other person has been inside, and if so take NOTHING for granted. Preference would be to get a service manual at this stage. Tell tale signs are resoldered components, wiring not looking routed correctly etc. If someone else was inside, chances are he couldn't fix it, and didn't put it together again correctly or messed it up trying, or the estimate to fix it was too high, and he reassembled it wrong.

2. Mark all cables you remove in some way so you know where they go. Even if the connectors are different. It will save you lots of heartache later on.

3. Mark positions of pots you play with before you play with them.

4. Check all marking printed on the board for help with things like cable location, alignment etc. This is partly how I was able to connect the cables again correctly (to CRT should goto CRT!!).

Anyway, the monitor is working with a small vertical burn only noticeable on white backgrounds, but it is my monitor and I am very happy with it. One of the best 17" monitors I've used.

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Repair Story #26: Keypad Determination

Author: David Forbes, Copyright © 2002, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or dforbes@azstarnet.com.

Patient: GE (Samsung) JES633WN microwave oven with worn keypad.

I just finished replacing my 1995 GE (Samsung) JES633WN microwave oven's keypad. It works now and it didn't cost anything to fix. It did take a few hours, however.

The problem was that the keypad had developed some open traces from rubbing plus water damage. I tried to fix them with Tech-Spray conductive ink and overcoat, but the overcoat ate through the original silver and rendered it unfixable.

So, I called GE to ask the price of a new keypad. $99 including shipping, one week delivery. Ouch. I politely told them where they could put their $3 Mylar keypad with a $96 markup.

Then I got to work replacing the keypad with my own version that's repairable and looks (and works) just like the original. I used a bunch of those low-cost 6 mm square tact switches like you find behind VCR front panel buttons. These were in my junk drawer from 1993, so they were free.

The Samsung model has the PC board mounted a good 3/4" behind the keypad, leaving lots of room to add a thicker keyboard mechanism. I'm glad for that space, as it allowed me to install a piece of perfboard to hold the tact switches. This perfboard is mounted behind the keypad's plastic bezel, spaced from it with 4-40 nuts on the mounting screws that I added. This gives the right switch depth with standard flat-button tact switches.

The first job was to drill holes in the plastic front bezel for the switches. I had already peeled off and separated the halves of the original keypad in my repair attempt. Using the inside piece of the membrane keypad as a guide, I drilled a 7/16" hole in the center of each switch position with a Unibit.

Then I cut a piece of perfboard to size of the keypad and cut away the necessary bits to allow it to fit around the PC board screw bosses. I also cut down the gussets on the screw bosses to make the job go faster. Once the perfboard fit, I installed the tact switches into the perfboard hole grid to fit in the 7/16" bezel holes. Some switches were rotated relative to the others to get the best centering in the big holes (the switch pin pattern is 0.2" x 0.3".)

Next I held the perfboard behind the bezel and drilled a couple #4 mounting holes at top and bottom of the array. I put 4-40x3/8" flathead screws and nuts in these holes to hold the perfboard to the bezel while drilling the other mounting holes. I used a total of ten mounting holes, countersunk into the bezel for the screw heads.

The correct spacing of the tact switches has the tops of their buttons flush with the top surface of the bezel where the touchpad cover sheet goes. If they stick out they will be pressed too easily, and if they are recessed they will be too hard to press. I used one hex nut between bezel and perfboard to get just the right spacing on my keypad. Yours may vary - use washers as needed.

Once I had the perfboard mounted behind the bezel with the switches installed, I wired them up with 24 ga. stranded hookup wire according to the chart so conveniently provided on the oven's built-in service guide stored in an envelope above the cooking chamber. If your oven doesn't have such a chart, just peel apart the keypad and trace out the lines from each key to its outside and inside membrane connector pins.

I replaced the original 13-pin flex connector with two 6-pin Molex KK series connectors that I had on hand. Pin 7 on the keypad flex-cable is tied permanently to pin 13 on my oven, so I added a wire for that job onto the PC board.

Then I stuck the original keypad cover sheet over the switches, installed the controller PC board, plugged in the Molex connectors, put the oven together, tested it and it worked fine. Hooray.

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Repair Story #27: Bogen PA Amplifier - Broken by Design

Author: George R. Gonzalez, Copyright © 2003, All Rights Reserved. **Edited by**: Samuel M. Goldwasser
Comments or Suggestions to: Sam or grg2@comcast.net.

Patient: Bogen tube-type PA amplifier, dead.

Sometimes you wonder how some products ever made it out of the design lab.

Sometimes there's so much wrong, you wonder if the item is a joke.

Someday I may relate the story of the no-name amplifier, but today's story is from a quite respected company, Bogen.

I acquired this Bogen PA amplifier, 50 watts out allegedly, pair of 8417s for output.

Nicely built, heavy-duty transformers.

Nothing works, so I put it on the bench.

I look it over.

The bad news: Output tubes have white getters, don't hold vacuum anymore.

The only visible good news: the pilot light is okay.

I don't have any 8417s, so I go to the computer to look them up. The number doesn't sound familiar.

I look up the tube specs, and whoo-boy, they have a heck of a transconductance, 23,000 micromhos!

I do a Google search, and find several references like "these tubes sometimes run away". Hmmm..... let's be careful...

I go to order some new ones, and no matter where I look, they're pricey-- $50-80 each. I finally find some on eBay for a somewhat reasonable price.

Meanwhile I look over the amp for obvious things wrong.

The cathode current balancing pot doesn't want to turn! It's not rusty, what's going on?

I open up the pot and see something unusual-- it's a wire-wound 30-ohm pot with a the wire wound around a gray plastic form. The form is badly MELTED and DEFORMED. How the ^#!$%!^? Let's see, 30 ohms, maybe takes 5 to 10 watts to melt it this badly, that's----- 400 to 800 milliamps!! No wonder the tubes gave up. I replace the pot.

The tubes apparently ran away to a very high current level. I check the bias circuit, looking for a bad voltage regulator, or a bad bias adjust pot.

No problems there.... there is no bias regulator OR bias adjust pot. Just your basic capacitor stealing a bit of the high-voltage AC and rectifying it, then dropping it down with some fixed resistors.

Hmmm, a pair of the most sensitive tubes ever made, and the designers don't make the bias adjustable! It's set by a couple of resistors, at about -15 volts. Luckily, this is just about right according to the cathode current I measure.

But if the line voltage goes low, so will the bias, and it doesn't take much of a drop to make these tubes conduct like crazy.... I make a mental note to add a Zener, or more appropriate for the era, a neon bulb, to regulate the voltage. And oh yes, I make a mental note to sell any Bogen stock I have.

A week later the tubes arrive, I plug them in, put a 8 ohm resistor and scope on the output, sine wave in. Time for FUN!

I turn up the line voltage slowly--- cathode currents are low and stable, whew. Everything looks good. I turn up the sine wave, and at about 20 watts out, the amp starts some ragged oscillating in the MHz on the sine-wave peaks. In about 5 seconds the tubes start running away! Good thing the Big Red Switch is nearby.

I look at the circuit to see what may have gone wrong with the oscillation-snubbing components. We'll there's nothing wrong with them, because they don't exist. There's NO snubbing resistors, not on grids, screens, cathode, or plates. No roll-off capacitors on the plates either. These are some of the highest gm tubes ever made, and apparently Bogen made NO ATTEMPT to tame the tubes!!

Argghh... I have no idea what the optimum value for grid-snubbers is for this tube, so I wire in a ballpark value, 2.2K. The combination "red red red" is a bit garish, but what the heck, we're somewhat peeved and desperate.

With the grid resistors in place there's no more trace of MHz oscillation at 20 watts. But when I crank it up to near-clipping, the fuzzies reappear and the tubes run away again. This time I'm soo befuddled I don't hit the switch until the cathode current has passed 500 milliamps! Well, at least we know these pricey tubes have plenty of cathode emission, or at least had it.

I think ahead about protecting these tubes in case they ever run away in the future when I'm not watching. The line fuse isn't going to do it, as it hasn't in the past. I ponder the desecrating effect of drilling two 1/2 inch holes to mount a pair of cathode fuse holders. Hmmm, better do it, originality be danged..

There's no easy way to add screen-snubbers without drilling holes and mounting terminal strips, so I look to taming the plates. I add a roughly in the ballpark plate-to-plate taming capacitor, 1,100 pF. Well actually, two 2,200 pF 1 kV capacitors in series. There's lots of voltage up there.

Now there's no oscillation on the peaks, and the tubes don't start any spiraling current death marches. But there's something else- the leading edge of the sine-wave has a big scallop cut out of it. How can this be?

A lot of probing around with scope probes and capacitors reveals nothing interesting. This is the worst of times, when everything looks okay except the output, and nothing you try seems to help.

For lack of anything better to try, I decide to measure the heater voltage.. I know, I know, the 6.3 volts on the heaters can't be far off, and even if it was it wouldn't scallop the sine wave this way, but let's waste 15 seconds anyway. I should use the voltmeter to measure the heater voltage, but I change my mind and use the scope. You see the new test leads on the meter have really hard to squeeze alligator clips, while the Tektronix scope probe is much easier to use. Plus I can use the mental practice of trying to divide the p-p voltage by 3 in my head. So due to pure lazyness, I use the wrong tool for the job. And due to this mistake, all the answers pop out at me!

The scope reveals that the heater voltage has a non-negligible amount of signal on it! I'm really puzzled now, wondering how 500 mV of signal gets into the heater lines, wondering how the designers never noticed this, wondering why I'm getting steamed at the shortcomings of a 45 year old design.

I decide to attack the symptom and put a .22 uF capacitor from heater to ground. The signal disappears from the heater voltage, and the output sine wave now looks perfect! Apparently there was feedback from the output tubes to the preamp tube, back through the heater wires!

What the bellepety-bleep! What the friggity-frig! How did this ever get past the designers? I solder in a 0.47 uF capacitor into the heater circuit. Lots of playing around with various frequencies and levels of sine waves, and I *think* the amplifier is finally stabilized.

(I should try it with some square waves too now that I think of it, but the square wave generator is out in the garage, which is at about 98 degrees, 90% humidity right now.)

So that's it so far. Had to get this off my chest. How could the designers have come out with such a shaky design? I put a nice sedate load on it, and it ran away every time! An expensive-looking amplifier, with many critical components apparently never designed into it.

If anyone has any ideas out there how this could have ever worked right, please contact me.

(From: Sam.)

Note that it's still possible that the modifications described above are just masking a more fundamental problem that is still present since it's likely the PA amplifier provided years of reliable service before being put on a shelf for a few decades. :)

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-- end V1.27 --

VCR Power Supply Hybrid Regulators

Version 1.29

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

Acknowledgements

Much of this list was compiled from entries in the ECG Semiconductor Master Replacement Guide and from

replies to postings on the sci.electronics.repair newsgroup.

Data for a several of the parts (those marked with *) has been generously provided by: Colin M. (colinmc@mail.zynet.co.uk).

> "Note that a number of chips produce the same output voltage at two pins: These outputs are separate. Separate DC inputs are also required. Our thanks to Sanyo Semiconductor (Europe) GmbH for supplying data on these devices and to Eugene Trundle for technical advice.
>
> Original data taken from a reference pulished by Television magazine. Scanned in by Colin McCormick. All errors to be blamed on Logitech Direct OCR software."

Device Pinouts Contributions

This list was compiled from replies to postings on the USENET newsgroup: sci.electronics.repair and will be updated as new requests come in. Contributions are welcome. Please email in a format similar to those listed below. If you provide additional comments, your name and email address will be listed as well.

DISCLAIMER

While every effort has been made to assure that the pinout information in this document is accurate, errors are possible and sometimes the databooks themselves are even in conflict.

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

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Introduction

Scope and Purpose of this Document

This document provides pinouts for some of the common hybrid multiple output voltage regulators used in a large number of VCRs. A good source for this information is the ECG Semiconductor Master Replacement Guide (or the SK/NTE or other similar databooks).

Does My VCR Use a Hybrid Voltage Regulator?

VCRs typically use one of these types of power supplies:

1. Power transformer with linear regulator using 78/79XX parts or discrete components. The power transformer will be large and right near the AC line cord.

2. Power transformer with hybrid regulator like STK5481 or any of its cousins - multioutput with some outputs switched by power on. Again, the power transformer will be large and right near the AC line cord. The regulator will be a black box with multiple pins soldered to a circuit board and will be mounted on a heatsink usually in the vicinity of the power transformer.

3. Small switching power supply. Most common problems: shorted semiconductors, bad capacitors, open fusable resistors. In this case there is usually no large power transformer near the line input but a smaller transformer amidships. See the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies for info on these types of supplies.

4. Combo of the previous (for example, a power transformer feeding a switching supply) - these are less common.

When to Suspect the Regulator

Failure of one or more outputs of the power supply can result in symptoms anywhere from a totally dead VCR to problems in one subsystem such as the tuner or display. Multiple systems failures are a likely indication of a power supply problem as well.

Safe Troubleshooting of Hybrid Regulators

WARNING: Read, understand, and follow the recommendations in the document: Safety Guidelines for High Voltage and/or Line Powered Equipment before attempting any power supply repairs. While most of the devices listed here operate at low voltages, there may be exceptions. And, you may be in the vicinity of exposed line voltage terminals when probing the hybrid's pins.

Testing

First identify a suitable ground for your multimeter. With the VCR unplugged, test for continuity between the ground pin of the regulator and the chassis or a metal shield. Don't use the hybrid's ground pin as clipping anything to it increases the chance of an unfortunate short circuit.

Check the outputs with the VCR both on and off if possible. The on/off should change with the power unless the unswitched output is dead and thus everything is dead.

If any are low or 0, the regulator is most likely bad. Failure of these regulator blocks is a very likely cause where a VCR exhibits multiple system failures. While it is possible for an excessive load to be dragging down the power supply output, failure of the hybrid regulator is a lot more likely.

However, also check the input voltage - typical values are 20 - 30 V DC. Defective rectifier diodes or filter capacitors can result in a low voltage or high ripple input which can result in low, noisy, or unstable outputs.

For erratic problems or those that only occur under certain operating conditions, monitor the outputs on an oscilloscope (a storage scope would be nice) to see if they dip or have any noise on them.

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VCR Hybrid Voltage Regulator Pinouts

STK791

```
VCR Regulator.

(From Ken Koskie (aw345@lafn.org).)

The voltages should be approximately the same in all modes: Off, EE, Play,
and Record.

Pin 1: VI1 6.7 V
Pin 2: VI1 6.7 V
Pin 3: 0.0V
Pin 4: 0.0V
Pin 5: VO  6.8 V
Pin 6: NC
Pin 7: GND
Pin 8: VI2 18.5 V
```

STK5331

```
* Three output series regulator in an eight-pin package:

Pin 1: +5.1 V output
Pin 2: +6.05 V input
Pin 3: Load resistor
Pin 4: Load resistor
Pin 5: +12.3 V output
Pin 6: on/off
Pin 7: +30 V max input
Pin 8: Chassis
```

STK5332

```
VCR Positive Voltage Regulator: 13 V at 1 A, 6.05 V at 1 A, 5.1 V at .5 A.

Pin 1: VO3 +5.1 V
Pin 2: VO2 +6.05 V
Pin 3: VI2
Pin 4: Vb
Pin 5: VO1 +13 V
```

Pin 6: Gnd/SW
Pin 7: VI1
Pin 8: Gnd

STK5333 - ECG7036

VCR Positive Voltage Regulator. 15 V at 1 A, 5.8 V at 1 A, 5.1 V at 1 A, 8 Pin SIP.

Pin 1: GND
Pin 2: VO3 +5.1 V
Pin 3: VO2 +5.8 V
Pin 4: VI2
Pin 5: Vb
Pin 6: VO1 +15 V
Pin 7: SW
Pin 8: VI1

STK5338

* Three output series regulator in an eight-pin package.

Pin 1: Chassis
Pin 2: 5.1 V output
Pin 3: 5.8V output
Pin 4: 30V max. do. input
Pin 5: Load resistor
Pin 6: 12.3V output
Pin 7: On/off switching
Pin 8: 30V max d.c. input

STK5339

* Three-output series regulator in an eight-pin package.

Pin 1: Chassis
Pin 2: +5.1 V output
Pin 3: +5.8 V output
Pin 4: +30 V max input
Pin 5: Load resistor
Pin 6: +12.3 V output
Pin 7: On/off switching
Pin 8: +30 V max input

STK5342 - ECG7035

VCR Positive Voltage Regulator. 12.3 V @ 1A, 6.0 V @ 1A, 5.3 V @ .6 A.

Pin 1: VO3 +5.25 V
Pin 2: VO2 +6.0 V
Pin 3: Vb
Pin 4: Vb
Pin 5: VO1 +12.3 V
Pin 6: Cutoff
Pin 7: VI1
Pin 8: GND

STK5372 - ECG1883

VCR Positive Voltage Regulator. 12.1 V @ .8 A, 12 V @ .8 A, 5.3 V @ 1 A.
8 pin SIP.

Pin 1: VO3 5.3 V (switched)
Pin 2: Cutoff (control input for 12 V output)
Pin 3: VI2 (input for VO3, 10 V typical)
Pin 4: VO2 12 V (switched)
Pin 5: VO1 12.1 V (and input to VO2)
Pin 6: Vb (control for VO1)
Pin 7: VI1 (input for 12 V outputs, 18 V typical)
Pin 8: Gnd

STK5421

* Four-output series regulator in a fifteen-pin package.

Pin 1: +12.3 V output
Pin 2: Load resistor
Pin 3: +12 V output (unswitched)
Pin 4: Decoupling
Pin 5: +30 V max input
Pin 6: Link to pin 5
Pin 7: +30 V max input.
Pin 8: +16 V output (unswitched)
Pin 9: Link to pin 8
Pin 10: +9.55V output
Pin 11: Load resistor
Pin 12: Chassis
Pin 13: On/off switching

Pin 14: Decoupling
Pin 15: Decoupling

STK5422

* Four output series regulator in a fifteen pin package.

Pin 1: +12V output
Pin 2: Load resistor
Pin 3: +12V output
Pin 4: Decoupling
Pin 5: +30 V max input
Pin 6: Link to pin 5
Pin 7: +30 V max input
Pin 8: +13 V output
Pin 9: Link to pin 8
Pin 10: +9.5 V output
Pin 11: Load resistor
Pin 12: Chassis
Pin 13: On/off switching
Pin 14: Decoupling
Pin 15: Decoupling

STK5431

Pin 1: Out 5.1 V
Pin 2: NC
Pin 3: Out 12 V
Pin 4: Ctrk 12 V
Pin 5: In 12 V
Pin 6: In 5 V
Pin 7: In 15 V
Pin 8: In 9.5 V
Pin 9: Out 15 V
Pin 10: Out 9.5 V
Pin 11: Ctrl 9.5 V
Pin 12: Gnd
Pin 13: Ctrl 4 V
Pin 14: Ctrl .6 V
Pin 15: Ctrl 15 V

STK5436 - ECG1876

Pin 1: VO4 +6V
Pin 2: NC
Pin 3: VO3 +12V
Pin 4: Bypass
Pin 5: VI2
Pin 6: VO3 +12V
Pin 7: VI1
Pin 8: VO1 +13V
Pin 9: VO1 +13V
Pin 10: VO2 +9.5V
Pin 11: IB2
Pin 12: GND
Pin 13: On/Off
Pin 14: Bypass
Pin 15 Bypass

STK5441 - ECG1734

VCR Positive Voltage Regulator. 12V @ 2A, 9V @ 1A, 5.5V @ .5A. 15 Pin SIP.

Pin 1: VO3 +5.5 V
Pin 2: NC
Pin 3: NC
Pin 4: NC
Pin 5: NC
Pin 6: VI2
Pin 7: VI1
Pin 8: VO1 +12V
Pin 9: VO1 +12V
Pin 10: VO2 +9V
Pin 11: Bias
Pin 12: GND
Pin 13: Cutoff
Pin 14: Bypass
Pin 15: Ripple Filter

STK5451 - ECG1735

VCR Positive Voltage Regulator.   16V @ 1A, 12V @ 1A, 12V @ 1.5 A, 11.9 V @ 1.5A.

Pin 1: 11.9 V Output 4
Pin 2: Control Volt
Pin 3: DC Input 2
Pin 4: Reference input
Pin 5: 12V Output 3

Pin 6: Reference input
Pin 7: 16V/12V Output 1/2
Pin 8: Reference input
Pin 9: DC input 2
Pin 10: DC input 1
Pin 11: Hi/Lo volt switch
Pin 12: GND
Pin 13: on/off control
Pin 14: Heater switch (??)
Pin 15: Reference input

STK5461 - ECG7027

VCR Positive Voltage Regulator. 12V @ 1A, 12V @ 1A, 5.1V @ .5A. 15 Pin SIP.

Pin 1: VO3 +5.1 V
Pin 2: NC
Pin 3: NC
Pin 4: NC
Pin 5: NC
Pin 6: VI2
Pin 7: VI1
Pin 8: VI1
Pin 9: VO1 +12V
Pin 10: VO2 +12V
Pin 11: IB2
Pin 12: GND
Pin 13: Cutoff VO1
Pin 14: Cutoff VO2
Pin 15: IB1

STK5464 - ECG7023

VCR Positive Voltage Regulator. 12V @ 1A, 12V @ 1A, 5.3V @ 1A. 12 Pin SIP.

Measured input voltages (your mileage may vary): VI1 = 18 V, VI2 = 8.5 V

Pin 1: VO3 +5.3 V
Pin 2: NC
Pin 3: NC
Pin 4: NC
Pin 5: VI2
Pin 6: VI1
Pin 7: VI1
Pin 8: VO2 +12V
Pin 9: VO1 +12V

Pin 10: VO1/VO2 Cutoff
Pin 11: GND
Pin 12: Vb

STK5466 - ECG1821

VCR Positive Voltage Regulator.

Pin 1: VO3 +5.3 V
Pin 2: NC
Pin 3: NC
Pin 4: NC
Pin 5: NC
Pin 6: VI3
Pin 7: VI1 and 2
Pin 8: VI1 and 2
Pin 9: VO2 +12 V
Pin 10: VO1 +12 V
Pin 11: NC
Pin 12: GND
Pin 13: On/off
Pin 14: On/off
Pin 15: Vb (probably around 13-14 V)

STK5467

* Three output series regulator in a twelve pin package.

Pin l: +5.3 V Output
Pin 2: NC
Pin 3: NC
Pin 4: NC
Pin 5: +30 V max input
Pin 6: +30 V max input
Pin 7: Link to pin 6
Pin 8: +12.1 V output
Pin 9: +12.1 V output
Pin 10: Pin 9 output cut off
Pin 11: Chassis
Pin 12: Load resistor

STK5471 - ECG1822

VCR Positive Voltage Regulator. 12 V @ 1.5 A, 12 V @ 1.5 A, 5.3 V @ .5 A.

10 Pin SIPP.

Pin 1: Iout 3 for 5.3 V
Pin 2: Vout 3 control
Pin 3: Iin 3
Pin 4: Iout 2 for 12 V (emitter)
Pin 5: Ib 2 (base)
Pin 6: Iin 2 (collector)
Pin 7: Iout 1 for 12 V (emitter)
Pin 8: Ib 1 (base)
Pin 9: Iin 1 (collector)
Pin 10: GND

It appears as though Pin 1 is the output of an IC regulator for the 5.3 V.
Pin 3 is the Vin - 20 V typ. Pin 2 is some kind of on off control.

Pins 4-6 and 7-9 are the emitter, base, and collector for the two
12 V outputs. These are simple Darlington transistors setup to
drive the outputs in an emitter follower configuration.
Vin typ of 30 V.

Deduced from schematic in ECG.

STK5477 - ECG7034

VCR Positive Voltage Regulator. 12v @ 1A, 12V @ 1A, 5.1V @ 1A.

Pin 1: GND
Pin 2: VI2
Pin 3: N/C
Pin 4: VO3 +5.1V
Pin 5: VO2 +12V
Pin 6: VB
Pin 7: VI1
Pin 8: VO1 +12V
Pin 9: VB
Pin 10: VI1
Pin 11: N/C
Pin 12: GND

STK5481 - ECG1823

Pin 1: Ib3
Pin 2: VI2
Pin 3: VO4 +5.3 V
Pin 4: VO3 +12.1 V

Pin 5: VO3/VO4 ON/OFF
Pin 6: VO2 +12.2 V
Pin 7: Ib2
Pin 8: VI1
Pin 9: VO1 +12.0 V
Pin 10: Ib1
Pin 11: VI1
Pin 12: GND

STK5482

* Four output series regulator in a fifteen pin package.

Pin 1: Chassis
Pin 2: +30 V max input
Pin 3: +5.1 V output
Pin 4: +12 V output
Pin 5: Bias/+12V output switching
Pin 6: +30 V max input
Pin 7: +5.8 V output
Pin 8: Bias/pin 7 output switching
Pin 9: Link to pin 2
Pin 10: Load resistor/pin 7 output switching
Pin 11: +13/+15V output
Pin 12: Pin 11 output switching
Pin 13: Link to pin 6
Pin 14: Pin 11 output switching
Pin 15: Chassis

STK5486 - ECG7038

VCR Positive Voltage Regulator. 13V @ 1A, 12.2V @ 1A, 6V @ 1A, 5.1V @ 1A, 5.1V @ 1A, 15 Pin SIP.

Pin 1: VO5 +5.1 V
Pin 2: NC
Pin 3: VO4 +5.1 V
Pin 4: VI2
Pin 5: NC
Pin 6: VO3 +6 V
Pin 7: VB
Pin 8: VB
Pin 9: VO2 +12.2 V
Pin 10: Cutoff
Pin 11: VI1
Pin 12: VO1 +13 V

```
Pin 13: Cutoff
Pin 14: VI1
Pin 15: GND
```

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-- end V1.30 --

Pinouts for Various Common Chips and Hybrids

Version 2.23b

For contact info, please see the Sci.Electronics.Repair FAQ Email Links Page.

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Preface

Author and Copyright

Author: Samuel M. Goldwasser

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1.This notice is included in its entirety at the beginning.
2.There is no charge except to cover the costs of copying.

Device Pinouts Contributions

This list was compiled from replies to postings on the USENET newsgroup: sci.electronics.repair and will be updated as new requests come in. Contributions are welcome. Please email in a format similar to those listed below. If you provide additional comments, your name and email address will be listed as well.

DISCLAIMER

While every effort has been made to assure that the pinout information in this document is accurate, errors are possible and sometimes the databooks themselves are even in conflict.

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

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Introduction

Scope and Purpose of this Document

This document provides pinouts for some of the common integrated circuits found in audio and video entertainment equipment like TVs, VCRs, and cassette decks and computer monitors. A good source for this information is the ECG Semiconductor Master Replacement Guide (or the SK/NTE or other similar databooks).

Note: the companion document: VCR Power Supply Hybrid Regulators contains similar information for many of the common parts found in VCRs with linear power supplies.

Much more info on most of these parts can be found on the Net via Chipdir and other semiconductor reference pages. See the links in Sam's Neat, Nifty, and Handy Bookmarks. Consumer electronics sites may have some of the hard-to-find datasheets. For example, for Sanyo datasheets (STK), more info can be found at:

> Datadart.com Sanyo Reference Page.

When to Suspect the One of These Chips?

The following are valid reasons for investigating the health of one of these parts:

- Scorch marks, discoloration, melted or bubbling plastic, device split in half, gobs of smoke, 6 foot flames.

- Excessive heat. While some of these chips or hybrids like power amplifiers will run hot, they should not be so hot that an egg would fry instantly.

- Functional fault. Since many of these parts have quite specific tasks to perform, the symptoms should provide some hint as to whether it is possible for the particular device to be at fault. For example, your monitor no longer syncs properly would point to the sync separator.

Safe Troubleshooting

WARNING: Read, understand, and follow the recommendations in the document: Safety Guidelines for High Voltage and/or Line Powered Equipment before attempting any repairs on equipment that operates directly from the wall outlet (not low voltage wall adapter).

Testing

First identify a suitable ground for your multimeter. With the equipment unplugged, test for continuity between the ground pin of the chip or hybrid and the chassis or a metal shield. Don't use the part's ground pin as clipping anything to it increases the chance of an unfortunate short circuit.

First, check for power to the Vcc or Vss (or whatever) pins. A large percentage of failures will be due to lack of power or incorrect voltages. The suspect device may or may not be at fault. In many cases, a fusable resistor has sacrificed itself possibly due to a short in the suspect part or elsewhere (or opened for no good reason).

However, note that the 'typical Vcc' or other supply voltages listed in this document or the device's datasheet may not be what your equipment actually uses. Therefore, a voltage that is moderately different than the one listed for the device may be normal.

Once good power is confirmed, test the inputs and outputs. Obviously, an oscilloscope is generally needed for these.

Where multiple identical devices are present, substitution is usually an acceptable troubleshooting technique but there is some risk involved as faulty circuitry can blow your 'good' part.

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Chips Starting with Numbers

4N33 - ECG3083

```
Opto isolator - Photo Darlington output.

Pin 1: Anode
Pin 2: Cathode
Pin 3: N.C.
Pin 4: Emitter
Pin 5: Collector
Pin 6: Base
```

6N138 - ECG3093

```
Optoisolater with split Darlington output.  Vcc = 18 V max., 8 pin DIP.

Pin 1: NC
Pin 2: LED Anode
```

```
Pin 3: LED Cathode
Pin 4: NC
Pin 5: Gnd/Q2 Emitter
Pin 6: Q2 Collector
Pin 7: Q1 Emitter/Q2 Base
Pin 8: Vcc/PD Anode/Q1 collector.
```

93C66

```
Serial EEPROM.  512 x 8 or 256 x 16 bits.  8 pin DIP.

Pin 1: CS chip select, active high
Pin 2: CLK, serial clock, xfer on positive edge
Pin 3: DI, data in
Pin 4: DO, data out
Pin 5: Vss (ground)
Pin 6: ORG  (x8=vxx or x16=vcc)
Pin 7: NU (not used?) or TEST
Pin 8: Vcc 5 volts for C, other versions (LC) can runs +2 to +6v
```

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A

AN6359 - NTE/ECG1812

```
VCR Servo Interface.  Vcc - 5 V.  20 pin DIP.

Pin 1:  Mode select B
Pin 2:  Gnd
Pin 3:  Mode select C
Pin 4:  Mode select X 1/2
Pin 5:  PAL/NTSC select
Pin 6:  B optput
Pin 7:  A output
Pin 8:  Error input
Pin 9:  Ref input
Pin 10: Amp input
Pin 11: Error output
Pin 12: Rec/Play select
Pin 13: Rec 2/4/6 H select
Pin 14: Mem
Pin 15: FG divide select
Pin 16: PB ctrl input
Pin 17: FG output
Pin 18: Vcc (5V)
Pin 19: FG input
Pin 20: Mode select A
```

AN5515 - ECG1684

```
TV vertical deflection.  Vcc = 24 V typ.  7 pin SIP-HS.

Pin 1: Ground
Pin 2: Output
Pin 3: Vcc for output
Pin 4: Input
Pin 5: Trigger pulse input
Pin 6: Pulse amp out
Pin 7: Vcc
```

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B

BA336

```
Audio Level Sensor, used for a 'skip track' function, 9 pin SIP:

Pin 1: Pulse Width
Pin 2: Sense Timing
Pin 3: Input
Pin 4: NFB
Pin 5: GND
Pin 6: Muting
Pin 7: Noise Filter
Pin 8: Output
Pin 9: Vcc (Min: 4.2V, Max: 12V)
```

BA5115

```
Pin 1: PB level adj
Pin 2: PB output
Pin 3: LP (eq switch)
Pin 4: PB +input
Pin 5: Bias filter
Pin 6: Vcc
Pin 7: Rec output
Pin 8: Rec amp in
Pin 9: Rec/EE control
Pin 10: Mute control
Pin 11: Line output
Pin 12: Ground
Pin 13: ALC level
```

Pin 14: ALC off
Pin 15: ALC att/recv
Pin 16: Line amp in
Pin 17: PB/EE control
Pin 18: Line input

BA6209 - ECG1716

VCR Motor Driver with braking. Vcc max = 18 V, I max = 1.2 A.

Pin 1: GND
Pin 2: Vout 1
Pin 3: Vz1
Pin 4: Vreg
Pin 5: Fin
Pin 6: Rin
Pin 7: Vcc1
Pin 8: Vcc2
Pin 9: Vz2
Pin 10: Vout 2

I would guess that you should be able to monitor Fin and Rin (forward and reverse, I would assume) and determine if the commands are correct. Vout 1 and 2 should probably be opposites of each other for forward (e.g., +,0) and reverse (e.g., 0,+). They would be the same for stop.

I have no idea what the Vzs are or the Vreg.

BA6247

Pin 1: Ground
Pin 2: Motor drive
Pin 3: Motor drive
Pin 4: Logic
Pin 5: Logic
Pin 6: Logic
Pin 7: Vcc 12 V
Pin 8: Voltage divide
Pin 9: Voltage divide
Pin 10: Motor return

BA7001

Audio power amp, single channel.

Pin 1: NC
Pin 2: Control Input
Pin 3: Ground
Pin 4: Output

```
Pin 5: NC
Pin 6: VCC
Pin 7: Input 1
Pin 8: Input 2
```

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C to L

C4558C

```
Dual op-amp.

Pin 1: Out 1
Pin 2: -In 1
Pin 3: +In 1
Pin 4: -Vcc
Pin 5: +In 2
Pin 6: -In 2
Pin 7: Out 2
Pin 8: +Vcc
```

CNY75GB

```
Optoisolator, NPN phototransistor.

Isolation voltage, Vmax = 5300 V, gain = 100, Vcemax = 80 V.

Pin 1: LED K
Pin 2: LED A
Pin 4: Phototransistor E
Pin 5: Phototransistor C
Pin 6: Phototransistor B
```

DS8884

```
High voltage display driver for gas filled tubes.

Pin 1: Current Prog. In
Pin 2: A in
Pin 3: B in
Pin 4: C in
Pin 5: D in
Pin 6: D.pt.
Pin 7: comma in
Pin 8: comma out
```

Pin 9: GND
Pin 10: d.pt out
Pin 11: g out
Pin 12: f out
Pin 13: e out
Pin 14: d out
Pin 15: c out
Pin 16: b out
Pin 17: a out
Pin 18: Vcc

HA12002

Speaker (or spike) protector/voltage/temp/overload IC.

Pin 1: Relay driver
Pin 2: GND
Pin 3: Temp detect
Pin 4: Audio sig. in
Pin 5: AC detect
Pin 6: Overload detect
Pin 7: Bias
Pin 8: Pos feedback

kA2206/LA4183 - ECG1667

Dual AF PO, 2.3 W, 9 V (4.7 W bidge BTL).

Pin 1: BTL out
Pin 2: Out 2
Pin 3: Bootstrap 2
Pin 4,5: Pwr amp GND (tab)
Pin 6: Neg feedback 2
Pin 7: In 2
Pin 8: Decoupling
Pin 9: Preamp GND
Pin 10: In 1
Pin 11: Neg feedback 1
Pin 12,13: Pwr amp GND (tab)
Pin 14: Bootstrap 1
Pin 15: Out 1
Pin 16: Vcc

L200C - ECG1942

Positive adjustable voltage regulator. Output: 3 to 36 V, 2 A.

Pin 1: Input
Pin 2: Limiting

Pin 3: Ground
Pin 4: Reference
Pin 5: Output

LA6324 - ECG987

Quad op-amp.

Pin 1: Out 1
Pin 2: -In 1
Pin 3: +In 1
Pin 4: +V
Pin 5: +In 2
Pin 6: -In 2
Pin 7: Out 2
Pin 8: Out 3
Pin 9: -In 3
Pin 10: +In 3
Pin 11: -V (or GND for some)
Pin 12: +In 4
Pin 13: -In 4
Pin 14: Out 4

LA7823 - ECG1647

TV Horiz/Vert Osc/Driver/Sync Sep/AFC. Vcc 12 V typ, 16 pin DIP.

Pin 1: Flyback pulse in
Pin 2: AFC Out
Pin 3: Horiz Osc In
Pin 4: Horiz Osc Out
Pin 5: Holddown In
Pin 6: Gnd
Pin 7: Vert Drvr Out
Pin 8: Vert Drvr In
Pin 9: Vert Out Center Voltage
Pin 10: Vert Osc
Pin 11: Vert Osc
Pin 12: Sync Sep Out
Pin 13: Vcc - Vert
Pin 14: Video In
Pin 15: Blanking Out
Pin 16: Vcc - Horiz

LA7824 - NTE7123

Sync Deflection Circuit for color TV. Vcc = 12 V typ. 16 pin DIP.

Pin 1: AFC Comparison Sawtooth Wave Input

Pin 2: AFC Output
Pin 3: Time Constant Circuit
Pin 4: Horizontal Output
Pin 5: Holddown Input
Pin 6: Gnd
Pin 7: Vertical Drive Output
Pin 8: Vertical Drive Sawtooth WaveInput

Pin 9: Vertical Output Middle Point Voltage
Pin 10: Time Constant Circuit
Pin 11: Vertical Trigger Output
Pin 12: Horizontal, Vertical Sync Sep Output
Pin 13: Vcc13 (Vertical)
Pin 14: Video Signal Input(Positive)
Pin 15: Composite Blanking Pulse Output
Pin 16: Vcc16 (Horizontal)

LA7831

TV Vertical Deflection, typical Vcc = 24 V.

Pin 1: NC
Pin 2: NC
Pin 3: GND
Pin 4: Vertical output
Pin 5: Vertical output stage Vcc
Pin 6: Input
Pin 7: Osc
Pin 8: 24 V Vcc
Pin 9: Pump up output
Pin 10 NC

LA7836 - SK10085

TV vertical deflection, 13 pin SIP.

Pin 1: +Vcc1
Pin 2: Vert Trig In
Pin 3: Vertical height control
Pin 4: 50/60 Hz Vert size control signal input
Pin 5: Ramp Waveform Generation
Pin 6: AC/DC Feedback Input to Vertical Output Section
Pin 7: Vcc7
Pin 8: Pump Up Output
Pin 9: Vertical Blocking
Pin 10: Gnd
Pin 11: Vertical Output
Pin 12: Power Supply for Vert Out
Pin 13: Ripple filter

(From: Tuck, Ryan (investbanker@webtv.net).)

I did a ton of research myself only to find that if you want to replace an LA7835, LA7835-TV, LA7836, LA7837, or LA7838, you are better off using the LA7838 for any of them or paying more for an ECG7104 or ECG7039 instead of crosswiring a SK10085 (which does work. Philips lists the LA7820 listed as being replaceable by an ECG7084 but I have seen it listed elsewhere as an ECG7840 or another transposition of those last three numbers I can't remember.

LA7837 - ECG7104

```
TV vertical deflection, 13 pin SIP.

Pin 1: +Vcc1 = 12 V typical
Pin 2: Vert Trig In
Pin 3: Time constant
Pin 4: Vertical amp control
Pin 5: Vertical size control input
Pin 6: Ramp waveform generation
Pin 7: Vertical output FB
Pin 8: Vcc8 - 24 V typical
Pin 9: Pump up output
Pin 10: Osc stop
Pin 11: Gnd
Pin 12: Vertical Output
Pin 13: Power Supply for Vert Out
```

(Also see note under LA7836 - SK10085.)

LA7838 - ECG7039

```
TV vertical deflection, Vcc1 = 12 V, Vcc8 = 24 V, 13 pin SIP.

Pin 1: +Vcc1
Pin 2: Vert trigger in
Pin 3: Time constant
Pin 4: Vertical amp control
Pin 5: Vertical size control
Pin 6: Ramp generator
Pin 7: Vert output AC/DC feedback
Pin 8: +Vcc8
Pin 9: Pump-up out
Pin 10: Osc stop
Pin 11: Ground
Pin 12: Vert output
Pin 13: Power supply for vertical out
```

(Also see note under LA7836 - SK10085/A>.)

LA7850 - ECG7086

TV/monitor deflection processor.

Pin 1: Horiz trig in
Pin 2: Phase adj time constant
Pin 3: Sync pulse time constant
Pin 4: FBP trig in
Pin 5: Sawtooth gen cap
Pin 6: Comp volt gen cap
Pin 7: Afc out
Pin 8: Horiz osc time constant
Pin 9: Discharge res
Pin 10: Vcc1
Pin 11: Horiz width set
Pin 12: Horz drive out
Pin 13: X-ray protect in
Pin 14: Ground
Pin 15: Vert drive out
Pin 16: sawtooth gen
Pin 17: Mid point volt control in
Pin 18: Vert osc time constant
Pin 19: Vert trig in
Pin 20: Vcc2

LA7851 - ECG 7062

Vertical Deflection Circuit/Sync/H V Osc/X-ray Prot. Vcc = 12 V. 20 pin DIP.

See LA7850 - ECG7086 for pinout (electrical specs
may differ slightly).

LM325

Dual Regulator, 14 pin dip.

Pin 1: +Boost
Pin 2: NC
Pin 3: +Vin
Pin 4: -Vin
Pin 5: -Current Limit
Pin 6: -Sense
Pin 7: -Vout
Pin 8: -Boost
Pin 9: NC
Pin 10: Reference
Pin 11: GND
Pin 12: NC
Pin 13: +Current Limit
Pin 14: +Sense

LM1881

Sync separator.

```
Pin 1: Composite Sync (out)
Pin 2: Composite Video (in)
Pin 3: VSync (out)
Pin 4: GND
Pin 5: Burst/Back Porch (out)
Pin 6: Reset
Pin 7: Odd/Even (hi/lo) (out)
Pin 8: Vcc
```

Chip Pinouts Table of Contents.

M to P

M51522A

Dual Audio Preamplifier by Mitsubishi Electronics.

```
Pin 1: Input 2
Pin 2: Feedback 2
Pin 3: Output 2
Pin 4: Ground
Pin 5: V+
Pin 6: Output 1
Pin 7: Feedback 1
Pin 8: Input 1
```

M54543L - ECG1628

VCR loading/bi-directional motor driver.

(From: Deon Maree (edm@pixie.co.za) I think the M54544L is the same as the M54543L)

```
Pin 1: Vcc
Pin 2: Driver Vcc
Pin 3: Output 2
Pin 4: Input 1
Pin 5: Ground
Pin 6: Input 2
Pin 7: Output 1
Pin 8: Driver Vcc
Pin 9: Vcc
```

MC34166

```
Switching power regulator.

Pin 1: Voltage Feedback
Pin 2: Switch Output
Pin 3: Gnd - Heatsink
Pin 4: Pwr Input
Pin 5: Compensation
```

NE5044N

```
Programmable 7 channel RC encoder.

Pin 1: IP1
Pin 2: IP2
Pin 3: IP3
Pin 4: IP4
Pin 5: IP5
Pin 6: IP6
Pin 7: IP7
Pin 8: GND
Pin 9: FR RC
Pin 10: OUT RC
Pin 11: SER OP
Pin 12: RANGE
Pin 13: SET RES
Pin 14: MPX CAP
Pin 15: VREG
Pin 16: VCC
```

PA230, PA238 - ECG847

```
Low level audio amp, 12V Vcc, 8 pin package (14 pin DIP outline).

Pin 1: NC
Pin 3: Vcc
Pin 5: Compensation
Pin 7: Output
Pin 8: Gnd
Pin 10: Inverting input
Pin 12: Non inverting input
Pin 14: NC
```

- Back to Chip Pinouts Table of Contents.

S to STK

SAA7321

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

Pin 1: CDR (Right channel Damping capacitor)
Pin 2: DER (Right channel De-emphasis network)
Pin 3: VRefR (Right channel reference)
Pin 4: VssAR (Right channel analogue ground)
Pin 5: VssA (Analogue ground)
Pin 6: VssAL
Pin 7: VRefL
Pin 8: DEL
Pin 9: CDL
Pin 10: INTL (Left channel Integrator output)
Pin 11: VddAL (Left channel +5V)

Pin 12: OALI- (Left channel Op-amp Inverting input)
Pin 13: OALI+ (Left channel Op-amp non-inverting input)
Pin 14: OALO (Left channel Op-amp output)
Pin 15: VddRef (+5V for reference)
Pin 16: VRO (Voltage reference output)
Pin 17: VRC (Voltage referece decoupling capacitor)
Pin 18: Test4
Pin 19: DAO (Serial data output (I2S) from the attenuator/clipper stage)
Pin 20: CLO (Serial bit clock output)
Pin 21: WSO (Word Select output)
Pin 22: Vdd1 (+5V)

Pin 23: Vdd2 (+5V)
Pin 24: Xtal2 (Crystal oscillator connections 11.2896MHz)
Pin 25: Xtal1
Pin 26: Xsys (System clock output from this oscillator)
Pin 27; Vss (ground)
Pin 28: Vss
Pin 29; Test1
Pin 30: WSI (I2S Word Select Input)
Pin 31: CLI (I2S Clock input)
Pin 32: DAI (I2S Data Input)
Pin 33: N/C

Pin 34: DEC (Demphasis control input)
Pin 35: Mute* (Active low mute input)
Pin 36: Att* (When low, attenuate outputs by 12dB)
Pin 37: Test2
Pin 38: tes3
Pin 39: VddA (Analogue +5V)
Pin 40: OARO
Pin 41: OARI+
Pin 42: OARI-
Pin 43: VddAR
Pin 44: INTR

Where signal names are uncommented, look for a similar name with L/R
swapped. It'll be the same signal in the other channel.

I2S input port is 16 bits, 44.1kHz. I2S output port is 4 times oversampled.

STK054 - ECG1028

20 W Audio Amp.

Pin 1 - -Vcc
Pin 2 - Out
Pin 3 - +Vcc
Pin 4 - Bootstrap
Pin 5 - NC
Pin 6 - NC
Pin 7 - FB
Pin 8 - In
Pin 9 - Gnd
Pin 10 - NC

STK082

Audio Power amp, 35 W, Vcc = +/- 30 V typical.

Pin 1: Input
Pin 2: Gnd
Pin 3: Neg FB
Pin 4: Vcc-
Pin 5: Phase
Pin 6: Vcc-
Pin 7: Output
Pin 8: Vcc+
Pin 9: N/C
Pin 10: Vcc+

STK457/STK459 - ECG1330

Dual AF PO, 15 W/channel, Vcc +/- 21 V typical. 16 pin SIP-M

See the section: "STK461/STK463 - ECG1331" for pinout.

STK461/STK463 - ECG1331

Dual AF PO, 25 W/channel, Vcc +/- 23 V typical. 16 pin SIP-M

Pin 1: Chan 1 input
Pin 2: Chan 1 feedback
Pin 3: Gnd
Pin 4: Chan 1 bias

Pin 5: -Vcc
Pin 6: Chan 1 feedback
Pin 7: Chan 1 output
Pin 8: +Vcc
Pin 9: +Vcc
Pin 10: Chan 2 output
Pin 11: Chan 2 feedback
Pin 12: -Vcc
Pin 13: Chan 2 bias
Pin 14: Gnd
Pin 15: Chan 2 feedback
Pin 16: Chan 2 input

STK563F - ECG1732 - RCA #200750

TV +135 V regulator and 4 watt AF output combination in a 12 pin SIP-M case.

Pin 1: Positive DC input
Pin 2: Reg drive
Pin 3: NC
Pin 4: Negative DC input
Pin 5: NC
Pin 6: Reg voltage output
Pin 7: Bootstrap
Pin 8: Bias res
Pin 9: AF output
Pin 10: Bypass
Pin 11: Gnd
Pin 12: AF input

STK0050

AF Power Amp, 50 W, Vcc = 36 V.

Pin 1: Input pos(+)
Pin 2: Vcc neg(-)
Pin 3: Output
Pin 4: NC
Pin 5: NC
Pin 6: NC
Pin 7: NC
Pin 8: Output
Pin 9: Vcc pos(+)
Pin 10: Input neg(-)

STK0050II - ECG1334

Mod AF PO, 60 W (ECG1334), Vcc = +/- 41 V typical, Rl = 8 ohms. 10 pin SIP-M.

(Note: ECG1334 may not be exact mechanical or electrical match but according to ECG should work for applications.)

Pin 1: +Input
Pin 2: -Vcc
Pin 3: Output
Pin 4: Filter Cap
Pin 5: Phase Comp
Pin 6: Phase Comp
Pin 7: Filter Cap
Pin 8: Output
Pin 9: +Vcc
Pin 10: -Input

STK0070 - ECG1322

See the section: "STK0080 - ECG1322". Note: power and maximum Vcc may not be the same as for the STK0080 or ECG1322.

STK0080 - ECG1322

AF PO, 80 W (ECG1322), Vcc = +/- 46 V typical. 10 pin SIP-M.

Pin 1: Input +
Pin 2: Vss -
Pin 3: Output
Pin 4: NC
Pin 5: NC
Pin 6: NC
Pin 7: NC
Pin 8: Output
Pin 9: Vss +
Pin 10: Input -

STK0070II - ECG1335

See the section: "STK0080II - ECG1335". Note: power and maximum Vcc may not be the same as for the STK0080II or ECG1335.

STK0080II - ECG1335

AF PO, 80 W (ECG1335), Vcc = +/- 47 V typical, RL = 8 ohms. 10 pin SIP-M.

Pin 1: Input +
Pin 2: Vss -
Pin 3: Output
Pin 4: Filter cap

Pin 5: Phase comp
Pin 6: Phase comp
Pin 7: Filter cap
Pin 8: Output
Pin 9: Vss +
Pin 10: Input -

STK4044V - ECG1882

AF PO. 100 W, Vcc, +/-51V max. 15 pin SIPP.

Pin 1: Input
Pin 2: NFB (whatever that is)
Pin 3: Substrate
Pin 4: Bias
Pin 5: Bypass
Pin 6: Test Point
Pin 7: I Adjust
Pin 8: Compensation
Pin 9: Emitter Bypass
Pin 10: I Adjust
Pin 11: Compensation
Pin 12: V(-)
Pin 13: Output
Pin 14: V(+)
Pin 15: Bootstrap

STK4101II - ECG1816

Audio Power Amp, 6 W, 8 ohms, Vcc = +/- 13.2 V, 18 pin SIP.

See the section: "STK4171V/STK4181V/STK4191V - ECG1317" for pinout.

STK4131

Dual AF PO, 20W/Ch, Dual Power Supply, Vcc=+/- 23V typ. 18-pin SIP.

Pin 1: Input 2
Pin 2: NFB2
Pin 3: GND 1
Pin 4: Feedback
Pin 5: I Bias 1
Pin 6: Muting
Pin 7: Mute Adjust
Pin 8: Mute T Cap
Pin 9: Power GND 1
Pin 10: Output 1
Pin 11: (+) Vcc
Pin 12: Bootstrap

Pin 13: Output 2
Pin 14: Power GND 2
Pin 15: I Bias 2
Pin 16: GND
Pin 17: NFB 2
Pin 18: Input 2.

STK4131II - ECG1817

Audio Power Amp, 20 W, 8 ohms, Vcc = +/- 22 V, 18 pin SIP.

See the section: "STK4171V/STK4181V/STK4191V - ECG1317" for pinout.

STK4141II/STK4142II - ECG1818

Audio Power Amp, 25 W, 8 ohms, Vcc = +/- 26 V, 18 pin SIP.

See the section: "STK4171V/STK4181V/STK4191V - ECG1317" for pinout.

STK4152II - ECG1819

Audio Power Amp, 30 W, 8 ohms, Vcc = +/- 27.5 V, 18 pin SIP.

See the section: "STK4171V/STK4181V/STK4191V - ECG1317" for pinout.

STK4161II - ECG1315

Audio Power Amp, 35 W, 8 ohms, Vcc = +/- 30 V, 18 pin SIP.

See the section: "STK4171V/STK4181V/STK4191V - ECG1317" for pinout.

STK4171II/STK4181II/STK4191II - ECG1316

Audio Power Amp, 50 W, 8 ohms, Vcc = +/- 35 V, 18 pin SIP.

See the section: "STK4171V/STK4181V/STK4191V - ECG1317" for pinout.

STK4171V/STK4181V/STK4191V - ECG1317

Audio Power Amp, 50 W, 8 ohms, Vcc = +/- 35.5 V, 18 pin SIP.

Pin 1: Left channel input (-)
Pin 2: Left channel input (+)

Pin 3: Compensation
Pin 4: Compensation
Pin 5: Compensation
Pin 6: Muting
Pin 7: Compensation
Pin 8: Compensation
Pin 9: -Vcc
Pin 10: Left channel Output
Pin 11: +Vcc
Pin 12: Bypass
Pin 13: Right channel output
Pin 14: -Vcc
Pin 15: Compensation
Pin 16: Gnd
Pin 17: Right channel input (+)
Pin 18: Right channel input (-)

STK4162II

Dual AF PO, 50 W/Ch, dual power supply. Vcc = +/-52.5V max.

Pin 1: Input 1
Pin 2: NFB 1
Pin 3: Gnd 1
Pin 4: Feedback
Pin 5: Input Bias 1
Pin 6: Mute
Pin 7: Mute Adjust
Pin 8: Mute T Cap
Pin 9: Power Gnd
Pin 10: Output 1
Pin 11: Vcc
Pin 12: Bootstrap
Pin 13: Output 2
Pin 14: Power Gnd 2
Pin 15: Input Bias 2
Pin 16: Gnd 2
Pin 17: NFB 2
Pin 18: Input 2.

STK5633 - ECG1742

130 volt regulator.

Pin 1: DC input (case)
Pin 2: Base
Pin 3: Common
Pin 4: Output

STK6982B - ECG1736

```
Four phase constant current step motor driver.  Vcc: 24 V, Il: 1.5 A typ.
18 pin SIP.

Pin 1: Vcc
Pin 2: Motor A common
Pin 3: Diode
Pin 4: Motor A
Pin 5: Input A
Pin 6: Motor A low
Pin 7: Low Input A
Pin 8: Re1
Pin 9: V ref
Pin 10: Ground
Pin 11: V ref
Pin 12: Re2
Pin 13: Motor B
Pin 14: Input B
Pin 15: Moto B low
Pin 16: Low B Input
Pin 17: Motor B common
Pin 18: Pause
```

- Back to Chip Pinouts Table of Contents.

STR

STR380 - ECG1548

```
Hybrid TV Voltage Regulator, 123 V, 1 A.

See the section: "STR381 - ECG1546" for pinout.
```

STR382 - ECG1553

```
Hybrid TV Voltage Regulator, 127 V, 1 A.

See the section: "STR381 - ECG1546" for pinout.
```

STR381 - ECG1546

```
Hybrid TV Voltage Regulator, 130 V, 1 A.  TO3 3 pin.

Pin 1: +DC Input
Pin 2: Output
```

Pin 3: Common
Pin 4: Base

Bottom view:

```
            Common
            3 o
        4 o       o 2
        Base    Output
```

Case is input - probably about 160 V.
Base is probably nearly the same as output.

STR11006 - ECG7092

Pin 1: V out/sense
Pin 2: Base drive
Pin 3: Input
Pin 4: Ground
Pin 5: Current detect

STR30115 - ECG1896

Hybrid TV Voltage Regulator, 115 V, 1 A. 5 pin SIP.

See the section: "STR30135 - ECG1778" for pinout.

STR30120 - ECG1839

Hybrid TV Voltage Regulator, 120 V, 1 A. 5 pin SIP.

See the section: "STR30135 - ECG1778" for pinout.

STR30123 - ECG1776

Hybrid TV Voltage Regulator, 123 V, 1 A. 5 pin SIP.

See the section: "STR30135 - ECG1778" for pinout.

STR30125 - ECG1897

Hybrid TV Voltage Regulator, 125 V, 1 A. 5 pin SIP.

See the section: "STR30135 - ECG1778" for pinout.

STR30130 - ECG1777

```
Hybrid TV Voltage Regulator, 130 V, 1 A.  5 pin SIP.
```

See the section: "STR30135 - ECG1778" for pinout.

STR30135 - ECG1778

```
Hybrid TV Voltage Regulator, 135 V, 1 A.  5 pin SIP.

Pin 1: Common
Pin 2: Base
Pin 3: +DC Input
Pin 4: Output
Pin 5: NC
```

Note: Pins 3 and 4 are the collector and emitter of the output transistor in a darlington configuration. Pins 2 and 4 are the two base emitter junctions in of the darlington pair.

STR50041A - ECG1894

```
TV Voltage regulator, 41.8 V, 1.1 A.  5 lead formed SIP.

Pin 1: Vout sense
Pin 2: Base drive
Pin 3: Input
Pin 4: Common
Pin 5: Soft start
```

STR51041 - ECG1895

```
TV Voltage regulator, 41.8 V, 1.1 A.  5 lead formed SIP.
```

See the section: "STR54041 - ECG1796" for pinout.

STR53041 - ECG1840

```
TV Voltage regulator, 41.8 V.  5 lead formed SIP.
```

See the section: "STR54041 - ECG1796" for pinout.

STR53043 - ECG1841

TV Voltage regulator, 43 V. 5 lead formed SIP.

See the section: "STR54041 - ECG1796" for pinout.

STR54041 - ECG1796

TV Voltage regulator, 114.5 V. 5 lead formed SIP.

Pin 1: Vout sense
Pin 2: Base drive
Pin 3: Input
Pin 4: Common
Pin 5: Vout control

STR5412

This is a 103 volt regulator typically used in live chassis TV SMPS.

Pin 1: Collector of chopper (NPN)
Pin 2: Base
Pin 3: Ground
Pin 4: Emitter
Pin 5: B+ adjust (if required)

STR58041

Hybrid voltage regulator, output 115 V.

Pin 1: V out sense
Pin 2: Base drive
Pin 3: Input
Pin 4: Common
Pin 5: V out control

STR80145

(From: yonymar@aol.com).

The STR80145 is used in computer monitors. It is called a "Hybrid Auto-Switch Module-Doubler". It allows monitors to operate at 110v or 220v without having to use a selector switch. At 220v AC the IC allows the bridge rectifier to function normally and pass the rectified AC to the filter caps, at 110v AC the bridge rectifier voltage is sent to this IC to be doubled to the equivalent of the 220v operation, automatically. The rest of the circuit operates as if the input were 220v AC.

```
Pin 1: Delay
Pin 2: T1
Pin 3: T2
Pin 4: Gate
Pin 5: Common
```

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T

TA7120

```
Audio Preamp.

Pin 1: Preamp Res
Pin 2: Input
Pin 3: Feedback
Pin 4: Gnd
Pin 5: Bypass
Pin 6: Output
Pin 7: Vcc
```

TA7136AP - ECG1464

```
Audio Preamplifier IC, Vcc = +/- 15v typical, Vg - 92 dB, 7 pin SIP.

Pin 1: Feedback
Pin 2: Input
Pin 3: Feedback
Pin 4: (-)Vcc
Pin 5: Bias
Pin 6: Output
Pin 7: (+)Vcc
```

TA7203 - ECG1154

```
AF Power Output, 2 Channel, 2 W/channel, 14 pin DIP-W, Vcc = 14 V typical:

Pin 1: Decoupling
Pin 2: Decoupling
Pin 3: Ch 2 in
Pin 4: Feedback Ch 2
Pin 5: Phase compensation
Pin 6: Phase compensation
Pin 7: Ch 2 out
Pin 8: Vcc
```

Pin 8: Ch 1 out
Pin 10: Phase compensation
Pin 11: Phase compensation
Pin 12: Feedback Ch 1
Pin 13: Ch 1 in
Pin 14: GND

TA7204 - ECG1153

AF Power Output, 4.2 W, 10 pin SIP HS, Vcc 12.5 V typical.

Pin 1: GND
Pin 2: AF out
Pin 3: Vcc
Pin 4: Bypass
Pin 5: Feedback
Pin 6: Feedback
Pin 7: Bypass
Pin 8: Feedback
Pin 8: Input bypass
Pin 10: AF input

TA7222AP - ECG1278

AF PO 5.8 W. 10 pin SIP-HS.

Pin 1: Vcc
Pin 2: Ripple reject
Pin 3: Muting control
Pin 4: AF signal input
Pin 5: FB filter
Pin 6: Gain adjust
Pin 7: GND
Pin 8: GND
Pin 9: AF output
Pin 10: Bootstrap

TA7267 - ECG7064

VCR loading/Bidirectional motor driver, 1 A. Vcc = 18 V (typical).

I would expect the normal output voltage to be close to whatever you have for Vcc (just a guess).

Pin 1: In 1
Pin 2: In 2
Pin 3: Out 1
Pin 4: Ground
Pin 5: Out 2

Pin 6: Ve
Pin 7: Vcc

TA7291S

Bidirectional motor driver.

Pin 1: In 1
Pin 2: Vcc
Pin 3: Out 2
Pin 4: NC
Pin 5: GND
Pin 6: Vs
Pin 7: Out 1
Pin 8: Vref
Pin 9: In 1

Not sure if the second (or first) In1 is a typo - this is from ECG7043.

TA7313AP - ECG1465

AP PO, .5 W, 8 ohms, Vcc = 6 V (typical), 9 pin SIP.

Pin 1: Hi Freq Comp
Pin 2: Input
Pin 3: Feedback
Pin 4: Hi Freq Comp
Pin 5: GND
Pin 6: Out
Pin 7: Vcc
Pin 8: Bootstrap
Pin 9: Ripple Filter

TA7317P

Speaker protection IC:

Pin 1: Power on-off detection/Over current detection (typical voltage -0.6V)
Pin 2: Direct voltage detection input (Typical voltage 0V)
Pin 3: Gnd
Pin 4: Gnd
Pin 5: Substrate (Typical voltage -0.8V)
Pin 6: Relay drive output/Typical voltage low 0.9v
Pin 7: Gnd
Pin 8: Muting circuit/Typical voltage 2.8v
Pin 9: Regulator input/Typical voltage 2.8v

This IC senses over current or a DC offset on the output to the speakers.
In the event of a offset it will operate a relay to remove any connection

between the amp and speakers so to prevent DC flowing through the speakers and damage them.

TA7559P - ECG778A

Dual op-amp.

Pin 1: Output one
Pin 2: Invert input 1
Pin 3: Noninvert input 1
Pin 4: V neg.
Pin 5: Noninvert input 2
Pin 6: Invert input 2
Pin 7: Output 2
Pin 8: V pos.

TA75902P - ECG987

Quad op-amp.

Pin 1: Out 1
Pin 2: -In 1
Pin 3: +In 1
Pin 4: +Vcc
Pin 5: +In 2
Pin 6: -In 2
Pin 7: Out 2
Pin 8: Out 3
Pin 9: -In 3
Pin 10: +In 3
Pin 11: . (I assume -Vcc or Ground?)
Pin 12: +In 4
Pin 13: -In 4
Pin 14: Out 4

TA8201AK - ECG1832*

* May not be identical mechanical or electrical equivalent but should work in majority of applications (!!).

12 W, AF PO. Vcc = 13.2 V, RL = 4 ohms. 7 pin inline.

Pin 1: Input
Pin 2: NFB
Pin 3: Ripple rejection
Pin 4: Gnd
Pin 5: Out 2
Pin 6: Vcc
Pin 7: Out 1.

TAA611A12 - ECG1113

2.1 W Audio Amp, 15 V Vs max. Rl = 8 ohms. 14 pin DIP.

Pin 1: Bootstrap
Pin 2: NC
Pin 3: Frequency Compensation
Pin 4: Frequency Compensation
Pin 5: Feedback
Pin 6: NC
Pin 7: Input
Pin 8: Ground
Pin 9: NC
Pin 10: Ground
Pin 11: NC
Pin 12: Output
Pin 13: NC
Pin 14: Vs

TAA2761A

Dual op amp.

Pin 1: +In A
Pin 2: -In A
Pin 3: V+
Pin 4: -In B
Pin 5: +In B
Pin 6: Out B
Pin 7: V-
Pin 8: Out A

TC9174P

(From: Kim (103114.1526@compuserve.com).)

Interface IC for I/O Port Extension from Toshiba.

It is used for extension of output of digital tuning system controller LSIs, TC9301AN/ 02AF/ 03AN.

Maximum Ratings (Ta=25 degree C)
Supply Voltage (Vdd) = -0.3 ~ 7.0 V
Input Voltage (Vin) = -0.3 ~ Vdd+0.3 V
Allowable Power Dissipation (Pd) = 600 mW
Output Voltage (Vout) = 20 V

Pin 1: GND   Pin 16: Vdd

Pin 2: Output Port (OP)-1
Pin 3: OP-2
Pin 4: OP-3
Pin 5: OP-4
Pin 6: OP-5
Pin 7: OP-6
Pin 8: OP-7
Pin 15: Strobe Signal Input (STB)
Pin 14: Clock Signal Input (CK)
Pin 13: Serial Data Input (SI)
Pin 12: Serial Data Output (SO)
Pin 11: OP-10
Pin 10: OP-9
Pin 9: OP-8

TDA1170 - ECG1289

TV Vertical deflection system IC.

Pin 1: Ramp Out
Pin 2: Vcc
Pin 3: Flyback

Tab 1: Gnd

Pin 4: Amp Out
Pin 5: Vs
Pin 6: Vreg Out
Pin 7: Height Adj
Pin 8: Sync in
Pin 9: Osc.

Tab 2: Gnd

Pin 10: Amp Im
Pin 11: Comp
Pin 12: Ramp Gen

TDA1175P

Vertical output IC, PowerDIP16, supply voltage +35 volts max, +10 V min.

Pin 1: Ramp out, 1 V
Pin 2: Supply voltage
Pin 3: Flyback
Pin 4: Ground and heatsink
Pin 5: Ground and heatsink
Pin 6: Power amplifier output
Pin 7: Power amp supply voltage, range -0.5 to +10 V
Pin 8: Reg voltage, +6.7 volts
Pin 9: Height Adjustment
Pin 10: Sync input
Pin 11: Oscillator

Pin 12: Ground and heatsink
Pin 13: Ground and heatsink
Pin 14: Amp input, 2.27 volts
Pin 15: Compensation
Pin 16: Ramp generator

TDA1541A

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

Pin 1: Latch Enable(split mode)/Word Select(multiplexed modes)
Pin 2: Bit clock input
Pin 3: Data input (left chanel data in split mode)
Pin 4: Right channel data in split mode, otherwise not used.
Pin 5: Analogue Ground
Pin 6: Right channel audio output
Pin 7-13: Decoupling. Connect to ground via separate 0.1 uF cap on each pin.
Pin 14: Digital ground
Pin 15: -15V supply
Pin 16,17: Oscillator capacitor (connect 470pF between these 2 pins)
Pin 18-24: Decoupling (7 more 0.1 uF capacitors)
Pin 25: Left channel audio output
Pin 26: -5V supply
Pin 27: Digital mode select input
Pin 28: +5V

Modes:

Pin 27 = -5V: Separate channel data streams on pins 3 and 4. Pin 1 = latch enable

Pin 27 = 0V: Time multiplexed offset binary data on pin 3. Pin 1 = word select (low = left, high = right)

Pin 27 = +5V: Time multiplexed 2's complement data on pin 3. Pin 1 = word select again.

TDA1670A/TDA1675 - ECG1862

TV vertical deflection output, 35 V max Vs, 15 pin SIP-HS.

Pin 1: Amp output
Pin 2: Amp supply
Pin 3: Osc
Pin 4: Osc
Pin 5: Sync in
Pin 6: Osc
Pin 7: Height adj
Pin 8: Gnd
Pin 9: Ramp generator
Pin 10: Ramp out
Pin 11: Amp in +
Pin 12: Amp in -
Pin 13: Blanking out
Pin 14: Vs
Pin 15: Flyback

TDA1770A

Pin 1: Blank ouput
Pin 2: +supply
Pin 3: Flyback
Pin 4: NC
Pin 5: Ground
Pin 6: Ground
Pin 7: Ampl out
Pin 8: Ampl supply
Pin 9: Osc
Pin 10: Osc
Pin 11: Sync input
Pin 12: Osc
Pin 13: NC
Pin 14: Height adj
Pin 15: Ground
Pin 16: Ground
Pin 17: Ramp generator
Pin 18: Ramp out

Pin 19: Ampl in+
Pin 20: Ampl in-

TDA1905 - ECG7000

AF PO, 5W, Vcc = 14 V, Rl = 4 ohms.

Pin 1: Out
Pin 2: Vcc
Pin 3: Bootstrap
Pin 4: Threshold
Pin 5: Muting
Pin 6: Invert In
Pin 7: Svr
Pin 8: Non-Inverting In
Pin 9-16: Ground

TDA2003 - ECG1288

10 W AF Power Amp. TO220 5 Pin.

Pin 1: + In
Pin 2: - In
Pin 3: Gnd
Pin 4: Out
Pin 5: V+

TDA2005 - ECG1396

20 Watt bridge amp for car radio, manufactured by SGS-Thomson.

Pin 1: Input 1 (+)
Pin 2: Input 1 (-)
Pin 3: Svrr
Pin 4: Input 2 (-)
Pin 5: Input 2 (+)
Pin 6: Ground
Pin 7: Bootstrap 2
Pin 8: Output 2

Pin 9: +Vs
Pin 10: Output 1
Pin 11: Bootstrap 1

TDA2040 - ECG1376

AF PO 22 W, Vcc = 32 V, Rl = 4 ohms.

Pin 1: -In
Pin 2: +In
Pin 3: -Vs
Pin 4: Out
Pin 5: +Vs

Pin 3 connected to case.

TDA2577 - ECG1632

Horizontal, Vertical Oscillator, Sync, Driver. Vcc1 = 12 V typical.

Pin 1: Vertical Drive Out
Pin 2: Vertical Feedback
Pin 3: Vertical Frrequency Adj
Pin 4: Vertical Sync Sep
Pin 5: Video Input
Pin 6: Horizontal Sync Sep
Pin 7: Horizontal Sync Sep
Pin 8: Slow Phse Det
Pin 9: Ground
Pin 10: Vcc
Pin 11: Horizontal Drive Out
Pin 12: Horizontal Flyback Input
Pin 13: Mute Out
Pin 14: Phase Det.
Pin 15: Horizontal Frequency Adjust
Pin 16: Start Circuit Stab
Pin 17: Sandcastle Out
Pin 18: Coincidence Det

Aside from those that have obvious meanings, I do not know what the
other signals do.

TDA2578A

Synchronisation circuit with vertical oscillator and driver stages.

Pin 1: Vertical Drive output
Pin 2: Veritcal feedback (e.g. from sense components, bottom of yoke circuit)
Pin 3: Vertical oscillator timing components
Pin 4: Vertical sync separator R/C network
Pin 5: Video input
Pin 6: Horizontal sync separator input
Pin 7: Sync slicer output (connnect to 6 via RC network)
Pin 8: Slow (horizontal) phase detector RC timing components
Pin 9: Ground
Pin 10: +12V
Pin 11: Horizontal Drive output
Pin 12: Horizontal flyback pulse input
Pin 13: Mute and 50/60Hz indentification
Pin 14: Phase detector 2 timing capacitor
Pin 15: Horizontal oscillator timing components
Pin 16: Startup current input
Pin 17: Sandcastle pulse output
Pin 18: Coincidence detector timing capacitor

TDA3505

Chroma Control Circuit.

Pin 1: Red Signal Out
Pin 2: Storage Cap Cutoff Green
Pin 3: Green Signal Out
Pin 4: Storage Cap Cutoff Blue
Pin 5: Blue Signal Out
Pin 6: Vcc
Pin 7: Storage Cap Blue

Pin 8: Storage Cap Green
Pin 9: Storage Cap Red
Pin 10: Sandcastle Pules In
Pin 11: Signal Switch In
Pin 12: B Signal In
Pin 13: G Signal In
Pin 14: R Signal In
Pin 15: Y Signal In
Pin 16: Sat Control Voltage
Pin 17: R-Y In
Pin 18: B-Y In
Pin 19: Contrast Control Voltage In
Pin 20: Brightness Control Voltage In
Pin 21: White Point Adjust Blue
Pin 22: White Point Adjust Green
Pin 23: White Point Adjust Red
Pin 24: GND
Pin 25: Beam Current Control In
Pin 26: Auto Cutoff Control In
Pin 27: Storage Cap Leakage Current
Pin 28: Storage Cap Cutoff Red

TDA3654 - ECG1754

TV vertical deflection, 26 V typ.

9 pin SIL (the TDA3654Q has the pins bent to a sort of 'DIL' pinout - either
can be easily converted to the other shape).

Pin 1: Vertical drive input
Pin 2: Ground
Pin 3: Vertical drive input (may be linked to pin 1)
Pin 4: Ground
Pin 5: Output
Pin 6: Output stage power (Diode to V+, capacitor between 6 and 8)
Pin 7: Protection (to shut down CRT if sacn fails)
Pin 8: Flyback (capacitor to pin 6)
Pin 9: V+ (supply voltage)

TDA4190 - ECG1633

TV sound IF, tone, volume, FM detector, preamp, Po = 4 W, Rl = 16 ohms,
Vs = 24 V typical. 20 pin DIP.

Pin 1: Turn iff muting
Pin 2: Sound IF input
Pin 3: IF decoupling/VCR switch
Pin 4: IF decoupling/VCR switch
Pin 5: Gnd
Pin 6: Gnd
Pin 7: Detector (FM)
Pin 8: Detector (FM)
Pin 9: De-emphasis/Aux output
Pin 10: VCR input/output
Pin 11: Tone control capacitor
Pin 12: Tone control
Pin 13: Volume control
Pin 14: DC VC output
Pin 15: Gnd
Pin 16: Gnd
Pin 17: AF output
Pin 18: Vcc
Pin 19: AF PA feedback
Pin 20: AF PA input

TDA4440

Video-If-Amplifier for color and monochrome television receiver.
Manufactured by Telefunken electronics. Vs = 10 to 15 V.

Pin 1: Input
Pin 2: NC
Pin 3: Gnd
Pin 4: Decoupling (connect to an electrolitic capacitor).
Pin 5: To Tuner
Pin 6: Tuner control
Pin 7: Gating pulse
Pin 8,9: 38.9 MHz tank
Pin 10: NC
Pin 11: Negative video output

Pin 12: Positive Video output
Pin 13: Vs
Pin 14: NC
Pin 15: Gnd
Pin 16: Input

TDA4555

Multistandard Color Convertor.

Pin 1: (R-Y) Out
Pin 2: SECAM (R-Y) De-emph
Pin 3: (B-Y) Out
Pin 4: SECAM (B-Y) Ref In
Pin 5: SECAM (B-Y) Ref Out
Pin 6: SECAM (B-Y) De-emph
Pin 7: SECAM (R-Y) Ref Out
Pin 8: SECAM (R-Y) Ref In
Pin 9: GND
Pin 10: Delay Chroma Signal In
Pin 11: DC Ref Delay Line
Pin 12: Out Chroma S/D Line
Pin 13: Vcc
Pin 14: Work PT Con Chroma Amp
Pin 15: Chroma Signal In
Pin 16: ACC
Pin 17: Hue Control/Service Switch
Pin 18: Phase Control Osc
Pin 19: Crystal for Osc
Pin 20: NTSC ID
Pin 21: PAL/SECAM ID
Pin 22: SECAM ID Ref
Pin 23: SECAM ID Sel
Pin 24: Sandcastle In
Pin 25: Switch Voltage In/Out NTSC 4.4
Pin 26: Switch Voltage In/Out NTSC 3.5
Pin 27: Switch Voltage In/Out SECAM
Pin 28: Switch Voltage In/Out PAL

TDA4601

SMPS controller. Vcc = 15 V typ.

Pin 1: Reference
Pin 2: Zero detection
Pin 3: Feedback
Pin 4: Sawtooth Generator
Pin 5: Shutdown
Pin 6: Gnd
Pin 7: Sink output
Pin 8: Source output
Pin 9: Vcc

TDA4605

SMPS controller.

Pin 1: Regulation input
Pin 2: Primary current simulation
Pin 3: Primary voltage monitoring
Pin 4: Gnd
Pin 5: Output
Pin 6: Supply voltage
Pin 7: Soft-start
Pin 8: Zero crossing detector

TDA8340

(From: Alex Suhisky (a1ex@q-net.net)
  and Peter Radlberger (p.radlberger@blackbox.at).)

Television IF amplifier and demodulator.

```
Supply voltage (pin 11)                              - 12V,
Video output voltage (peak-to-peak, pin 12)      - 2.7 V
AFC output voltage swing (peak-to-peak, pin 5)  - 10 V
```

Pin 1: Balanced IF input
Pin 2: IF amplifier decoupling
Pin 3: Tuner AGC starting point adjustment
Pin 4: Tuner AGC output

Pin 5: AFC output
Pin 6: AFC on/off switch and sample-and-hold capacitor
Pin 7: Reference carrier pi/2 rad.phase shift
Pin 8: IF picture carrier passive regeneration
Pin 9: IF picture carrier passive regeneration
Pin 10: Reference carrier pi/2 rad.phase shift
Pin 11: Positive supply (Vcc)
Pin 12: Video output
Pin 13: Gnd (Vee)
Pin 14: IF AGC capacitor and VCR switch
Pin 15: IF amplifier decoupling
Pin 16: Balanced IF input

TDA9102C

Pin 1: R1
Pin 2: C2
Pin 3: Phase comparater out
Pin 4: Horizontal TTL in
Pin 5: C5
Pin 6: H power Gnd
Pin 7: H out
Pin 8: H playback
Pin 9: Phase comparator out
Pin 10: H phase adjust
Pin 11: Substrate digital Gnd
Pin 12: V frequency preset
Pin 13: C13
Pin 14: V TTL in
Pin 15: V ramp out
Pin 16: V amplifier adjust
Pin 17: V linearity adjust
Pin 18: Linear output
Pin 19: Vertical reference
Pin 20: Vs

TEA2037A - ECG1888

Horizontal/Vertical deflection output, Vcc = 14 V. 16 pin DIP.

```
Pin 1: Frame osc
Pin 2: Flyback generator
Pin 3: Frame flyback
Pin 4: Gnd
Pin 5: Gnd
Pin 6: INPUT Inverse
Pin 7: Frame power supply
Pin 8: Frame OUTPUT
Pin 9: Line Osc.
Pin: 10: Phase Detector
Pin: 11: Flyback
Pin: 12: Gnd
Pin: 13: Gnd
Pin: 14: Output Line
Pin: 15: Input Video
Pin: 16: +Vcc
```

TEA5500

Coded locking circuit for security systems.

(From: Paul Grohe (grohe@galaxy.nsc.com).)

Vs 7V max, Is 1.8-3.2 mA, 8 V zener across supply pins!!!

```
Pin 1: Gnd
Pin 2: Cosc     Ocsillator capacior to Vp ~1nF
Pin 3: S2       Output 2        Open collector, active low
Pin 4: S1       Output 1              "
Pin 5: E10
Pin 6: E9
Pin 7: E8
Pin 8: E7
Pin 9: E6
Pin 10: E5
Pin 11: E4
Pin 12: E3
Pin 13: E2
Pin 14: E1
Pin 15: DATA    Data input
Pin 16: Vp      Pos. supply
```

Encoder: Pin 15 to Vp, Output: tie pins 3&4 together, this is your output, open collector. E1-E10 set code (connect to either Vp or gnd).
Key V+ to transmit.

Decoder, pin 15 to Vp, E1-E10 set code, pins 3&4 open collector outputs
active when code matches. Third unsucessfull try disables input! (three
strikes and your out!)

Illegal codes are E1-E10=High or E1-E9=High with E10=low.

TL494 - ECG1729

Pulse width modulator control circuit. Vcc = 15 V typical. 16 pin DIP.

Pin 1: Non-inverted in
Pin 2: Inverted in
Pin 3: Feedback
Pin 4: Dead time control
Pin 5: CT
Pin 6: RT
Pin 7: Ground
Pin 8: Collector 1
Pin 9: Emitter 1
Pin 10: Emitter 2
Pin 11: Collector 2
Pin 12: Vcc
Pin 13: Output control
Pin 14: Vref
Pin 15: Inverted in
Pin 16: Non-inverted in

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U to Z

UA78GU(1C) - ECG953

Adjustable regulator, 5 to 30 V, 1 A.

```
               -----
               | O | <-Common (heatsink tab)
               -----
               |   |
               -----
                ||||
                1234
```

Pin 1: Common
Pin 2: Input
Pin 3: Output
Pin 4: Control

UA2240CN - ECG893 - SK7712

Programmable Timer/Counter. Vcc = 5 V typ.

Pin 1: Fo (out)
Pin 2: Fo/2 (out)
Pin 3: Fo/4 (out)
Pin 4: Fo/8 (out)
Pin 5: Fo/16 (out)
Pin 6: Fo/32 (out)
Pin 7: Fo/64 (out)
Pin 8: Fo/128 (out)
Pin 9: Ground
Pin 10: Reset
Pin 11: Trigger
Pin 12: Mod/sync
Pin 13: Timing/rc network
Pin 14: Time-base (out)
Pin 15: Regulator (out)
Pin 16: Vcc

UC3842AN

Switchmode power supply controller. 8 pin DIP.

Pin 1: Comp
Pin 2: Vfb
Pin 3: Isen
Pin 4: Rt/Ct
Pin 5: Gnd
Pin 6: Out
Pin 7: Vcc
Pin 8: Ref (+5)

UDN2993LB

Pin 1: Load supply
Pin 2: Enable(A)
Pin 3: Phase(A)
Pins 4-7: Gnd
Pin 8: Out(1A)
Pin 9: Out(2A)
Pin 10: V(ea)
Pin 11: V(eb)
Pin 12: Out(2B)
Pin 13: Out(1B)
Pin 14-17: Gnd
Pin 18: Phase (B)
Pin 19: Enable (B)
Pin 20: Logic supply

ULN2003A - ECG2013

7 Input Darlington Driver 500mA

Pin 1: In 1
Pin 2: In 2
Pin 3: In 3
Pin 4: In 4
Pin 5: In 5
Pin 6: In 6
Pin 7: In 7

Pin 8: Gnd
Pin 9: Common connection point for the cathodes of the internal free
wheeling diodes connected to each driver output.

Pin 10: Out 7
Pin 11: Out 6
Pin 12: Out 5
Pin 13: Out 4
Pin 14: Out 3
Pin 15: Out 2
Pin 16: Out 1

ULN3718M

Pin 1: Decoupling
Pin 2: Power Ground
Pin 3: Signal Ground
Pin 4: Output
Pin 5: Vcc
Pin 6: N/C
Pin 7: N/C
Pin 8: Input

ULN3751Z

Pin 1: Non-inverting input
Pin 2: Inverting input
Pin 3: Substrate/-Vs
Pin 4: Output
Pin 5: +Vs

uPA53C - ECG2084

5 Input Darlington Driver, 500mA.

Pin 1: NC
Pin 2: In 1

Pin 3: In 2
Pin 4: In 3
Pin 5: In 4
Pin 6: In 5

Pin 7: Gnd
Pin 8: NC

Pin 9: Out 5
Pin 10: Out 4
Pin 11: Out 3
Pin 12: Out 2
Pin 13: Out 1
Pin 14: NC

uPC177C

Quad Comparator.

Pin 1: Output 1
Pin 2: Output 2
Pin 3: Vcc
Pin 4: Neg input 2
Pin 5: + input 2
Pin 6: - input 1
Pin 7: + input 1
Pin 8: - input 3
Pin 9: + input 3
Pin 10: - input 4
Pin 11: + input 4
Pin 12: Gnd
Pin 14: Output 3
Pin 13: Output 4

uPC1238 - ECG1378

AF Power Out, 10W, Vcc = 12V typ. TO220, 5 pin.

Pin 1: Non-inverting input
Pin 2: Inverting input

```
Pin 3: -Vcc
Pin 4: Output
Pin 5: +Vcc
```

X24C44

```
8 pin DIP.

Pin 1: Chip enable
Pin 2: Serial clock
Pin 3: Data input
Pin 4: Data output
Pin 5: Vcc
Pin 6: Store
Pin 7: Recall
Pin 8: Vss
```

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-- end V2.23b --